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2009 AWS Welding Show in Review

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Steel Dynamic - concentrated and flexible arc for welding with deep and narrower penetration

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**Where Are AWS Certifications Heading?**

In 1976, AWS administered the first Certified Welding Inspection (CWI) exams in Philadelphia and Miami. At that time, the newly organized AWS Qualification and Certification Committee had developed the exam out of a desire to provide industry with a welding inspector qualification program consisting of central certification testing. The program was based on the QC1-76 document.

Many of the early committee members like Butch Sosnin (AWS president 1977–78), Wally Urbick (Boeing), and Bill Smith (Bechtel) struggled on issues regarding whether welding inspector candidates had to prove their proficiency in welding as a prerequisite to taking the CWI exam. That requirement lost majority support, and the welding skill requirement gave way to a documented five years of code welding experience in the areas specified in QC1-76.

You may find it interesting that for a couple of years, AWS did not offer any preparatory courses for those first test candidates. The early exams consisted of the same three parts that remain today. The difference in the Part B practical exam in 1976 was the totally written format, which subsequently changed into the “hands-on” test we now take, which utilizes weld replicas and visual inspection tools.

As the program matured, the exam was updated and the program expanded to include a Senior Level CWI (SCWI). The SCWI test includes advanced welding processes, quality management, and welding procedure development qualification questions.

Through the board of directors, the AWS membership requested the development of other certifications. So today AWS offers several Certification Credentials giving individuals, fabricators, and other institutions Certification and Accreditation Credentials designed to demonstrate competence in general and specific weld areas.

Today, government agencies, construction codes, manufacturers, and engineering organizations specify many of these certification credentials.

Following are the current certifications AWS offers:

The popularity of these programs is obvious from looking at the number of people currently certified by AWS as of September 2009:

- CWI 26,239
- CAWI 2,916
- SCWI 473
- CWE 1,581
- CW 3,624
- CWS 359
- CRI 185
- CWEEngineer 22

— continued on page 6
#1 FOR A REASON

With 35 years of experience across all levels of the welding and cutting industries, Tom Wermert still has the same devotion for work as he did at age 20. “I just love the industry and what I do,” he says.

As Product Line Manager for Thermadyne® Welding Products, Tom insists the products go through rigorous testing to ensure only the highest quality product makes it to the market. “Our customers expect the best performance and the most dependable welding and cutting products, and it’s my job to see that they get it.”

As a former lab employee, testing new welding products and processes, Wermert understands what it takes to make professional-grade tools. “Take the Arcair® Angle-Arc® K4000® Manual Gouging Torch for example,” he says. “It didn’t become the industry standard by accident.”

The K4000 is used to scarf or remove defective welds and defective metal blemishes from castings or weldments. It’s made for heavy-duty metal removal applications, ideal for weld preparations in fab shops and shipyards.

“Products like the K4000 are why Arcair remains the number one name in air carbon arc manual torches,” he says.

TOM WERMERT
Product Line Manager, Welding Products
Thermadyne Industries

Tom carries the torch – will you?

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The growth of these programs continues as shown in the chart below.

So what does the future look like for the CWI/SCWI program? First, the program outlined in QC1-07, Standard for the AWS Certification of Welding Inspectors, is rapidly expanding internationally. Currently, more than 25% of all CWIs and SCWIs are from outside the United States. The two countries representing the majority of this growth are India and China. The chart below shows the countries with the most significant numbers of CWIs.

Secondly, revisions have been made to QC1-2007. One of the most significant changes involves the allowance for a CWI/SCWI to take supplemental inspection exams called endorsements. These exams are available for CWIs/SCWIs who may have need for additional exam-based qualification credentials. Following are the current endorsements available:

- AWS D1.1, D1.2, D1.5, and D15.1
- ASME Section IX + B31.1 + B31.3
- ASME Sections VIII (Div. 1) + IX

In the past, QC-1 had no provision for allowing a CWI/SCWI to take additional code book exams. Now, if needed to meet a particular customer, agency, or job requirement, these endorsements are available. As a bonus, many of these code book endorsements may be used as an alternate means of meeting the CWI nine-year renewal requirements. Those CWIs selecting this renewal option can elect to take a code endorsement exam any time after their original CWI certification date and if they pass, they have met their nine-year renewal requirements. Of course, the other two options, i.e., retaking the Part B exam, or accumulating 80 professional development hours are still available, but neither of these options give the CWI/SCWI a new additional credential at such a low investment of time and money.

Endorsements issued as of September 2009 in this first year of their offering are as follows:

As you can see, the AWS Certification programs have evolved over the years to meet the needs of industry and certified individuals. There are other changes in QC1-07 such as one 3-year certification limit for CAWIs, and exam question numbers. I urge all CWIs and candidates to review the revised document. And, finally, keep an eye on the AWS Web site. There are more endorsements coming.
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Bill Would Focus Training Programs on Transferable Credentials

Introduced at the end of 2009, the American Manufacturing Efficiency and Retraining Investment Collaboration Act, popularly known as the AMERICA Works Act, would require that several major federal job training and career education initiatives give priority to programs that provide a national industry-recognized and portable credential.

Funding awarded through the Workforce Investment Act, the Perkins Vocational-Technical Education Act, and similar federal programs would be required to give preference to local workforce and education programs that result in successful participants receiving a portable, industry-recognized credential. The intent is to better align education and job training with needed skills and meaningful career pathways.

OSHA to Revisit Ergonomics Injuries

The U.S. Occupational Safety and Health Administration (OSHA) is proposing to require employers to report “work-related musculoskeletal disorders” as part of the usual injury and illness reporting and record-keeping mandates. This action revives an issue that OSHA declined to pursue in 2001, in particular the task of defining exactly what constitutes a “musculoskeletal disorder.” This action by OSHA is also assumed to be the first step toward developing a broader rule regulating ergonomics generally. OSHA considers musculoskeletal injuries to be one of the biggest worker health and safety problems in the country.

DOE Develops New Energy Technology Information Web Site

The U.S. Department of Energy (DOE) has launched Open Energy Information (www.OpenEI.org) — a new open-source Web platform that will make DOE resources and open energy data widely available. DOE hopes that the data and tools housed on the Wiki platform will be used by government officials, the private sector, project developers, the international community, and others to help deploy clean energy technologies.

The site currently houses more than 60 clean energy resources and data sets, including maps of worldwide solar and wind potential, information on climate zones, and best practices. OpenEI.org also links to the Virtual Information Bridge to Energy (VIBE), which is designed as a data analysis hub that will provide a portal for energy data.

Federal Report Measures Impact of Cap and Trade Law

In response to an inquiry from a group of U.S. Senators with significant manufacturing activity in their respective states, several federal agencies have issued an interagency report estimating the impact on manufacturing of proposed cap and trade legislation intended to reduce greenhouse gases. The report, entitled “The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries,” addresses the potential near-term international competitiveness impacts of domestic energy and climate legislation, specifically, whether the adoption of a domestic cap-and-trade program would lead some manufacturing activity to shift to countries that do not have comparable greenhouse gas regulations. The report concludes that domestic production costs would increase by no more than 2.5%, which the report concludes is not material.

The report is available at the following link: www.epa.gov/climatechange/economics/pdfs/InteragencyReport_Competitiveness&EmissionLeakage.pdf.

‘Clean’ Technology Manufacturing Promoted

The American Clean Technology Manufacturing Leadership Act (S. 2857) would extend a tax credit that allows companies to write off 30% of the cost of creating, expanding, or re-equipping facilities to manufacture renewable energy technologies like solar panels, wind turbines, and advanced batteries. The bill would add another $2.5 billion to the $2.3 billion in tax credits that the Departments of Energy and the Treasury awarded in 2009.

Legislation Would Aid Small-Scale Nuclear Energy

Two bills pending in the U.S. Senate, the Nuclear Energy Research Initiative Improvement Act (S. 2052) and the Nuclear Power 2021 Act (S. 2812), would establish research programs designed to reduce the cost of construction of small nuclear reactors. Proponents of small reactors, i.e., less than 300 megawatts, claim they can utilize modular construction techniques where plant subassemblies can be built and assembled on-site, thereby reducing nuclear plant construction costs overall.

EU Moves Toward Single Patent Regime

Members of the European Union (EU) have approved a broad outline for a single EU patent, replacing the several national patents. Such a system would, at least in theory, be more efficient and less expensive. There would also be a patent appeals court for the entire EU that would resolve patent infringement suits. If finalized, this would be a significant development for the business community, as the current system is fragmented, with companies often having to pursue legal proceedings in several European countries at once, and national courts issuing conflicting decisions on identical cases.

First Federal Anti-SLAPP Legislation Considered

For the first time, legislation has been introduced that would create a federal anti-SLAPP law. So-called “strategic lawsuits against public participation,” or SLAPPs, are characterized by their opponents as lawsuits brought with the intent of intimidating and silencing opponents in public disputes. The Citizen Participation Act (H.R. 4364), currently pending before the House Judiciary Committee, would create the first anti-SLAPP law that applies to federal cases. Currently, 28 states have anti-SLAPP statutes. The bill, in effect, would provide immunity from liability based on conduct considered to be protected First Amendment activity.

Contact the AWS Washington Government Affairs Office at 1747 Pennsylvania Ave. NW, Washington, DC 20006; e-mail hwebster@we-b.com; FAX (202) 833-0243.
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Hodgson Custom Rolling has the expertise to roll curved structural sections into a wide range of shapes and sizes (angle, wide flange beam, I-beam, channel, bar, tee section, pipe, tubing, rail, etc.). We specialize in Spiral Staircase Stringers, flanges, support beams, gear blanks, etc.

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Iowa Mold Tooling Expands into New Manufacturing Facility to Manage Increased Welding Activities

Iowa Mold Tooling Co. Inc. (IMT) recently expanded its manufacturing operations into McIntire, Iowa, by opening a new facility to handle its increased welding activities. This plant opening created about 40 welding jobs. Also, the company has hired additional welders at its main facility in Garner, Iowa. Despite the global recession, business at IMT increased in 2009, primarily due to a partnership between IMT and its parent company, Oshkosh Corp., that supports the military’s need for new equipment overseas. “With the increased workload at IMT, it became clear that we would need to expand our operations to meet demand,” said Steve Fairbanks, IMT president. “In these tough economic times, this is great news for IMT and our community. Our manufacturing expansion not only supports our military efforts, but also allows us to quickly respond to increased customer needs when the economy improves.”

Apollo Alliance Unveils Plan to Boost Clean Energy Jobs

The Apollo Alliance, San Francisco, Calif., released a clean energy investment five-point plan that will create up to 1.2 million domestic jobs while increasing U.S. energy security and climate stability. Recommendations for inclusion in a larger Congressional and administration plan to spur economic recovery and create jobs are as follows:

- creating 255,000 jobs by driving short-term investment in efficiency and renewables in ways that will leverage private capital in the long term;
- creating 278,000 jobs by laying the groundwork for a 21st century transportation system;
- creating 700,000 manufacturing jobs (and an additional 1.9 million indirect jobs in related industries) by supporting American manufacturers in retooling and expanding their operations, and positioning domestic clean energy manufacturers to compete in the global marketplace;
- creating a large-scale financing mechanism that drives investment and creates jobs researching, developing, and manufacturing the technologies and products of the clean energy economy; and
- creating 31,000 jobs by putting Americans back to work serving their communities and preparing a workforce to build the clean energy economy.

Odessa College’s Welding Center Gets Services Extension

The Odessa College Welding Training Center, Odessa, Tex., has been approved for a one-year extension of services through the U.S. Department of Labor’s Community-Based Job Training Grant. It received the no-cost extension because of positive results leading to more than 400 students completing their welding training over the last two years, while still meeting strict budget controls. With this, the center will offer five morning entry-level welding classes and five evening pipe welding procedures classes during 2010, which were expected to begin Jan. 19 and run through March 11.

Motion Controls Robotics Introduces Revamped Web Site

Motion Controls Robotics, Inc., Fremont, Ohio, launched a redesigned Web site at www.motioncontrolsrobotics.com. It features updated content, videos, and photos showcasing various applications the company integrates including case and bag palletizing, depalletizing, container handling, descrambler and case packing, warehouse automation, pallet dispensing, and automatic guided vehicles and carts. Extra applications include arc welding, assembly, machine tending, material removal, vision integration, and engineering services. The site further features a case studies and testimonials area, database of used/refurbished robots available for purchase, and online catalog of service options and spare parts.
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NASA Uses Friction Stir Welding, Spin Forming to Develop New Tank Dome Technology

NASA has recently partnered with Lockheed Martin Space Systems, Denver, Colo., and MT Aerospace, Augsburg, Germany, to manufacture the first full-scale friction stir welded and spun formed tank dome designed for use in large liquid propellant tanks. The NASA and Lockheed Martin team traveled to Germany to witness the first successful aerospace application of these two manufacturing processes.

Friction stir welding and spin forming were used by MT Aerospace to produce an 18-ft-diameter tank dome using high-strength 2195 aluminum-lithium. The diameter of this development dome matches the tank dimensions of the upper stage of the ARES I launch vehicle under development by NASA.

“This new manufacturing technology allows us to use a thinner, high-strength alloy that will reduce the weight of future liquid propellant tanks by 25%, compared to current tank designs that use a lower-strength aluminum alloy that weighs more,” said Louis Lollar, project lead for the Friction Stir Weld Spun Form Dome Project at NASA’s Marshall Space Flight Center, Huntsville, Ala.

The concave net shape spin forming process, patented by MT Aerospace, also simplifies the manufacturing of large tank domes and reduces cost by eliminating manufacturing steps required when manufacturing traditional gore panel construction domes.

The spherical tank dome was manufactured from a flat plate “blank” made of 2195 alloy. The blank was constructed by friction stir welding together two commercial, off-the-shelf plates to produce a large starting blank. The welded plate blank was then spun formed to create the single-piece tank dome.

This is the first time this combination of twin manufacturing processes has been successfully applied to produce a full-scale 2195 aluminum-lithium dome. Two more, full-scale development tank domes are scheduled for manufacture and testing as part of the joint, two-year technology demonstration program.

ABB Wins $26 Million Order to Power Greece Refinery

ABB, Zurich, Switzerland, has won an order worth $26 million from Hellenic Petroleum SA to provide an integrated power and automation system for upgrading Hellenic Petroleum’s Elefsina refinery, west of Athens, Greece. The company will design, supply, install, and commission the electrical and automation system to power the refinery. This turnkey electrical solution aims to strengthen the reliability and quality of power supply to the refinery, while improving energy efficiency and reducing overall electricity consumption and costs.

Pueblo Community College Furthers Its Manufacturing Center Excellence

Vestas Towers Americas, Inc., recently formed a partnership with Pueblo Community College (PCC), Pueblo, Colo. The college has an exclusive role in training employees for the new ABB Wins $26 Million Order to Power Greece Refinery

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Vestas Towers plant that was expected to begin manufacturing operations in Pueblo in late fall. This past summer, PCC’s Economic & Workforce Development Division began training some of the 500+ employees the Vestas plant will eventually employ. That training was expanded to include utilizing submerged arc welding equipment that Vestas provided for the college’s Gorisch Advanced Technology Center.

In addition, the college showcased three new mobile learning labs developed as part of a $2 million U.S. Department of Labor grant awarded to the college in May 2008. Along with a fourth mobile lab developed two years ago, the Economic & Workforce Development Division now has a fleet capable of delivering on-site training in welding along with electrical, manufacturing, and mechanical systems.

PCC offers an energy maintenance technology program as well that includes a solar energy component providing skills training in the development and maintenance of solar systems.

**Kobe Steel to Establish Welding Company in China**

Kobe Steel, Ltd., plans to establish a company in Shanghai, China, for marketing its welding products and welding robot systems. The new company, to be called Kobe Welding of Shanghai Co., Ltd., is anticipated for establishment in March 2010 and plans call for capitalization to be at $800,000. It will be wholly owned by Kobe Steel and have 11 employees. In China’s energy field, demand has been active for petroleum and spherical tanks, plus LNG terminals in recent years.

**Truex Receives Sixth Environmental Compliance Award**

Mark Buchan (left), quality manager, and Geoff Marchant, wastewater treatment facility manager, pose next to the filter press with Truex’s six awards.

Truex Inc., a manufacturer of deep drawn stampings, recently received its sixth Environmental Perfect Compliance Award from the Narragansett Bay Commission of Rhode Island. Each year

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the commission recognizes industrial users demonstrating a perfect record of compliance to its environmental regulations. “This marks the fifth consecutive time we have achieved this award,” said Mark Buchan, the company’s quality manager. “At Truex, we place great importance on the protection of the environment and set our standards high enough to meet or exceed all state and federal requirements.”

University of the Fraser Valley Welding Students Create Rotary Wheel

The Abbotsford Rotary Club recently commissioned a group of first-year welding students from the University of the Fraser Valley, Canada, to produce a Rotary wheel. It measures 12 ft in diameter and weighs 1400 lb.

“Whenever we do a project like this, it’s a learning experience for all students going through the program — not just the handful who worked on it,” said welding instructor Sheldon Frank. He also liked the idea of doing a community project and decided it would be something different for the new welding students. This year, there are 80 students taking welder training at Chilliwack’s Trades and Technology Centre (TTC).

The raw material, ¾-in. carbon-plated steel, was donated by the Rotary Club to the university. It arrived at the TTC in seven 4- x 8-ft pieces. Frank drew the wheel using AutoCAD and programmed it to a CNC cutting table, then the group cut metal pieces using a plasma torch. The students were left with seven big pieces of metal and the task of getting them prepared, fitted, and welded together.

This completed wheel will be installed on large grassy area,

First-year welding students from the University of the Fraser Valley, Canada, helped to make this large Rotary wheel for the Abbotsford Rotary Club. Shown (from left) are students Brayden Welsh, Roxanne Meer, Travis Medley, and James Motion. Instructor Sheldon Frank stands to the right.

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and it is designed to break down into two pieces for shipping, but a hoist will be required to position it at the roadside location.

**Trident Workforce Investment Board Prepares Customers for Welding Careers**

Thirteen customers from Trident One Stop Career System, North Charleston, S.C., have graduated from the Welding Training Program, a Trident Workforce Investment Board initiative in partnership with Trident Technical College.

The college provided the site and instructors for this 280-h flux cored arc and shielded metal arc welding training program, while the board provided funding, through the Workforce Investment Act, so eligible students could attend for free. Training was also provided in carbon arc gouging, cutting with oxyacetylene torches, and weld grinding and plate preparation.

Immediately after the graduation ceremony, human resources managers representing Pegasus Steel, Force Protection, Detyens Shipyards, and Laurentide interviewed the graduates.

**Industry Notes**

- **Edison Welding Institute (EWI)**, Columbus, Ohio, has an agreement with **S-Bond Technologies** giving the company the ability to distribute its lead-free, fluxless solder, EWI SonicSolder®.
- **FLIR Systems** delivered its 100,000th commercial-use infrared camera. This was sold by **Professional Equipment** to Bob Childs, owner of **Bob the Inspector, Inc.**, Green Valley, Ariz.
- **Solar Atmospheres**, a vacuum heat treating, brazing, and carburizing company, is opening a new plant in Fontana, Calif. The entire project will cost $9 million.
- **Central Welding Supply Co. Inc.**’s Chairman and Founder, Mickey Wilton, and President/CEO Dale Wilton recently announced **Pacific Welding Supplies LLC**, Tacoma, Wash., has been added to its family of companies.
- **Eriez®, Erie, Pa.**, purchased a robotic welding machine to improve efficiency, maintain accuracy, and meet production volumes, according to President and CEO Tim Shuttleworth.
- The **North American Die Casting Association**’s updated Web site at www.diecasting.org offers easier navigation, an updated news system, as well as a new calendar program.
- The **board of trustees** for **Flathead Valley Community College**, Mont., approved two proposals — the **Welding Technology Certificate** providing additional certification in specialized welding techniques and **Welding and Inspection Technology Associate of Applied Science** degree that includes a nondestructive examination component.
- **Photron, Inc.**, San Diego, Calif., is donating a high-speed video system to the Edgerton Center at **Massachusetts Institute of Technology** for long-term use by students and researchers.
- Beam Reach Education’s **Tulsa Welding School** acquired The **Refrigeration School, Inc.**, featuring heating ventilation, air conditioning, and refrigeration curriculum with more than 500 students and 45 instructors and administrators.
- **Lucas-Millhaupt** launched a newly designed, information-enhanced Global Brazing Solutions Web site. It includes an added knowledge base section, case studies, and a multilevel locator.

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Friends and Colleagues:

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

For specifics on the nomination requirements, please contact Wendy Sue Reeve at AWS headquarters in Miami, or simply follow the instructions on the Fellow nomination form in this issue of the Welding Journal. Please remember, we all benefit in the honoring of those who have made major contributions to our chosen profession and livelihood. The deadline for submission is July 1, 2010. The Committee looks forward to receiving numerous Fellow nominations for 2011 consideration.

Sincerely,

Nancy C. Cole
Chair, AWS Fellows Selection Committee
American Welding Society

Fellow Description

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

- Sustained service and performance in the advancement of welding science and technology
- Publication of papers, articles and books which enhance knowledge of welding
- Innovative development of welding technology
- Society and chapter contributions
- Professional recognition

RULES
1. Candidates shall have 10 years of membership in AWS
2. Candidates shall be nominated by any five members of the Society
3. Nominations shall be submitted on the official form available from AWS Headquarters
4. Nominations must be submitted to AWS Headquarters no later than July 1 of the year prior to that in which the award is to be presented
5. Nominations will remain valid for three years
6. All information on nominees will be held in strict confidence
7. No more than two posthumous Fellows may be elected each year

NUMBER OF FELLOWS
Maximum of 10 Fellows selected each year.

AWS Fellow Application Guidelines
Nomination packages for AWS Fellow should clearly demonstrate the candidates outstanding contributions to the advancement of welding science and technology. In order for the Fellows Selection Committee to fairly assess the candidates qualifications, the nomination package must list and clearly describe the candidates specific technical accomplishments, how they contributed to the advancement of welding technology, and that these contributions were sustained. Essential in demonstrating the candidates impact are the following (in approximate order of importance).

1. Description of significant technical advancements. This should be a brief summary of the candidates most significant contributions to the advancement of welding science and technology.
2. Publications of books, papers, articles or other significant scholarly works that demonstrate the contributions cited in (1). Where possible, papers and articles should be designated as to whether they were published in peer-reviewed journals.
3. Inventions and patents.
4. Professional recognition including awards and honors from AWS and other professional societies.
5. Meaningful participation in technical committees. Indicate the number of years served on these committees and any leadership roles (chair, vice-chair, subcommittee responsibilities, etc.).
6. Contributions to handbooks and standards.
7. Presentations made at technical conferences and section meetings.
8. Consultancy — particularly as it impacts technology advancement.
9. Leadership at the technical society or corporate level, particularly as it impacts advancement of welding technology.
10. Participation on organizing committees for technical programming.
11. Advocacy — support of the society and its technical advancement through institutional, political or other means.

Note: Application packages that do not support the candidate using the metrics listed above will have a very low probability of success.

Supporting Letters
Letters of support from individuals knowledgeable of the candidate and his/her contributions are encouraged. These letters should address the metrics listed above and provide personal insight into the contributions and stature of the candidate. Letters of support that simply endorse the candidate will have little impact on the selection process.

Return completed Fellow nomination package to:

Wendy S. Reeve
American Welding Society
Senior Manager
Award Programs and Administrative Support
550 N.W. Lejeune Road
Miami, FL 33126

Telephone: 800-443-9333, extension 293

SUBMISSION DEADLINE: July 1, 2010
CLASS OF 2011
FELLOW NOMINATION FORM

(please type or print in black ink)

DATE__________________________

NAME OF CANDIDATE__________________________

AWS MEMBER NO.__________________________
YEARS OF AWS MEMBERSHIP__________________________

HOME ADDRESS__________________________

CITY_______________________STATE________ZIP CODE_________PHONE________

PRESENT COMPANY/INSTITUTION AFFILIATION__________________________

TITLE/POSITION__________________________

BUSINESS ADDRESS__________________________

CITY_______________________STATE________ZIP CODE_________PHONE________

ACADEMIC BACKGROUND, AS APPLICABLE:

INSTITUTION__________________________

MAJOR & MINOR__________________________

DEGREES OR CERTIFICATES/YEAR__________________________

LICENSED PROFESSIONAL ENGINEER: YES______NO_______ STATE__________________________

SIGNIFICANT WORK EXPERIENCE:

COMPANY/CITY/STATE__________________________

POSITION__________________________YEARS__________________________

COMPANY/CITY/STATE__________________________

POSITION__________________________YEARS__________________________

SUMMARIZE MAJOR CONTRIBUTIONS IN THESE POSITIONS:

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

IT IS MANDATORY THAT A CITATION (50 TO 100 WORDS, USE SEPARATE SHEET) INDICATING WHY THE NOMINEE SHOULD BE SELECTED AS AN AWS FELLOW ACCOMPANY NOMINATION PACKET. IF NOMINEE IS SELECTED, THIS STATEMENT MAY BE INCORPORATED WITHIN THE CITATION CERTIFICATE.

SEE GUIDELINES ON REVERSE SIDE

SUBMITTED BY: PROPOSER_________________AWS Member No.__________________

Print Name__________________________

The Proposer will serve as the contact if the Selection Committee requires further information. Signatures on this nominating form, or supporting letters from each nominator, are required from four AWS members in addition to the Proposer. Signatures may be acquired by photocopying the original and transmitting to each nominating member. Once the signatures are secured, the total package should be submitted.

NOMINATING MEMBER:_________________NOMINATING MEMBER:_________________

Print Name_________________AWS Member No.__________________

NOMINATING MEMBER:_________________NOMINATING MEMBER:_________________

Print Name_________________AWS Member No.__________________

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Q: I am currently involved with an aerospace project that requires the development of welding procedures to be used for friction stir welding of aluminum alloys. I am looking for information relating to the type of tests I can perform and appropriate acceptance criteria that may be used for the inspection and testing of joints made by the friction stir welding process. In the past, I have used AWS D1.2, Structural Welding Code — Aluminum, for my aluminum arc welding procedure qualifications. However, the AWS D1.2 Code does not include friction stir welding as a designated welding process. I have been unable to find a specification that provides precise guidelines for friction stir welding. Is there a specification available specifically for this process?

A: You are quite correct. The AWS D1.2/D1.2M:2008, Structural Welding Code — Aluminum, provides requirements for four welding processes that are listed in section 4.1 of the code. These are gas metal arc welding (GMAW), gas tungsten arc welding (GTAW), plasma arc welding with variable polarity (PAW-VP), and stud welding (SW).

Friction Stir Welding Specifications

There have been limited resources available in the form of an American national standard welding specification that addresses a procedure qualification and inspection criteria for friction stir welding (FSW), due to the fact that in terms of welding processes, FSW is a relatively new one. This process was conceived, developed, and subsequently patented in 1991 by The Welding Institute (TWI) in Cambridge, UK. It has taken time since the conception of this welding process for it to be tested, further developed, and recognized by the industry.

After the need for a FSW standard was recognized, additional time has been spent in the development and approval of a suitable specification. In late 2009, the American Welding Society (AWS) released the first specification for FSW of aluminum alloys. This new specification was created for aerospace applications. I have been informed by TWI that the International Institute of Welding (IIW) is currently working on a standard for FSW that covers aluminum and is intended for use by all industries using the process. The standard (ISO 25239) is in the final stages of agreement and is expected to be issued in 2010. As the inventor of FSW, TWI has historically and presently committed to working with manufacturing organizations to assist in the development of welding procedures associated with FSW and also assisting in achieving approval of procedures through third-party organizations.


The AWS D17 Committee on Welding in the Aircraft and Aerospace Industries determined that it was necessary to form a subcommittee to write a specification for FSW. It was appropriate that the setting for the subcommittee’s kickoff meeting in October 1999 was at the Kennedy Space Center in Florida. Kennedy Space Center is where the first friction stir welded commercial aerospace component, the fuel tank for the Delta launch vehicle, went into service. Representatives from industry, welding institutes, government agencies, and universities met to dedicate themselves to forming a specification for the friction stir welding of aluminum for aerospace applications. AWS D17.1:2001, Specification for Fusion Welding for Aerospace Applications, served as the model for this specification.

Specification Content

1. Scope. The scope of the specification is quite brief. It contains the requirements for designing, friction stir welding, and inspecting aerospace hardware followed by a description of the process. Friction stir welding produces a weld between two abutting workpieces by the friction heating and plastic material displacement caused by a rotating tool that traverses along the weld joint — Fig. 1.

2. Normative References. The normative references list various standards that contain provisions, which through reference in the standard constitute mandatory provisions of the AWS standard.
3. Terms and Definitions. This section provides some very useful material, six full pages of definitions supported by illustrations to help interpretation. Many of these definitions are specific to the FSW process and are therefore very important to the understanding of this relatively new welding process and the use of the standard.

4. General Requirements. This section of the specification deals with the classification of welds, class A – critical, class B – semicritical, and class C – noncritical. It also addresses approval, drawing precedence, and specification precedence.

5. Design of Weld Joints. This section addresses information about weldment design data, drawing information requirements (listing essential information that will be specified on drawings), weld dimensions, and inspection requirements.

6. Development and Qualification of a Welding Procedure. This section provides a very comprehensive section of the specification, providing all the information required for the development of a preliminary welding procedure specification (pWPS), welding procedure qualification record (WPQR), and welding procedure specification (WPS). This section includes information on the sequence for qualifying a welding procedure, selection of a welding procedure qualification method, preparation of a preliminary WPS with required variables, evaluation of test welds, visual inspection, destructive tests, acceptance criteria, and WPS variables. All this material is supported by a flow chart and a number of comprehensive figures and tables providing details of test specimens for various joint designs.

7. Welding Operator Qualification. This section addresses operator qualification requirements, vision testing, test weld requirement, inspection, qualification limitations, qualification/certification validity, and test records. This material is supported by various drawings that show test plate detail.

8. Fabrication. The fabrication section of the specification provides information on welding equipment requirements, FSW tools, preweld joint preparation and fitup, preheat temperature control, tack welding, postweld surface preparation, weld identification requirements, and acceptance inspection.

9. Inspection. This section begins with a discussion on the three quality levels that are used by the standard to facilitate the application of a wide range of welded construction. It also includes requirements for inspection personnel qualification, visual weld inspection, and nondestructive examination (penetrant, radiographic, and ultrasonic testing plus provisions for other NDE methods). The topic of acceptance criteria is also included in this section primarily addressed by section 9.5.1 that provides the general rules for acceptance criteria and Table 9.1 — Acceptance Levels for Discontinuities. The table is divided into three quality levels for class A, B, and C welds and addresses the following discontinuities: cracks, incomplete joint penetration, inclusions, internal cavity, or cavity open to the surface, linear mismatch across joint, overlap, angular distortion of the joint, underfill, and weld flash.

Annex A — Illustrations of Test Specimens and Test Fixtures. Annex A provides drawings and tables that outline the requirements for reduced section tension specimens both rectangular and round as well as an alternate tension specimen for pipe.

Annex B — Example of a Welding Operator Qualification Test Record Form. A typical qualification test record is provided for information purposes only.

Annex C — Examples of Welding Procedure Specification Forms. This section provides examples for a preliminary procedure specification form and an example of a welding specification form.

Annex D — Examples of Welding Procedure Qualification Record Forms. This section contains two examples of welding procedure qualification record forms.

Conclusion

The AWS D17.3/D17.3M:2010, Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications, is the first national standard for friction stir welding, but others will no doubt follow. AWS D17.3 would appear to provide the information you are inquiring about, which may make it appropriate for your project. I would suggest that you acquire a copy of this specification and evaluate it for your application.

TONY ANDERSON is corporate technical training manager for ESAB North America. He is a Fellow of the British Welding Institute (TWI), a Registered Chartered Engineer with the British Engineering Council, and holds numerous positions on AWS technical committees. He is chairman of the Aluminum Association Technical Advisory Committee for Welding and author of the book Welding Aluminum Questions and Answers currently available from the AWS. Questions may be sent to Mr. Anderson at Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126, or via e-mail at tanderson@esab.com.
The phenomenon of discoloration of which cause the change of the crystal's showed that this does not happen. Ticusil® braze alloy containing 4.5 wt-% not improve the ceramic quality. The brazed joint at temperatures as low as on the ceramic surface can appear around nealing. During brazing, the black region temperatures than that of the vacuum an- cia or PSZ ceramic contacts with a melt crease oxygen-depletion of the zirconia for oxygen. They react with oxygen and in- cur disruption of a zirconia stoichiometry oc- curs during vacuum annealing at or below 1600°C. The discoloration was also ob- served in zirconia ceramics stabilized ei- ther with yttrium oxide or with cerium or calcium oxides.

Conventional active brazing filler met- als contain 1–10 wt-% of titanium, zirco- nium, vanadium, which have high affinity for oxygen. They react with oxygen and in- crease oxygen-depletion of the zirconia surface region. Therefore, when pure zirconia or PSZ ceramic contacts with a melt of such braze alloys, the oxygen-depletion and discoloration starts at much lower temperatures than that of the vacuum annealing. During brazing, the black region on the ceramic surface can appear around the brazed joint at temperatures as low as 700°C. This may explain why, in your case, decreasing the brazing temperature did not improve the ceramic quality.

One could expect that switching from Ticusil® braze alloy containing 4.5 wt-% of titanium to Cusil® ABA, containing 1.75 wt-% of titanium, may help to dimin- ish the said discoloration effect. However, appropriate experiments (Refs. 1, 2) showed that this does not happen.

Very low content of farben-centers — about 0.0001 at.-% — is sufficient for an appearance of the discolored effect.

Decreasing the brazing time from 10 to 5 min resulted in a slight decrease of the width of the black zone, while adding of holding time to 60 min resulted in a dou- bled width of the black zone (Ref. 2). Also important, the area of discoloration grows while the joint bending strength remains constant when the brazing temperature was increased from 850°C (using Cusil® ABA) to 1000°C (using Ticusil®). This means that the joint strength and discol- oration are independent of each other (Ref. 1).

Enlarging of the black-colored zone around the brazed joint is driven by diffusion of farben-centers. Therefore, the size of the black zone increases at higher temperature and longer brazing time. Irregu- larity and smearing of the boundary be- tween black and white zones depends on the structure of the ceramic because grain boundaries play a role in trapping oxygen vacancies. A dark zone boundary looks sharp on fine-grained zirconia ceramics, while it is smeared on zirconia monocrystals (Ref. 2).

The question then is how can you braze zirconia to metals in order to avoid the discol- oration of the ceramic part? We would recommend a traditional approach for ce- ramic joining: metallization of ceramic with a nonactive metal formulation fol- lowed by vacuum brazing with a silver- based or gold-based filler metal. However, there is problem with the traditional Mo- Mn metallization process. It is not suitable for zirconium oxide ceramic because a glassy intergranular phase is not formed (Ref. 1).

I would recommend using a combina- tion of thin-film metallization with nickel, palladium, or platinum deposited by PVD and application of silver-based brazing filler metal such as Cusil® (AWS BAg-8). Brazing parameters should be established experimentally. If you do choose to con- tinue brazing zirconia with Ticusil® or any other active brazing filler metal, the rec- ommended vacuum should be 5 × 10⁻³ torr or better in order to prevent oxidation of the active filler metal.

Acknowledgments

My thanks to Yury A. Flom of NASA Goddard Center and Charles A. Walker of Sandia National Laboratories for their advice on this brazing problem.

References


This column is written alternately by TIM P. HIRTHE and ALEXANDER E. SHAPIRO. Both are members of the C3 Committee on Brazing and Soldering and several of its subcommittees, ASH Sub-committee on Filler Metals and Fluxes for Brazing, and the Brazing and Soldering Manufacturers Committee (BSMC). They are coauthors of the 5th edition of AWS Brazing Handbook.

Hirthe (timhirthe@aol.com) currently serves as a BSMC vice chair and owns his own consulting business. Shapiro (ashapiro@titanium-brazing.com) is brazing products manager at Titanium Brazing, Inc., Columbus, Ohio.

Readers are requested to post their questions for use in this column on the Brazing Forum section of the BSMC Web site www.brazingandsoldering.com.
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Twin-Wire Arc Spray Alloy Protects Oilfield Parts

WearSox, a new, patented thermal spray alloy, can be applied to virtually unlimited thicknesses and is highly wear resistant and tough. The material is applied via twin wire arc spray (TWAS) using proprietary cored wires and compressed air.

The alloy is being applied extensively in oilfield drilling and production applications to coat wear surfaces on drill pipe and downhole tools, to create stabilizer/centralizer ribs for casing drilling and running, and to create internal end stops for bowspring centralizers.

The alloy has been applied to steel, aluminum, nickel alloys, and nickel copper, and the process has been found to be highly cost effective compared to traditional alternatives.

Laboratory Testing

The product has been tested extensively for fatigue, shock, wear, friction, casing wear, metallurgical changes to the base material, and effect of operational variables.

Fatigue tests were run using the resonant bend test. For this test, a joint of pipe was coated in the center, strain gauges applied, and pipe was precessed to simulate drilling through the bend or build section of an extended reach horizontal well — Fig. 1. Through 4 million cycles at up to 25 deg per 100 ft, the coating was undamaged.

Shock testing was performed using a new procedure that is a modification of the ASTM drop weight test. For this test, a short section of pipe was sprayed to the required thickness, then placed in a special fixture and the 100-lb weight dropped from successively greater heights until cracking occurred. This modified drop weight test is used to characterize materials, procedural variables, and to qualify operators. Acceptance criteria are based on the height required to initiate a crack.

Wear. Abrasive wear was assessed using the ASTM G-65 dry sand abrasion test, pin-on-disc test, and the DEA 42 open hole/casing wear test.

Friction. The coating exhibits friction that is substantially less than steel on steel. It has been measured in classical sliding friction tests, pin-on-disc test, and the DEA 42 casing wear test.

Casing wear. It is imperative that coat-
ings on drill pipe wear the casing as little as possible. This product has been evaluated through several DEA 42 casing wear tests in which the sample is rotated inside the casing with high lateral force in the presence of drilling mud with measured additions of silica sand.

The product exhibited lower casing wear than uncoated steel-on-steel drill pipe.

Metallurgical changes to the base material. This is a critical feature of TWAS with WearSox, as it does not raise the temperature of the base material beyond that required for metallurgical changes to the base material. Typically, this is less than 300°F without supplementary cooling. This was evaluated using microhardness scans of the bond area, optical metallography, and scanning electron microscopy. No changes were detected even on aluminum.

Uses for the Coating

Application to drill pipe. Drill pipe comes in two lengths: 30 and 45 ft. When the longer 45-ft pipe is used in extended reach wells, it will contact the side of the hole formations and wear. This can also occur when the pipe is run in compression. When the pipe is worn beyond usable thickness, it is scrapped.

The new alloy is used to apply bands in the center or nodal contact points of the pipe to prevent wear and reduce friction — Fig. 2.

Application to casing. The coating is unique in that it can be used to create stabilizers and centralizers on the casing tube itself. The ribs can be built up to any required height and length with curvatures from 0 to 360 deg. Additionally, they can be placed at the optimum locations on the pipe for maximum stability during casing drilling or casing/liner running.

The coated centralizers have very low impedance to cement flow compared to clamped-on, hydroformed, or other added-on devices — Fig. 3. In addition, use of the coating eliminates the need for expensive threaded-into-the-string integral blade stabilizers, which add cost and make-up time on the rig, and are a potential failure point.

The coating is also being used to add stabilizers directly onto the shank of certain bits, eliminating the need for integral blade stabilizers. Drilling reports indicate that this method of near-bit stabilization allows much straighter hole paths without drift.

Application to down-hole tools. The alloy is being used successfully to create wear pads on measuring-while-drilling and other tools as a cost-effective wear-mitigation solution. The low thermal signature of the application allows for the tools to be selectively wear coated without removal of instrumentation.

Application to bow spring centralizers. In this application, WearSox is applied to the inside of the end rings as stops. This allows the centralizer to be “pulled” through rather than pushed, which is the case with stop rings beyond the ends of the centralizers. API and full destruction tests indicate that this combination of WearSox and centralizers greatly exceed run-in forces and avoid buckling and seizing.

Joe L. Scott (joes@devasco.com) is a partner, WearSox LP, Houston, Tex.
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Modernizing a Midwest Refinery

The BP Whiting, Ind., Refinery Modernization Project (WRMP), one of the country’s premier modernization projects, is transpiring right now — Fig. 1. The refinery is located on the banks of Lake Michigan, 25 miles south of Chicago, Ill. BP’s second-largest refinery, the 1700-acre complex currently processes up to 405,000 barrels of crude oil daily. That is enough fuel to operate 430,000 cars, 22,000 commercial trucks, 2000 commercial jetliners, and to fill 350,000 propane tanks.

Taking into account both the scope of construction and its positive impact on the region, the shear scale of the WRMP is awe inspiring. The project consists of installation of a modern gasoil hydrotreater, enhancements to the existing sulfur recovery complex, erection of a new state-of-the-art coker, and reconfiguration of the refinery’s distillation unit to accommodate the heavier crudes. The shear size of the major assemblies being received is impressive. The 12 Pipe Still vacuum tower weighs in at 1.7-million lb (771,120 kg) and is 46 ft (14 m) in diameter and 166 ft (50.6 m) tall — Fig. 2. The six coker drums are each 30 ft (9.1 m) in diameter, 125 ft (38.1 m) tall, and weigh 793,000 lb...
The work being conducted at the oil company’s Whiting, Ind., refinery is the largest private investment ever in the state of Indiana

BY STEVEN DISBROW AND CHRIS KRAMER

(359,705 kg). The recently received gasoil hydrotreater reactors each weigh nearly 2-million lb (907,200 kg), and are constructed of 8.7-in.- (22.1-cm-) thick steel. Equally impressive is the size of the cranes used to set these large components. The Mammoet PTC crane will be the largest crane on site and has the capability to lift 1764 tons (1600 tonnes) at a 66-ft (20-m) radius with a 262-ft (80-m) main boom. For its transportation to the site, the Mammoet PTC crane requires approximately 169 containers broken down into 20- and 40-ft (6.1- and 12.2-m) sections. Figure 3 shows a model of the Mammoet PTC crane setting the 12 Pipe Still vacuum tower.

Of tremendous value is WRMP’s economic impact on the region. It is anticipated the project will create thousands of temporary construction jobs, while helping to sustain 1700 jobs over the long term. In addition, hundreds of contractor jobs will be required to support the facility once construction is completed and the units are operational. The WRMP is the largest private investment ever in the state of Indiana and will have a lasting positive impression on the community for many years.

The Importance of Safety

Safety in the WRMP workplace is of the utmost importance. Before a welder ever steps onto the job site or an arc is ever struck, workers are rigorously trained in the proper procedures and policies to promote proper Health, Safety, Security, and Environmental (HSSE) practices. But safety goes beyond just policies and procedures, a culture that supports an incident- and injury-free workplace is essential. It is all about working as a team, safeguarding yourself and coworkers to ensure you arrive home to your family in the same condition that you left in the morning. On the WRMP, BP has shown an unwavering commitment to ensuring the project is completed with no accidents, no harm to people, and no damage to the environment while minimizing any potential disruptions to the community.

Workforce Demands and Skills

The availability of skilled workers is essential for the success of large capital projects, especially in the welding arena. The WRMP consists of more than 1,400,000 feet of pipe, 600 modules, 100,000 piping spools, and 33,000 tons of structural steel, so it is an understatement to say a lot of welding will be performed. Skilled welders with a broad range of experience on alloy materials are essential. Carbon steel, stainless steel, and chrome alloys are the predominant materials utilized in refineries primarily because of their strength, corrosion resistance, and high-temperature performance. Welders need to know the many differences when welding carbon and alloy steel such as proper welding machine settings, techniques, electrode selection, etc. Also, “in position” welding is some of the hardest welding to perform and requires a high level of skill and experience, even if welding is being performed indoors or in optimal conditions. Welders must possess the skills to weld various materials and to perform in-position welds to ensure the highest quality to the client — Fig. 4.

Screening by way of performance testing is a viable method of determining a welder’s skill set before an arc is ever struck on the job. In many cases, the welder performance tests can be modified to effectively screen and define a prospective welder’s talent, while meeting all code requirements. Examples of this may include the number of tests administered, weld positions, inclusion of a restrictor plate, and the time allotted to conduct the test. Some contractors primarily administer the 6G position test, but we have seen the value of performing both the 2G and 5G position tests, in lieu of a single 6G. The 2G/5G tests better represent refinery welding applications and allow the fabricator to further assess a welder’s ability because more welds are being evaluated. In addition to the performance tests stipulated by code, client specifications are typically invoked to further review a welder’s ability because more welds are being evaluated. With the level of examination being relatively high on welders, it is very important that welders prepare for examinations of this nature.

A weld that can pass radiographic examination (RT) is not just any run of the mill weld. Refinery welds have to meet certain RT requirements based on the al-
allowable indication sizes defined per code and/or client specifications. It is important to understand the difference between a weld that is acceptable by visual examination and an RT-quality weld. While both types of welds take skill to perform, RT scrutinizes the soundness of a weld greater than does visual examination. Radiographic acceptance criteria are designed to complement visual examination to ensure that no subsurface discontinuities of a rejectable nature exist. It is harder for a welder to ensure RT-quality welds since the indications are primarily forming within the molten pool, making them difficult to see during welding. It is only with a trained eye and through experience that a welder can anticipate problems, alleviate them, and produce RT-quality welds.

Quality Considerations

Refinery Construction Codes and Client Specifications

To understand what is meant by a "quality" weld, it is best to first define weld quality in terms relative to the refinery and construction industry. Weld quality is measured by the ability of a weld to meet all applicable design specifications, codes, and client requirements. This entails meeting many forms of examination criteria that may include material and composition checks, visual inspections, and a variety of other nondestructive examinations (NDE). Welds that meet their specified quality criteria will ensure their fitness for service, mitigate potential safety risks, and greatly reduce rework and associated repair costs.

Codes form the backbone of the job requirements, but often client specifications are more stringent. Codes and specifications rely heavily on NDE inspections such as visual, magnetic particle, penetrant, ultrasonic, and radiographic testing to measure quality. Often, clients opt to increase the code baseline requirements based on historical data, service environment, and criticality. Service environments typically encountered in a refinery include corrosives, high pressures, and combustible toxic liquids and gases. Nondestructive examination requirements often vary based upon the codes and specifications that govern the work.

For new refinery construction, ASME B31.3, Process Piping, is typically the principal code that specifies weld quality based on flaw sizing and frequency of inspection. Relevant weld flaws are evaluated based upon defined acceptance criteria for each NDE method utilized and its service condition. Frequency of NDE is primarily based upon service conditions and ranges from 5 to 100% and must be representative of each welder. Client specifications are usually applied based on historical engineering/design data, safety, and/or standardization but, at a minimum, all applicable codes must be adhered to. In addition, it is essential to fully understand the level of quality the client wishes to attain, to ensure adequate resources are allocated to the project and to avert potential project delays.

Another element that must be managed when determining NDE frequency is lot size. A lot is a defined group of welds, based upon the frequency of spot RT, used to verify the ability of a welder to consistently produce quality welds. It is crucial that lot sizes are established and mutually agreed upon by the contractor and client prior to commencing welding. The reason for that is if a welder fails a lot weld, the entire lot is subject to progressive examination, up to 100%. For instance, if the frequency of inspection is 5%, a lot could be defined as 1 X-ray for 20 welds, 2 for 40, or even 5 for 100. If 5 radiographs in 100 is invoked, it is conceivable that a welding problem is not discovered until the 95th weld, subjecting the entire lot (95 + welds) to RT. If the lot size was 1 in 20, the problem would have been discovered much sooner. Improper administration of lots can result in unnecessary examinations, adversely impacting both project cost and schedule.

Weld Reject Rates and Welder Performance

One quality metric of particular inte-
est is the weld reject rate, which can be calculated in different ways. The generally accepted equation, however, is the number of butt-joint welds rejected through RT divided by the number of total butt-joint welds tested by radiography. The reject rate is typically broken down by project and performing contractor. The individual welder reject rate is also of importance. A welder’s reject rate is calculated in the same fashion as the weld reject rate, but is specific to that person. This is important because it further refines the reject rate, making it easier to narrow down welding problems. One should not use the welder’s reject rate solely to isolate the problem to the welder. In many instances, the defects associated with the welder may point to a larger problem, such as a broad area in need of help or inclement welding conditions. The reject rate is an important tool that both contractors and clients use to track and trend defective work — Fig. 5. While trending a reject rate alone is a reactive response, the information contractors gain through examining these defects can be used to perform root cause/corrective action analysis. BMW Constructors, Inc., has seen immense value in tracking and trending indications. The data can be compiled and proactive measures implemented to prevent their recurrence. In addition, feedback of data to the field is a critical step in the improvement process and paramount for continuous improvement.

Significance of Feedback and Recognition Programs

It is important to cultivate a feedback program to convey lessons learned and promote continuous improvement. Feedback programs foster a proactive approach and strengthen and grow communication lines. Weld inspection and examination findings must get passed back down to the welders. This can be achieved by conducting regular meetings with the workforce or meeting with the welders individually. What has been most effective on WRMP is reviewing the actual X-ray film with the welders. When welders physically see their film under the RT viewer, they can better visualize the flaw and adapt accordingly. However, the focus must not always be negative, positive feedback is a key ingredient of any improvement program. When concerns are discussed up front, and proactive measures are implemented, the impact on cost, schedule, quality, and safety are rewarding.

Welding is a highly skilled trade that many also consider an art. Many challenging goals have been set in the industry, and it is imperative the workforce is commended when goals are achieved. Recognition programs such as “employee of the month” are used by many to praise achievement and foster healthy competition. BMW Constructors has developed a hard hat sticker recognition program to acknowledge welder achievements. Stickers are awarded to welders upon each successful completion of an X-ray quality weld. The stickers are a simple and effective means to convey appreciation and act as a visual reminder that continually acknowledges the workforce’s achievements. By recognizing welders who have performed at a high level, others become engaged, which further promotes quality and productivity.

Making a Difference

BP has assembled a highly efficient and effective team for the WRMP. Considering the vast number of contractors working at the site, BP has done an astonishing job of seamlessly integrating this talent base. Success of the project is the common goal of every person working on the project. Evidence of this is the workforce’s untiring commitment to an incident- and injury free culture. The mindset is “Everyone will go home safely at the end of the day.” The 5-Star Safety program was recently rolled out to further heighten safety awareness and to recognize and reward safety-conscious individuals. Further, weld quality has significantly improved in 2009; the defect rate decreased two-fold. This did not happen by chance, but rather by the hard work and dedication of many to ensure WRMP realizes and sustains unparalleled safety and quality.

There have been few refinery projects in the United States in recent decades that rival the scope of the BP Whiting, Ind., Refinery Modernization Project. Contractors embarking upon large capital projects of this scale must put safety first and thoroughly understand code and client quality requirements. Welders need to be methodically screened and tested accordingly to make sure they possess the necessary skills to ensure consistent high-quality welding. Effective communication and recognition of the workforce is key to cultivating a proactive approach and strengthening the communication lines. WRMP will prove to be the flagship project in the industry and pave the way for more refinery expansion and modernization projects to come.

Acknowledgments

The authors would like to express their gratitude to personnel at the BP Whiting, Ind., Refinery for their support in the preparation of this article and the opportunity to share information regarding the WRMP.
The Windy City blew softly on the 2009 FABTECH International & AWS Welding Show, including Metalform, held Nov. 15–18 at Chicago’s McCormick Place. Not only were exhibitors and attendees greeted with pleasant fall weather, but the show floor was busy with more than 26,000 visitors looking for just the right piece of welding and metal fabricating technology. Of those visitors, 45% were attending the exposition for the first time and 10.6% were international. Another good sign was anecdotal reports from welding-related companies that they were seeing an uptick in business during the final quarter of the year.

AWS Annual Meeting

The American Welding Society held its yearly business meeting on Monday, Nov. 16. Chris Raguso, acting commissioner, Dept. of Community Development, city of Chicago, said, “The spirit of innovation (at the exposition) matches that of the city of Chicago, especially that of bringing jobs and keeping manufacturing in Chicago.” She said there were 24 industrial corridors in the city, with 3000 industrial companies that employ 100,000 workers. She mentioned companies working with the city to obtain grants to improve the skills of their current workers, train new workers, and improve their facilities.

“These days success comes to those of us who are looking for it,” she said.
This year’s show drew thousands of visitors to see the latest welding products and research developments

BY KRISTIN CAMPBELL, ANDREW CULLISON, CARLOS GUZMAN, AND MARY RUTH JOHNSSEN

AWS President Victor Matthews discussed the challenges the industry faced in 2009 and the advances made in solving them. He emphasized the importance of today’s welding students to the future of the industry and mentioned that he had given talks to more than 1000 students during the year. Matthews said he gave them the same advice his first boss gave to him: “Be the best at something, whether it be the best MIG welder, the best TIG welder, have the cleanest work area.” In order to get noticed and advance in your field you need to strive to be the best in some area of your work, he said.

Incoming President John Bruskotter said the theme for his year as president is “AWS energizes the world.”

Bruskotter entered the oilfield construction industry in 1973. “Welding was a stepping stone for me,” he recalled. As he grew in skills, opportunities for other jobs in the offshore construction industry opened up. He likened AWS to an offshore oil platform, and on a video screen he built the platform layer by layer using elements from AWS. The platform’s layers are summarized as follows: “It starts with education, and motivating young people, and continues through career development. (It is built) on a solid foundation of standards and quality assurances in every industry through its volunteers.”

Adams Lecture

Wayne Thomas presented the Adams Lecture on the topic Innovative Developments in Friction Stir Welding. Thomas, a principal research engineer at TWI, has been instrumental in the research and development of emerging technologies, including friction stir welding (FSW), for the past 23 years.

His lecture gave details of the dynamics of friction stir welding. He began by tracing its development from solid-state welding, which goes back thousands of years. Friction stir welding was invented in 1991, and it has expanded from the relatively simple welding of a butt joint in aluminum to a variety of present-day variants, including surfacing, spot welding, fusion extrusion, and friction hydro pillar welding. The process has expanded to where it is not beyond its capabilities to weld 1-in.-thick 6082-T6, as well as 12Cr stainless steel. “There are those who say it will not be a success until it can weld steel,” said Thomas. “I am here to say friction stir welding will eventually be successful with steel.” Experimentation has been progressing with perfecting FSW of steel, and once it becomes feasible, he sees shipbuilding as a prime application for FSW. Millions of dollars could be saved by eliminating in-deduction heating of ship panels alone.

Thomas noted the forge force in friction stir welding refines the microstructure of the weld. To build on this concept research is being conducted into bobbin tool design and different ways of using it, including restirring, twin stirring, and skew stirring. Future investigations will also look at applying additional forge force by using a forge roller in combination with the stirring mechanism. Thomas sees a bright future for friction stir welding and its expanded use. He noted it is a process whose birth ignored conventional wisdom for joining metals, but instead nurtured creative thinking, discovery, invention, and innovation.

Plummer Lecture

Jack D. Compton, who recently retired from the College of the Canyons, Santa Clarita, Calif., delivered the Plummer Lecture on Nov. 17 — Fig. 1. His topic, “Teaching Human Development Skills to Welders — 20 Years Later,” was based on the Plummer Lecture Richard Sabo gave 20 years ago and featured a perspective on what Sabo proposed in 1989 vs. the current art and science of welding education.

“A well-run welding class should be a microcosm of an efficiently operated business,” Compton said. He spoke about successful welder training and provided a seven-point plan for effective welding instruction. Plus, Compton made the following observations based on his experience: living skills that bolster technical excellence include responsibility, self-discipline, individual initiative, dressing for success, personal hygiene, clear communication, teamwork, and analytical/critical thinking; keep a written record of how much time is spent with each student, then see to it that time is equalized; devise rewards that motivate achievement such as having in-shop competitions; and teach and encourage students to understand and use synergy.

Special Sessions

Social Media 101. The 2009 show presented a group of interesting free sessions at the Solutions Showcase, an open auditorium located in the South Hall.

The Social Media 101 session, which took place Nov. 18, addressed the trendy topic of social media sites and how they can be used to communicate with customers and prospects. Chris Campbell, SEO specialist at Lakeshore Branding, gave attendees a primer on the most popular services, including Facebook, Twitter, LinkedIn, and blogging sites in general.
“Social media sites have transformed the way people communicate, and businesses should see how they can benefit from being active in these networks,” Campbell explained.

Founded in 2004, Facebook is the fastest-growing site of this type, with 350 million members as of Dec. 2009 (according to its Web site). Facebook primarily is a social site for individuals, not companies, but retailers are quickly catching onto the trend and are creating brand and fan sites to which customers can subscribe. “Social media sites are focused on what’s hot and new, and businesses can take advantage of this by providing daily or weekly content to their customers,” Campbell said.

Twitter, founded in 2006, is labeled as a social networking and micro-blogging service, and has quickly become a staple in social networking. Although it has not published official member statistics, various Internet sources suggest that Twitter has between 6 and 10 million users. Many retail businesses are discovering the potential of Twitter by getting their customers to “follow” their Twitter stream and posting special offers on a regular basis. These posts, or “tweets,” reach their followers instantly with fresh, updated information, which consequently increases business. Campbell continued, “The key is to keep your followers interested by posting daily, or at least weekly.”

LinkedIn, founded in 2003, has more than 53 million users (according to its site), and is geared specifically toward business-to-business networking. LinkedIn allows professionals and companies to introduce themselves to potential customers, be found for business opportunities, and make relevant connections using industry-specific networks.

“Companies should experiment with these services to see if they work for them, although they must spend time and resources creating content and finding potential customers,” Campbell said.

Social media sites are becoming so popular that it’s worth it for any business in any industry to explore them, and ensure that they are not losing opportunities for attracting and keeping customers. Traditional advertisement methods, nevertheless, still might be needed to make sure that customers are aware of the presence of a company in these sites. LinkedIn seems like a sensible option for companies to get their feet wet in social media, because its business-to-business focus creates a network that is open to interaction on a professional level, and that can be essential in the welding industry.

What’s clear is that social media is a worldwide phenomena here to stay, and it should not be overlooked.

Keynote Presentation Addresses Ways to Thrive in Difficult Times. On Nov. 16, the Keynote Presentation “Best Practices for Thriving in Tough Times” provided business strategies for making it through and prospering during these challenging economic circumstances — Fig. 2.

Jeff Knauf, president, Medalist Laserfab, Inc., moderated the event. Its six-member panel consisted of Steve Hasty, president, A & E Custom Manufacturing; Chris Kuehl, FMA economist and founder, Armada Corporate Intelligence; William Citron, president, Mazak Optronics; Dick Kallage, president, KDC Associates; Ron Bullock, chairman, Bison Gear and Engineering Corp.; and Douglas K. Woods, president, Association for Manufacturing Technology.

The panelists spoke about the companies they worked for and provided 2009 year-end forecasts for their businesses as well as expectations for 2010. The general feeling was hopeful that conditions would get better, yet there was concern about recovery. Other issues discussed were credit availability, unemployment, down sales, marginal tax rates, foreclosures, health-care, managing customer relationships along with employees, and contrarian approaches during the recession.

In addition, it’s important to know what’s going on around you and make your point heard. “If you don’t get directly involved in what your Congressmen and what your Senators do on behalf of you as the American public, it doesn’t matter, they’re just going to do whatever lobbyists make them do,” Citron said. Kuehl added that voting matters because a difference can be made this way.

Cash flow was another major topic. “Cash is the emperor,” Kallage said. He noted two primary things can be done to improve this: employ lean manufacturing practices not by letting people go but by reducing costs and cycle times, plus manage your supply base. Kallage further stressed obtaining credit insurance from a well-known source to prevent bankruptcy. Knauf agreed with these points: “Today, more than ever, it’s important to build cash, eliminate waste, and show your banker that you’re one of the clients who he wants to hang on to.”

A Look at the Show Floor

In McCormick’s North Hall, 463 exhibitors, who covered more than 146,000 sq ft of space, showcased the latest welding products. However, showgoers not only had the opportunity to view demonstrations or even try their hand at using some of the new products, but there were educational opportunities as well. The Pipefitters Union Local 597 brought...
its mobile training unit, and District 2 Director Ken Stockton was instrumental in bringing the Public Service Enterprise Group’s (PSEG’s) mobile training unit to the show as well — Fig. 3. These tractor-trailers garnered much interest from showgoers, who got to see demonstrations of how welder training could be brought to a work site rather than the trainees having to drive to a school. 

Flap Disc Features Radial Shape. The POLIFAN® CURVE SG-PLUS has a radial shape that allows for aggressive grinding with not only the bottom and edge of the flap disc, but also with the top edge — Fig. 4. It’s recommended for use with high-powered angle grinders having a minimum output of 1200 W and is useful for precision grinding of fillet welds as well as deburring, chamfering, and all grinding of steel and stainless steel. A ⅜-in.-wide disc is available for fillet welds up to ¼ in. wide and a ½-in.-wide disc handles weld widths up to ⅝ in. The unthreaded arbor hole version has a ⅜-in. bore, and the threaded version has a ⅜-11 thread. All work at a maximum speed of 12,200 rev/min. PFERD, Inc., Leominster, Mass., (800) 342-9015, www.pferduss.com.

Regulator Provides Good Flow Control. The Victor® Professional Edge™ series regulator offers a compact design along with several safety features. With a single point of contact, the product minimizes potential impact points to protect the integrity of the gas delivery system. Additionally, it allows a more natural and safer hand/body position for the user when adjusting delivery pressure. The dual gauges contain high-contrast graphics for enhanced visibility in a smaller size, and color-coded knobs enable users to determine the gas type at a glance. Oxygen, acetylene, inert, and L.P. gas regulators are currently available — Fig. 5. Carbon dioxide and nitrous oxide models will be available in spring 2010. Highlights include a bolt-on housing cap and newly designed internals that deliver optimum torque and compression to the diaphragm and internal seals. A Victor exclusive is the shock limitation and absorption mechanism (SLAM) technology, which is built into the knob. Thermadyne Industries, Inc., Chesterfield, Mo., (636) 728-3000, www.thermadyne.com.

Plasma Hole Cutting Technology. Hypertherm’s patent-pending True Hole™ technology improves the capability of HyperDefinition plasma. It uses a combination of cutting parameters optimized for mild steel applications. The end result, demonstrated in internal and customer testing, shows up to a 50% improvement in the shape of the hole. At the same time, taper and dings are virtually eliminated on holes with an equal diameter-to-thickness ratio. In addition, the technology is a mixture of the following parameters that are linked to a given amperage, material type, and thickness, and hole size: process gas type, gas flow, amperage, piercing methodology, lead in/out technique, cut speed, and timing. The company demonstrated the product using HPRXD® technology with MTC’s ProNest® 2010 software and two new motion controls from Hypertherm Automation, the EDGE® Pro CNC and ArcGlide™ THC — Fig. 6. Hypertherm, Inc., Hanover, N.H., (800) 643-0030, www.hypertherm.com.

Good Access for Hard-to-Reach Welds. Tregaskiss has enhanced all the top features of its TOUGH GUN™ GMA guns in the air-cooled TOUGH GUN G2 series robotic GMA gun — Fig. 7. This series features a next-generation QUICK LOAD™ gooseneck system with thick-walled aluminum armor that resists bending in the event of a collision. Also, its alignment features maintain an accurate, repeatable tool center point. The company has merged the clutch with the connector housing to increase the gun’s working envelope while improving joint accessibility. The gun’s QUICK LOAD robotic gooseneck system incorporates a hand nut mechanism that requires no tools for neck replacement. At 60% duty cycle, this series provides 500-A of air-cooled welding capacity using mixed gases. It’s useful for thin-metal and automated welding applications as well as the automotive market. Tregaskiss, Windsor, Ont., Canada, (877) 737-3111, www.tregaskiss.com.
Fig. 8 — The line of SafeHold XPL magnets has lifting capabilities up to 5000 lb.

Automated Hardfacing. A new introduction at the exhibition was Rankin Automation’s two-axis automated welding/GMA carbide machine. This unit is for hardfacing applications that require wear and erosion resistance. Granular tungsten carbide is automatically fed into the molten weld pool as welding progresses. Coarse or fine powder can be accommodated depending on the application. The weld pattern can be programmed into the unit, and step time, carriage speed, wire feed speed, and meltback can all be automatically controlled. The unit uses an 800-A water-cooled welding gun. Rankin Industries, Inc., Rancho Cucamonga, Calif., (909) 483-3222, www.strongweldingproducts.com.

Added Axis Increases Flexibility. Motoman added another degree of versatility to its robot line with the introduction of VA 1400 — Fig. 10. This robot is designed with a 7th axis, giving it flexibility similar to adding an elbow. Its arm can position itself around objects resulting in access to tighter areas. The 7th axis also reduces workspace, which can mean more robots in a given space and a more compact work cell. The robot is capable of adaptive welding with laser vision signal variations in fitup. Motoman, Inc., West Carrollton, Ohio, (937) 847-6200, www.motoman.com.

Improved Orbital Welding. New software has improved the M200 orbital welding power source by Swagelok. The software provides improved graphics that make it easier to follow the progression of the weld, as well as determine in real time deviations from the preset weld parameters. If there is a problem an error sign will appear, and the location is pinpointed on the graphic. The software also tracks data, such as speed, current, flow rates, and gas coverage so the operator can more thoroughly evaluate the weld — Fig. 11. Swagelok Co., Solon, Ohio, (440) 349-5934, www.swagelok.com.

Small Footprint, More Affordable. Featuring a small footprint (half the floor space of a typical 5- x 10-ft machine) and a competitive price, Trumpf’s TruLaser 1030 cutting system was designed and is built in the United States, and is geared toward manufacturers that want to add laser beam cutting to their services for the first time — Fig. 12. The new 1030 brings together a sturdy drive system with a 2-kW, diffusion-cooled RF laser resonator, and the system ships as one complete package. The TruLaser 1030 features 3-axis flying optics with a maximum XY speed of 3340 in./min, and cuts a maximum thickness of ¼-in. mild steel. Trumpf, Farmington, Conn., (860) 255-6000, www.us.trumpf.com.

Increased Nozzle Life. PerfectArcs offers a proprietary coating process that re-
duces spatter and increases nozzle life up to 20 times longer than nontreated nozzles, according to the company — Fig. 13. The company does not manufacture nozzles; instead, customers send in their nozzles to be treated. For qualifying customers, PerfectArcs offers a risk-free trial nozzle kit ($75) that includes coating six nozzles. PerfectArcs coating services usually cost between $15 and $75 per nozzle, depending on nozzle type, size, shape, and order quantities. PerfectArcs, Dalton, Ga., (706) 272-0133, www.perfectarcs.com.

Follow that Arc. Diversi-Tech, Inc., showcased a prototype that tracks the arc so that the fume extraction arm is always in proper position to capture welding fume — Fig. 14. According to the company, the drawback to regular fume extraction arms is that welders forget to move them during welding, so they don’t receive full benefit of the arm’s fume extraction capability. The patent-pending Intelligent Capture Arm™ will be available in the traditional arm lengths of 10–14 ft, be capable of moving air at 1000 ft³/min, and will be hexavalent chromium compliant. It can be positioned initially just like any other fume extraction arm, but once the arc is struck, it tracks the light from the arc. The company plans to release the product in a few months after getting input from potential customers. Diversi-Tech, Inc., Canada, (800) 361-3733, www.fredfiltration.com.

Preheat and Welding Combo. ARCON’s Workhorse 300SH combines an SMA/GTA welding machine with a preheater in one package — Fig. 15. The company believes it will be especially useful for applications such as in shipyards where this portable unit can be easily carried to the spot where preheat is needed rather than having to run long cables. The unit has settings for SMAW, GTAW, and controlling the heat. The user can set the temperature that is needed as well as the ramp for how fast the machine must come up to temperature. Up to four heat mats can be connected, and the machine provides up to 8 kW of heating power. The list price for the machine with basic mats and cables is $5600. ARCON Welding Equipment, LLC, Salisbury, Md., (888) 512-7266, www.arconweld.com.

Fig. 13 — Comparison of a nozzle with PerfectArcs coating (left) and a nontreated nozzle.

Fig. 14 — Diversi-Tech used this toy train to demonstrate how its Intelligent Capture Arm™ positions itself automatically by tracking the light from the arc.

Fig. 15 — The Workhorse 300SH provides up to 8 kW of preheating power as well as performing shielded metal arc and gas tungsten arc welding.

Fig. 16 — The Power Wave® S350 is a multiprocess machine with 120-kHz output.

Triangular-Shaped Grains for Grinding. Instead of being made with an abrasive media that is produced in large quantities then crushed so it forms grains of many shapes, 3M’s Cubitron™II fibre
discs feature engineered, triangular-shaped crystals that are electrostatically oriented to form sharp peaks. According to the company, these triangular-shaped grains cut cleaner, faster, and last longer. This means the operator exerts less pressure and is, therefore, less fatigued. The abrasive is available in fibre disc and grinding belt forms currently, and in 36 grit, with more products to follow. The fibre discs are available in 4½- to 7-inch sizes. 3M, Abrasive Systems Div., Minneapolis, Minn., (800) 362-3550, www.3M.com/Abrasives.

Heavy-Duty Precision Cutting

ESAB’s Sabre DX cutting machine provides high-production plasma and oxyfuel cutting — Fig. 17. It features a high-stiffness welded beam assembly with a precision guiding system, three-axis rack-and-pinion drives, digital AC drives, and AC brushless motors. It is available with up to eight cutting torches, including up to two plasma cutting heads featuring the company’s M3 Precision Plasma Arc system that allows the machine to cut and mark with the same plasma torch. It is available with a choice of 200-, 360-, 450-, or 600-A m3 plasma systems, which are capable of 100% duty cycle and feature CNC output current for improved starting and longer consumable life. The company touted the benefits of cutting underwater: less noise and brightness, elimination of fumes, and a cooler plate. ESAB Welding & Cutting Products, Florence, S.C., (800) 372-2123, www.esabna.com.

Look Ahead to Next Year

Plan now to attend the 2010 FABTECH International & AWS Welding Show, Nov. 2–4, at the Georgia World Congress Center, Atlanta, Ga. It will be North America’s largest welding, metalforming, and fabricating event. For more information, visit www.aws.org/expo.

Foundation Fights Decline In Skills Careers

Actor and producer John Ratzenberger of Cheers fame (see figure), and founder of the Nuts, Bolts and Thigamajigs Foundation, made an appearance at the exhibition to bring home the message that young people are not encouraged to use their hands to build things, or as he notes, we are becoming a nation of non tinkers. This trend is placing manufacturers in a position of dire need for skilled labor. “Companies may think this is a local problem, but I am here to tell you it is national,” said Ratzenberger.

To emphasize the extent of the problem, a recent survey of 1000 adults and 500 teens 13 to 17 revealed 73% of the teens had little or no interest, or were ambivalent, in becoming a blue-collar worker. Additionally, 61% said they have never visited or toured a factory or manufacturing facility. On the adult side, 57% indicated average or below average skill in fixing things, and 58% never built a toy.

Ratzenberger feels educational leaders and counselors who do not emphasize the value of a skills education encourage this situation. As an example, he noted the superintendent of education in Boston has the motto — every day, every student, college bound. “Bright kids come out of school who don’t know how to read a ruler,” said Ratzenberger. “Last year twice as many degrees were awarded in sports management than engineering,” he continued. He also feels the entertainment industry is at fault when Hollywood depicts blue-collar workers as dumb, dirty, and crude.

He is adamant that minds have to be changed or this country will decline as its manufacturing base declines. Those who pursue a skill profession can take pride in their abilities as well as prosper from their jobs, he stated. “Every industry on the earth must have one person inventing one thing,” he emphasized.

The Nuts, Bolts and Thigamajigs Foundation can act as a catalyst. It is the foundation of the Fabricators & Manufacturers Association, Int’l, Rockford, Ill. Gerald Shankel, FMA president and CEO, directs the organization. The foundation provides scholarships and grants to students who pursue careers in manufacturing at educational institutions with manufacturing programs. The foundation (www.nutsandboltsfoundation.org) also extends funding to organizations that put together manufacturing camps for young people.

Welders Enjoy Competitive Spirit at Professional Contest

Carissa Love made history by becoming the first woman to win the American Welding Society’s Professional Welders Competition. “It’s a really big accomplishment,” she said. Achieving this top spot left Love speechless, excited, surprised, and relieved. She added this distinction proves women can weld, too.

Love will use the $2500 prize toward her education. The 19-year-old welding student attends Texas State Technical College, Waco, Tex., and has one semester left before completing an associate in applied science degree. She also serves as secretary of the college’s AWS Student Chapter, which District 17 Director J. Jones helps guide.

The contest took place during three days of the exhibition. In total, 138 welders entered the event. AWS President Victor Matthews announced the winners at a ceremony on Nov. 18.

Contestants had 5 min to make a ¾-in. fillet weld on low-carbon steel around the circumference of a pipe section to a plate using shielded metal arc welding (SMAW) with a ¾-in. E7018 electrode. This task required welding in the 6F upright position. Each participant received a T-shirt and had to be at least 19 years old, sign a form stating they are a professional welder, and pay a $20 entry fee.

A team of AWS Certified Welding Inspectors (CWIs) judged the competition. They utilized the criteria for this fillet weld’s size and appearance according to AWS D1.1/D1.1M:2008, Structural Welding Code — Steel. Results were verified with automated inspection equipment, and speed was taken into consideration upon final judging.

At first, Love became nervous for this was her first time competing in any welding competition, but she said she set her mind in order, got ready, and went for it. She found the task wasn’t as challenging as she thought it would be because she’s used to — continued on page 44

Fig. 17 — ESAB cut out the Chicago skyline to demonstrate the Sabre DX, which provides high-production plasma and oxyfuel cutting.

John Ratzenberger warns of a declining skilled labor force.
At the 2009 Professional Welders Competition awards ceremony held Nov. 18, AWS President Victor Matthews (left) congratulated first-place winner Carissa Love, who received $2500. Keith Cusey won $1000 for coming in second at the event.

A welder tries his best with just 5 min to finish a 3/8-in. fillet weld using shielded metal arc welding with a 3/8-in. E7018 electrode on low-carbon steel while in the 6F uphill position.

Carissa Love shows off the fillet weld she created using shielded metal arc welding on low-carbon steel. It earned her top honors at the competition. The welding major will be graduating soon from Texas State Technical College.

Students from North Point High School, Waldorf, Md., worked at the event. Shown in the front row (from left) are Freddie Triche, owner of LAPCO Mfg. Inc., who donated the students red shirts; Steve Joyner, Tom Belle; Brian Rollins; Carl Kupniewski; and Student Chapter Advisor Alan Badeaux. In the back row (from left) are Alex Fowler, Shane Cleaveland, Casey Poncher; and Jeremy Yohe.

During the recent welding contest, participants had a short time frame in which to weld and cleanup their completed entry.
SMAW, 6G pipe, and welding in various positions. Love admitted getting the weld clean was a bit hard with the 5-min time frame, a sentiment that many welders who were interviewed for this article shared.

Love has been welding four years, starting the trade in high school and continuing on during college. “Being in a man’s field is challenging. There’s hardly ever any girls there,” Love said. She noted it would be nice if more women got involved in welding because they bring advantages of more patience, steadier hands, and a desire to make their welds look perfect. “It’s hard work, but it’s fun,” she said.

In the future, she would like to move back to her hometown in Montana, pursue a career in weld inspection, and become a CWI. “I’ll never leave the welding field. I love it,” she said.

Keith Cusey, a welding instructor at Decatur Area Technical Academy, Decatur, Ill., took second-place honors and won a $1000 award. He has been welding 22 years, is a CWI and Certified Welding Educator, and serves as chair of the AWS Sangamon Valley Section.

“I wish they had more contests like this for professionals,” Cusey said. “It’s a great opportunity.” As a SkillsUSA advisor, he enjoys seeing his students compete and was glad to participate in an event himself.

To prepare for the contest, Cusey tried mockups. He found making the weld itself was not hard, but completing it all in the short time frame was tough. “It’s a manual process, and it doesn’t weld as fast as gas metal arc welding. Plus, you have more cleanup to do,” he said.

Cusey’s efforts paid off and helped take away some pressure. “It was actually not as stressful as I was planning on,” he said. After all, he was familiar with what to do after working on a lot of SMAW and pipe in the past. He also liked the brand of electrodes used. “You have to have a little bit of luck on your side,” Cusey added, because one mistake might make you get off guard.

James Tucker, a weld technician at Manitowoc Cranes, Manitowoc, Wis., achieved the third $500 prize. He has been welding 25 years and is affiliated with the AWS Lakeshore Section. “I think it was very well organized,” he said of the contest. “They had everything you needed, all your personal protective equipment.”

Tucker entered the competition at the request of his supervisor, Jim Hoffman, a weld engineer for the company. His colleague, Todd Gilbert, who is also a weld technician at the company, competed with Tucker and placed in the top 12.

“We don’t get to weld often. We mostly do training,” Tucker said. Before going to the contest, he welded two pipes to see how he would do and felt pretty comfortable; prior to competing, to ease his nervous feelings, he walked around the show floor.

Andrew Miller won AWS’s first-ever Professional Welders Competition in 2004 and placed in the top 12 this time around. He has 30 years of welding experience and works as a welder for Rochester Gas & Electric, Rochester, N.Y. His daughter, Julia, accompanied him to the show.

Miller felt this contest was much more of a challenge vs. his last time competing. In preparation, he tried a couple of coupons to get a feeling for it with a quick mock up. “That’s a very difficult position with a 45 deg,” Miller said, noting good shoulders and a back are needed for this. Taking some deep breaths helped calm his nerves. While competing, however, Miller had problems with one of his electrodes, but he got another one, chipped the slag off, and started a new weld. He’s used to performing SMAW and occasionally doing uphill welding at work, which came in handy.

The following contestants were also among the top 12 winners and received an AWS duffel bag: Scott Miner, Jason Fry, Shane Stetter, Peter Larou, Devin Mettam, Gregory Larson, and George Rolla.

Members of the AWS Indiana Section donated their time and expertise to run the competition. Chair Tony Broso, Vice Chair Gary Tucker, Treasurer Mike Anderson, Bennie Flynn, Gary Dugger, and Secretary Bob Richwine served in this group. The Section members along with the planning committee came up with the event’s test specifications.

Many other individuals helped make this a successful event. AWS President-Elect John Bruskotter organized the competition. Dean Dreddy, a CWI who is corporate quality control director with National Steel Constructors, LLC, Plymouth, Mich., and AWS staff member Nichole Bradley also provided services.

The following students from North Point High School, Waldorf, Md., under the direction of Alan Badeaux, assisted at the booth as well: Steve Joyner, Tom Belle, Brian Rollins, Carl Kupniewski, Alex Fowler, Shane Cleaveland, Casey Poncheri, and Jeremy Yoho.

The next Professional Welders Competition will be held at the 2011 FABTECH International & AWS Welding Show in Chicago, Ill.
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American Welding Society
Copper Contamination Cracking in Austenitic Stainless Steel Welds

Welding of austenitic stainless steel with copper-nickel wire resulted in cracking, which was not detected by radiography, but subsequently leaked during pressure testing.

BY SANYASI RAO AND ALI Y. AL-KAWAIE

Newly installed austenitic stainless steel piping joints leaked at girth welds during a precommissioning hydrotest and low-pressure air leak test. The piping was ASTM A312 Grade TP316L seamless pipes and was part of a natural gas liquids (NGL) recovery project. The failed joints were intended for hydrocarbon gas, diglycolamine (DGA) or instrument air service. Some of the failed joints were subjected to radiographic testing in the field and accepted prior to pressure testing as part of the code and company standard requirement. Failure analysis of the welds and the subsequent inspection plan to inspect thousands of suspected welds in the project are discussed.

Failure Analysis

Background

The NGL recovery project consisted of extensive austenitic stainless steel piping of ASTM A312 Grade TP316L. The piping was intended for hydrocarbon gas, DGA, and instrument air. The piping meant for hydrocarbon gas and DGA service was required to be hydrotested, and the piping intended for instrument air was required to be air leak tested at low pressure. During pressure testing, seven welds from three different lines leaked during different times. All the failed girth welds between seamless pipes were of 2-in. diameter and 0.154-in. wall thickness. Three of the leaked welds were radiographed prior to pressure testing and accepted as per ASME B31.3. Details pertaining to the leaked welds are given in Table 1.

The first two welds (SB-103 and SB-106) that leaked were repaired and hydrotested and no investigation was conducted on the cause of failure. Subsequently, three more welds (FB-100, SB-101, and SB-22) leaked during hydrotest. These three welds were sent to the Saudi Aramco lab for failure analysis. During the same time period, two more welds (FB-30 and FB-31) leaked during an air leak test. These two welds were sent to a third-party lab by the EPC contractor for failure analysis. The NGL recovery project also had 90/10 cupro-nickel (UNS C70600) piping.

Nondestructive Testing

Radiographs of all three welds (FB-100, FB-30, and FB-31) that had passed radiographic testing before the leak testing were reviewed again after the leaks and no relevant indications were seen. Figure 1 shows the samples as received for failure analysis. The leaked welds were tested by dye penetrant. A round to linear indication was seen at the location of the leak as shown in Fig. 2. Cracks were

Fig. 1 — The as-received samples.

Fig. 2 — Indication at the leak location.

SANYASI RAO (sanyasi.rao@aramco.com), engineering specialist (welding), and ALI Y. AL-KAWAIE (ali.kawaie@aramco.com), engineering technician, are with Consulting Services Department, Saudi Aramco, Saudi Arabia.
were done for further identification of weld. This is shown in Fig. 6 at a higher magnification. Line analysis at the same location is shown in Fig. 9. It can be seen from both the elemental mapping and line analysis that the crack is rich in copper and also relatively rich in nickel as compared to the adjacent weld metal.

**Discussion**

The EDS analysis, elemental mapping, and line analysis showed that the small darkly etched part of the weld in Fig. 4 is primarily an alloy of copper and nickel. This part of the weld is probably from a tack weld that was made with ERCuNi welding wire. It is possible that a mix-up in filler metal was realized and the tacks were ground off. The removal of cupro-nickel tack weld by grinding was incomplete as revealed by Fig. 4. The chemistry of the residual cupro-nickel tack weld and the rest of the weld are consistent with the assumption that the rest of the weld was made with the gas tungsten arc welding (GTAW) process, using the required ER316L welding wire, taking dilution into consideration. It was concluded that accidental use of ERCuNi filler metal resulted in copper contamination cracking (CCC) due to penetration of molten copper into the grain boundaries of the weld, HAZ, and base metal. The source of copper is the residual cupro-nickel weld. Copper is known to penetrate the grain boundaries of an austenitic stainless weld, HAZ, and base metal up to a zone that experiences a temperature higher than the melting point of copper (Refs. 2-7). Solidification cracking in the weld due to unfavorable chemistry is also possible (Ref. 8). It is noted that the third-party lab also independently reported that the welds failed due to CCC.

Accidental use of ERCuNi filler metal in lieu of ER316L was possible because the project also had 90/10 cupro-nickel piping that was welded with the GTA process, using ERCuNi filler metal. The contractor had set up a fabrication shop on the site. Cupro-nickel and stainless steel piping spools were being fabricated by the same contractor in the same shop although in different bays. It was found that cupro-nickel spools were being fabricated during the same time period as the failed stainless steel spools. Some of the welders were qualified on both materials and they were welding in both the bays when required. It should be noted that three of the leaked welds were welded in the field (FB-100, FB-30, and FB-31) and the rest were welded in the shop.

Once the damage mechanism was established as CCC, it was required to establish the integrity of thousands of welds that were already completed. Hydrotesting for most of these welds were completed. Since the leak was minor and some of the girth welds were in inaccessible locations, the reliability of the hydrotest/leak test was questionable.

**Mock Ups**

To develop an inspection plan for the completed weld and to ascertain the damage mechanism, mock ups were welded to simulate the failure. Two mock ups were

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**Table 1 — Details of Leaked Welds**

<table>
<thead>
<tr>
<th>Weld No.</th>
<th>Intended Service</th>
<th>NDE</th>
<th>Type of Test</th>
<th>Required Test Pressure (lb/in.²)</th>
<th>Leak Pressure (lb/in.²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB-103</td>
<td>Hydrocarbon gas</td>
<td>No</td>
<td>Hydrotest</td>
<td>2175</td>
<td>1500</td>
</tr>
<tr>
<td>SB-106</td>
<td>Hydrocarbon gas</td>
<td>No</td>
<td>Hydrotest</td>
<td>2175</td>
<td>1500</td>
</tr>
<tr>
<td>FB-100</td>
<td>Hydrocarbon gas</td>
<td>RT</td>
<td>Hydrotest</td>
<td>2175</td>
<td>1500</td>
</tr>
<tr>
<td>SB-101</td>
<td>Hydrocarbon gas</td>
<td>No</td>
<td>Hydrotest</td>
<td>2175</td>
<td>1500</td>
</tr>
<tr>
<td>SB-22</td>
<td>DGA</td>
<td>No</td>
<td>Hydrotest</td>
<td>900</td>
<td>600</td>
</tr>
<tr>
<td>FB-30</td>
<td>Air</td>
<td>RT</td>
<td>Air leak test</td>
<td>150</td>
<td>125</td>
</tr>
<tr>
<td>FB-31</td>
<td>Air</td>
<td>RT</td>
<td>Air leak test</td>
<td>150</td>
<td>125</td>
</tr>
</tbody>
</table>
welded using pipes of the same size (2 in. diameter, 0.154 in. thick) and grade (ASTM A312 Grade TP316L). The first mock up (Mix-1) was welded with the GTA process, using ERCuNi welding wire, for the complete root and ER316L for the rest of the passes. The second mock up (Mix-2) was welded with the GTA process, using ER316L for the root and the rest of the passes, except that one full circumferential pass at one edge of the capping pass was made with ERCuNi.

Both welds were subjected to dye penetrant test, radiographic test and hydrotest. These tests were carried out in the presence of the project inspectors as these tests (except radiography) would be used to inspect the suspect welds. The results of the dye penetrant tests are shown in Figs. 10 and 11. It can be seen from Fig. 11 that the indication can be minute and could be missed. This possibility was highlighted to the inspectors concerned.

Subsequently both welds were subjected to radiographic testing. Radiographs of both welds were interpreted to ASME B31.3 requirements by ASNT Level II qualified personnel. Linear indications were seen in the radiograph of Mix-1 and the weld was rejected. No indications were seen on the radiograph of Mix-2 and the same was accepted by the film interpreter. This is consistent with the DP test results.

The two welds were subsequently hydrotested and found to leak at a pressure of 900 lb/in\(^2\) for Mix-1 and at 500 lb/in\(^2\) for Mix-2. The leak during hydrotest was very minor and the same is shown in Fig. 12. It is possible that leaks of this magnitude could have been missed, especially at joints in locations inaccessible to the inspector.

Positive metal identification (PMI) was done on the pipe and capping pass of the weld metal on both the mock ups. The results are shown in Table 2.

To ascertain the correctness of the damage mechanism, both mock ups were subsequently sectioned and subjected to metallographic analysis, elemental mapping, and line analysis. The results of these tests were in agreement with what was observed on the failed welds. The cracks seen in the failed weld were essentially reproduced on the mock ups.
The time these leaks were seen. Since the stainless welds in this project. Hydrotesting for most of the lines was completed by Mix-1. Inspection Plan—Mix-2. There were several thousand austenitic PMI Results on Mock Dye penetrant test result on Weld Location 3 Weld Location 2 Weld Location 1 Pipe Element (%) Ups Cr Ni Mo Cu 15.01 15.55 21.66 21.69 11.51 12.69 21.69 21.69 16.77 11.32 2.14 0.99 16.39 16.89 11.51 11.99 0.36 2.79

Table 2 — PMI Results on Mock-Ups

- All piping in nonhazardous service such as instrument air was excluded from the inspection plan.
- Dye penetrant test (DPT) was included in the inspection plan. The DPT on mock ups was used to demonstrate the manifestation of CCC to the inspectors.
- Based on the literature (Ref. 9) and the present work, CCC cannot be reliably detected by radiographic testing. Hence, radiographic testing was excluded.
- The PMI was to be done on four locations (12, 3, 6, and 9 o'clock positions). Since use of ERCuNi was possibly restricted to tack welding, multiple locations were specified to increase the possibility of detecting the mix up. It was specified that Cu content greater than 1% should be considered as a possible case of mix-up requiring further inspection for confirmation. A lower level of Cu could not be set because some heats of A312 Grade ER316L can contain up to 0.75% Cu. It was decided to inspect 5% of the suspect welds, and the level of inspection was to be based on the results. The inspection plan was based on the following salient points:
  - Some of the critical lines were recommended for rehydrotesting.
  - Some of the 90/10 cupro-nickel welds were also included in the inspection plan due to the possibility of accidental use of ER316L welding wire.
- Careful inspection was recommended during hydrotest for the welds that were yet to be hydrotested. Leaks on the mock ups during hydrotest were demonstrated to the inspectors.
- Some of the critical lines were recommended to be rehydrotested.
- Some cracks could not be detected by radiographic testing that preceded leak testing. Mock ups simulating the mix up of filler metal were welded and tested to assist in inspecting suspect welds and to ascertain the correctness of the damage mechanism. A detailed inspection plan comprising of DPT test, PMI, and hydrotest was developed for inspection of the completed welds that were suspected to have CCC.

Fig. 10 — Dye penetrant test result on Mix-1.

Fig. 11 — Dye penetrant test result on Mix-2.

Fig. 12 — Mix-1 weld showing minor leak at 900 lbf/in² during hydrotest.

Inspection Plan

There were several thousand austenitic stainless welds in this project. Hydrotesting for most of the lines was completed by the time these leaks were seen. Since the extent of leaking during the hydrotest was minor and several welds are in elevated and inaccessible positions, it was possible that some of the leaks were not detected by inspection during the initial field hydrotest. Hence, all the austenitic stainless steel welds that were welded during the time period when cupro-nickel piping spools were being fabricated were identified. There were about 9500 such welds and all joints were considered suspect due to the possibility of accidental use of ER-CuNi filler metal. It was decided to inspect 5% of the suspect welds, and the level of inspection was to be based on the results. The inspection plan was based on the following salient points:

- All piping in nonhazardous service such as instrument air was excluded from the inspection plan.
- Dye penetrant test (DPT) was included in the inspection plan. The DPT on mock ups was used to demonstrate the manifestation of CCC to the inspectors.
- Based on the literature (Ref. 9) and the present work, CCC cannot be reliably detected by radiographic testing. Hence, radiographic testing was excluded.
- The PMI was to be done on four locations (12, 3, 6, and 9 o'clock positions). Since use of ERCuNi was possibly restricted to tack welding, multiple locations were specified to increase the possibility of detecting the mix up. It was specified that Cu content greater than 1% should be considered as a possible case of mix-up requiring further inspection for confirmation. A lower level of Cu could not be set because some heats of A312 Grade ER316L pipes had 0.6% Cu, which could show up in the weld due to dilution. Moreover ER316L can contain up to 0.75% Cu as per ASME Section II part C.
- Careful inspection was recommended during hydrotest for the welds that were yet to be hydrotested. Leaks on the mock ups during hydrotest were demonstrated to the inspectors.
- Some of the critical lines were recommended to be rehydrotested.
- Some cracks could not be detected by radiographic testing that preceded leak testing. Mock ups simulating the mix up of filler metal were welded and tested to assist in inspecting suspect welds and to ascertain the correctness of the damage mechanism. A detailed inspection plan comprising of DPT test, PMI, and hydrotest was developed for inspection of the completed welds that were suspected to have CCC.

Conclusions

Austenitic stainless steel welds leaked during hydrotest due to CCC caused by accidental use of cupro-nickel filler metal. These cracks could not be detected by radiographic testing that preceded leak testing. Mock ups simulating the mix up of filler metal were welded and tested to assist in inspecting suspect welds and to ascertain the correctness of the damage mechanism. A detailed inspection plan comprising of DPT test, PMI, and hydrotest was developed for inspection of the completed welds that were suspected to have CCC.

Acknowledgments

The authors would like thank Peter D. Keen, Mohammed S. Tariq, and Hasan M. Al-Ghabari of project inspection for providing the data and for assisting in welding and testing of mock ups.

References

Oil Industry Challenges for the 21st Century

BY HARDY H. CAMPBELL III

Everyone is keenly aware of how vital oil and gas are to the economy, industry, and fabric of modern industrial societies. The slightest uptick in the prices of these essential hydrocarbons is watched with trepidation, fear, and a clutching of everyone’s wallet. Everyone, too, has seen the ubiquitous laced towers gushing black gold in movies and TV shows, the very imagery of some Texas wildcatter striking it rich.

A Drilling 101 Primer Course

These towers are either derricks or masts (Fig. 1), which are the principal structures used to drill for oil. Both have the primary function of supporting very long lengths of steel pipes, known as drill strings, that drill into the concealing earth to find that precious liquid beneath. These drill strings, which can reach 45,000 ft in length, are extremely heavy (up to 750 tons), and hence the supporting derricks or masts must be stout and robust steel assemblies.

Additionally, these towers are supported on a drill floor that is part of a larger substructure, often called a drilling equipment structure (DES, see lead photo), that contains various ancillary equipment required to support the drilling operations, such as the drilling mud supply tanks, circulation pits, “iron rough necks” (Fig. 2), etc. The popular term for the whole kit ‘n’ kaboodle is “drilling rig” — Fig. 3A, B. The drilling rig, in turn, is supported on some kind of foundation. Onshore, it’s supported on top of compacted or wood-matted dirt, and offshore, it is supported on top of steel girders.

That, in the proverbial nutshell, is a very rough ‘Drilling 101’ primer intended to give the reader a sense of the complex and heavy welded steel structures required to seek the lifeblood of 21st century civilization.

Factors Affecting Welded vs. Bolted Designs

Since welding plays such a significant role in the oil and gas industry, this article showcases some of the popular fabrication approaches, problems, and economic solutions unique to the industry.

Masts are typically welded, as opposed to derricks that are bolted. The reasoning is that masts are typically permanent structures that are shipped as a single, complete assembly to the drill site, while derricks are typically temporary structures that are assembled on-site.

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whereas derricks may be erected either as a single piece or as an erector-set-type assembly on site. However, with the cost of such piece-by-piece erection going up every day, this theory behind the bolted justification is questionable. The DES substructures, on the other hand, are always welded except where the bolted equipment supports or other maintenance-removable items are called for. Mud tanks, circulating pits, anchor supports, crown blocks, racking boards, and all the other sundry bits and pieces of a rig are almost always welded.

Factors Affecting the Designs

A fundamental issue with most rigs is weight. Whether a rig is intended for onshore or offshore drilling, weight imposes a significant penalty on transportation and structural/foundation design. Thus, efforts to minimize weight are a principal design goal, and this often requires the use of high-strength steels and carefully controlled welding procedures (WPSs).

The skid bases are typically heavy girders that support a drilling equipment structure and allow it to move to different well locations, using heavy-duty horizontal jacks. These skid bases are nonredundant built-up girders supporting heavy loads in all kinds of severe conditions, including very cold temperatures in places like Alaska and Siberia. Failure of these beams would be crippling, if not catastrophic, to the drilling program. As such, they require very high toughness steels and welds. Though the traditional quenched and tempered ASTM steels such as 100-ksi A514 have been popular for these applications for onshore rigs, the need in the offshore industry for a premium toughness steel has necessitated the use of lower-strength alternatives. Typically, for such applications, API 2Y and 2W plate steels are preferred in the 60-ksi grade, even though weight savings are not maximized to the extent that A514 could provide. This is because there are steel producers who have a proven history in rolling 2Y and 2W with the crack-tip opening displacement (CTOD) properties that clients require for such critical elements. The CTOD tests are a fracture-mechanics-based quantitative assessment of resistance to brittle fracture and propagation, as opposed to the popular Charpy V-notch (CVN) tests, which are a qualitative cracking evaluation.

Having said that, the 2Y and 2W S11 supplement that must be invoked to require the steel producer to provide these CTOD tests calls for the American Petroleum Institute's API RP 2Z, "Recommended Practice for Preproduction Qualification for Steel Plates for Offshore Structures", to be used, and this document also requires CVN tests. All of these are expensive and time-consuming tests that only specialist labs should be trusted to perform.

The reader may well ask why ASTM A514 could not be CTOD tested as well. The fact is that the CTOD values required (for example, 0.30 mm at −10°C or lower) would be difficult to achieve in this high-yield steel, so the client, in effect, is willing to accept the weight penalty for the enhanced confidence in service reliability. It should be noted that, even though the API RP 2Z tests are made with welds, the procedures are not intended to be WPSs for production welding. Rather, the welds are made to test the base metal heat-affected zone (HAZ) for microstructural sensitivity to cracking. The fabricator would be responsible for the testing of WPSs, which would have to be controlled by the fairly strict boundaries established by the steel producer's RP 2Z testing protocol.

The API design and fabrication document for drilling rigs is API 4F, "Specification for Drilling and Well Servicing Structures." This document provides inspection requirements for welds that should guide the design engineer in weld type selection.

Clause 11.3.4 of the current third edition requires that all complete-joint-penetration (CJP) or partial-joint-penetration (PJP) groove welds on a rig that are loaded in tension and that are loaded up to or beyond 70% of their allowable stresses, be inspected with a volumetric nondestructive examination (NDE) method per Section 6 of AWS D1.1, "Structural Welding Code — Steel." For portability as well as safety reasons, ultrasonic testing (UT) is the preferred method.

For the CJP welds, this imposes no undue hardship. Welds that penetrate the entire thickness are easy to scan with UT's acoustic energy. Any reflectors found at the root will be discontinuities that could be rejectable based on size and reflected energy, i.e., indication rating. However, PJP welds only partially penetrate thicknesses. The UT scans of PJP welds will in-
evitably provide a screen indication at the root, where the welds have failed to completely seal the abutting gap between the two elements to be attached. Such reflectors can be interpreted as cracks, which are always prohibited, even though such “natural” reflectors are a built-in part of the PJP design. So the UT operator will face a conundrum: reject the reflector as a weld defect based on its size and indication or accept the indication as being an innocuous part of the design. Clearly, the latter interpretation is not part of an NDE operator’s purview; he or she can only report what they see on the screen and grade it based on the code’s strict evaluation protocol. So, the weld may be rejected when it is perfectly suitable for its intended use.

Such complications unnecessarily drive up costs and add delays. Additionally, the UT accept-reject criteria for Section 6 are based on CJP welds; therefore, strictly speaking, Section 6 should not be used for UT evaluation of PJP welds in the first place. But, as indicated above, even if it was, it would be unwise to do so. So, there are two solutions. The least-preferred option is to have the NDE Level III inspector responsible for writing NDE procedures to develop a procedure based on PJP welds and recognize the built-in reflectors prior to production scanning. There are several ways to do this, but the D1.1, Annex S, UT Examination of Welds by Alternative Techniques, provides guidelines on how to do this for mock-up PJP welds.

My personal preference for a whole host of other non-NDE-related reasons is to do away with PJP welds altogether. The perceived economies of such welds are illusory, but the final PJP coup d’grace, for rig designers at least, should be this NDE clause, which faces a number of difficulties independent of fabrication costs. I personally recommend using CJP and fillet welds exclusively for drilling rigs. CJP’s are readily inspected volumetrically with UT, while fillets are routinely tested using magnetic particle.

An additional requirement even when only CJP welds are used is frequently neglected: the design engineer has to identify which CJP welds are subject to the tensile 70% threshold so that the fabricator can instruct its NDE operators as to which welds require UT. Such indications are preferably done on drawings. This requirement may be negated if the designer requires all CJP welds to be ultrasonically tested, but this approach is probably overkill. Not all CJP welds merit UT, unless they are critical elements. In any case, the engineers designing rigs need to be aware of their NDE responsibilities.

The preferred shop welding process is gas shielded flux cored arc welding (FCAW-G). For most applications, 70 ksi tensile strength electrodes are adequate. However, for good toughness joints in 50-ksi steels, 80-ksi electrodes have been frequently selected because of the higher-nickel contents in the wires. The use of equivalent toughness 70-ksi electrodes is now coming into vogue. The use of AWS D1.1 prequalified joint details is encouraged, even when WPSs require qualification testing. Prequalified WPSs are not uncommon, though, since most of the ASTM, API, and ABS steels used in rigs are selected from D1.1’s Table 3.1, and toughness testing is not always a client or code mandate. But drilling companies that do business overseas frequently deal with foreign contractors, who face the issue of having non-D1.1 steels readily available, rather than the standard grades American fabricators are accustomed to using.

Using such steels requires WPS testing, regardless of how similar in chemistry, strength, and properties these might be to the D1.1 “prequalified steels.” This imposes extra costs that many think are unjustified, considering the high quality of many of these foreign “equivalents.” Alas, other than the engineers of record having the freedom to do as they please with code requirements, the fabricator has no option but to qualify the WPS that uses this unlisted steel. Unfortunately, many structural and mechanical engineers have only a cursory knowledge of metallurgy or welding and are reluctant to grant such waivers. However, the AWS D1 Structural Welding Committee Task Group on Materials recently made the addition of prequalified non-U.S. steels a priority for inclusion in future D1.1 editions. Hopefully, these steels will first appear in the 2015 edition. This will be a boon to rig fabricators outside the United States as well as drilling contractors working overseas.

**Welding Is Essential**

This article presents a very brief overview of some welding topics pertinent to a small slice of the oil and gas industry. Pipelines, offshore platforms, floating drilling units, refineries, coastal offloading terminals, and a whole host of other essential petroleum infrastructural elements also rely on welding for safety and integrity, and each has its own unique requirements, challenges, traditions, and idiosyncrasies. Suffice it to say that welding is to oil as rain is to crops. Without the one you can hardly have the other.
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What Caused Corrosion in a Refinery’s Sour Water Unit?

The reasons for failures of Alloy 20 piping due to corrosion near welds were analyzed and some mitigation recommendations developed

BY JORGE J. PERDOMO

As part of the sour water unit system at the CITGO Petroleum Corp. refinery in Lake Charles, La., the pH of ammonia-containing sour water upstream of the sour water stripper vessel is controlled by adding 15% by weight (15 wt-%) sulfuric acid solution. A dilute sulfuric acid addition is used to control pH between 7 and 9 to ensure that H₂S is effectively stripped in the vessel overhead into the sour water gas stream.

The sour water dilute acid injection system of Alloy 20 (UNS N08020) material, a sulfuric acid-resistant alloy, was specified. The line operates at 30 lb/in.² and 125°F maximum temperature at a maximum velocity of 2.6 ft/s.

Alloy 20 is a fully austenitic stainless steel alloy used as an upgrade over carbon steel and Type 300 series stainless steels to provide corrosion resistance in sulfuric acid service. It contains niobium for stabilization against sensitization and intergranular attack. Alloy 20's nickel content provides improved resistance to chloride stress corrosion cracking and boiling sulfuric acid conditions over stainless steel alloys with a lesser amount of nickel (Ref. 1).

Laboratory corrosion data under static conditions (Ref. 1) show corrosion rates below 4 mils per year (mpy) penetration for the operating conditions stated above. Technical Document API 581 Appendix G (Ref. 2) indicates a maximum corrosion rate of 5 mpy at a flow rate of 2.6 ft/s.

For this article, failures of Alloy 20 piping at corrosion rates in excess of 45 mpy near welds after three years at the service conditions stated above were analyzed. The causes for failures and some mitigation recommendations are shown.

Material

The piping and fittings in the acid injection system corresponded to ASTM-approved materials B 464 and B 462, respectively. Grade UNS No. N8020 (aka Alloy 20), and design in accordance with the requirements of the ASME B31.3, Process Piping Code. The piping was 1.0 in. diameter with 0.133-in.-thick nominal wall (Schedule 40). Piping-to-fitting connections were of socket-weld design joined with the manual gas tungsten arc welding (GTAW) process and matching filler metal ER320LR (low residuals) per AWS A5.9/A5.9M:2006, Specification for Bare Stainless Steel Welding Electrodes and Rods, with 100% argon shielding gas. The fillet weld leg size was approximately 0.233

Fig. 1 — Pin hole found on the outside of the pipe next to a socket weld welded to a coupling (removed). (Scale in inches.)

Fig. 2 — Cross section of pipe end from Fig. 1 next to a socket weld welded to a coupling (location highlighted in dashed area) previously removed with a grinder on the outside. (Electrolytic oxalic etch. Scale in inches.)

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Fig. 3 — Inside corrosion of 1-in. pipe welded to slip-on flange as seen from the inside of the forged flange. Pipe diameter is 1 in.

Fig. 4 — Inside corrosion of 1-in. pipe welded to slip-on flange after axially splitting the sample. (Scale in inches.)

Fig. 5 — Metallographic cross section of pipe-to-flange joint area showing preferential crevice corrosion in the gap formed between pipe and flange (area highlighted in Fig. 3). (Electrolytic oxalic etch.)

Table 1 — Optical Emission Spectroscopy Results of Piping

<table>
<thead>
<tr>
<th></th>
<th>SB-464 UNS N8020</th>
<th>Pipe</th>
<th>AWS A5.9 E320LR</th>
<th>Weld</th>
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<tr>
<td>C</td>
<td>0.07 max</td>
<td>0.02</td>
<td>0.025 max</td>
<td>0.02</td>
</tr>
<tr>
<td>Mo</td>
<td>2.00–3.00</td>
<td>2.10</td>
<td>2.00–3.00</td>
<td>2.92</td>
</tr>
<tr>
<td>Nb</td>
<td>8% C–1.00</td>
<td>0.32</td>
<td>8% C–0.40</td>
<td>0.3</td>
</tr>
<tr>
<td>Cu</td>
<td>3.00–4.00</td>
<td>3.94</td>
<td>3.00–4.00</td>
<td>3.28</td>
</tr>
<tr>
<td>Ni</td>
<td>32.50–35.00</td>
<td>32.32</td>
<td>32.00–36.00</td>
<td>32.61</td>
</tr>
<tr>
<td>Fe</td>
<td>Balance</td>
<td>Balance</td>
<td>Balance</td>
<td>Balance</td>
</tr>
<tr>
<td>P</td>
<td>0.045 max</td>
<td>0.032</td>
<td>0.015 max</td>
<td>0.009</td>
</tr>
<tr>
<td>S</td>
<td>0.035 max</td>
<td>0.017</td>
<td>0.02 max</td>
<td>0.013</td>
</tr>
<tr>
<td>Si</td>
<td>1.00 max</td>
<td>0.4</td>
<td>0.15 max</td>
<td>0.10</td>
</tr>
<tr>
<td>Mn</td>
<td>2.00 max</td>
<td>2.00</td>
<td>1.5–2.0</td>
<td>1.84</td>
</tr>
<tr>
<td>Cr</td>
<td>19.00–21.00</td>
<td>19.21</td>
<td>19.0–21.0</td>
<td>19.34</td>
</tr>
</tbody>
</table>

The system experienced several pinhole leaks. This article concentrates on leaks confined at socket weld areas between a pipe and a fitting (coupling, elbow, or flange). All of them had similar characteristics, which are exemplified in the visual description of two different pipe failures grouped in Figs. 1-5. Visual inspection of the failed components showed the following:

- A pinhole visible on the outside next to a fillet weld — Fig. 1.
- Preferential corrosion inside the pipe and fillet weld that joined the pipe to the flange (or fitting) as seen in Figs. 2–4.
- Preferential corrosion of the piping end. Also some corrosion within a crevice formed between the pipe end and the flange (or fitting) as seen in Figs. 1-5.
- In a few cases, pitting corrosion inside the pipe, away from welds, in low points but not necessarily through wall — Fig. 6.

**Visual Observation**

The system experienced several pinhole leaks. This article concentrates on leaks confined at socket weld areas between a pipe and a fitting (coupling, elbow, or flange). All of them had similar characteristics, which are exemplified in the visual description of two different pipe failures grouped in Figs. 1-5. Visual inspection of the failed components showed the following:

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- In a few cases, pitting corrosion inside the pipe, away from welds, in low points but not necessarily through wall — Fig. 6.

**Metallography**

Two cross sections from two different areas of pipe that corroded were mounted for metallographic examination as shown in Figs. 2 and 5. No evidence was found of grain boundary carbide formation on the base metal or the presence of cracks in the weld, to indicate preferential corrosion at grain boundaries or stress corrosion cracking or any other metallurgically related mechanism.

**Discussion**

Chemical analysis confirmed that the pipe and weld corresponded to Alloy 20 base material and corresponding matching filler metal. Metallographic evaluation provided no evidence of sensitization of the material where corrosion occurred.

Based on our observations, the following three mechanisms were identified that contributed to corrosion in this system:

- Preferential Corrosion of Heat Tinted Areas

The largest amount of wall loss occurred inside pipe sections at regions where heat tint occurred during welding. All the socket weld joints in the system were welded in the absence of a backing (purge) gas. The degree of heat tint color in arc welding depends on several factors such as the chromium content of the alloy, the effectiveness of the shielding gas or electrode coating, and other weld parameters such as welding speed. The higher the chromium content in the stainless steel, the more heat resistant; therefore, the development of the heat tint colors is delayed. The level of oxygen available for the oxidation process also affects the colors formed.

In order to show the exact location of heat tinted areas and the effects of the backing gas two pipe sections were welded to a coupling. One side was welded without backing gas while the other end of the coupling was welded with 100% argon at a flow rate of 40 ft³/h. Welds were performed in the 2G position with the same heat input maintained. Subsequently, the joints were
Crevice and pitting corrosion occurred in a gap formed between the pipe end and the fitting to which the pipe was being welded. Crevices tend to form a local environment different from the bulk where corrosive (e.g., chlorides) species can concentrate and further disrupt the passive film.

Pitting Corrosion

Pitting corrosion was observed in the base metal. Although not the cause of the failures, it shows the limited corrosion resistance of Alloy 20 base material to chloride-containing sulfuric acid solutions. Molybdenum as an alloying element is beneficial in mitigating chloride pitting corrosion. In the case of Alloy 20, the nominal amount of molybdenum present (~2.5%) is the same as that of Type 316 stainless steel. Therefore, it is expected Alloy 20 will have limited chloride pitting corrosion resistance as does Type 316 stainless steel.

Fluid velocity reportedly has an effect on corrosion resistance of Alloy 20. Higher sulfuric acid velocities are said to contribute to higher corrosion rates by shifting the material from a passive to an active state (Ref. 4). The refinery’s system operated at 2.6 ft/s, which is considered low velocity. However, the geometrical change intrinsic with a socket weld design could be causing turbulence and higher local velocities than anticipated. This could be increasing the corrosion rate as well, which would explain corrosion of the pipe ends of the socket welds.

An alternate solution would be upgrading to Alloy C-276 or nonmetallic materials resistant to sulfuric acid. These are resistant to sulfuric acid solutions contaminated with chlorides.

Heat tint can be reduced with the use of an inert backing gas. However, some heat tint will still be present. A combination of mechanical and chemical means is an effective way to remove it. The presence of heat tint in the system is only a problem because of the chlorides present in the sulfuric acid solution. The protective nature of the chromium oxide film can be restored by 1) mechanical abrasion for removing the heat tinted oxide; 2) subsequently using a pickling solution (or paste) containing a mixture of HNO₃ and HF to remove contaminants and promote passivity; and 3) by rinsing the pickling medium with enough chloride-free water (Ref. 3). This whole procedure poses a challenge in applications to small-bore piping (<1.5 in.) as in this system because heat-tinted areas are difficult to access.

One way to decrease the negative effect of velocity is to change from a socket weld to a butt-joint weld design; however, that could be cost prohibitive.

References

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Consumables: Care and Optimization. Free online e-courses presenting the basics of plasma consumables, designed for plasma operators, distributor sales and service personnel, etc. Visit www.hyperthermcuttinginstitute.com.
CWI/CWE Course and Exam. Troy, Ohio. This is a 2-week preparation and exam program. For schedule, contact Hobart Institute of Welding Technology, (800) 332-9448, www.welding.org.

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

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

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

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


Hellier NDT Courses. Contact Hellier, 277 W. Main St., Ste. 2, Niantic, CT 06357; (860) 739-8950; FAX (860) 739-6732.


Preparation and Exam for AWS Certified Welding Inspector/Educator. Two-week-long courses beginning Feb. 22, April 12, May 17, June 21, Aug. 9, Sept. 20, Nov. 1, and Nov. 29. Contact Hobart Institute of Welding Technology, Troy, Ohio; (800) 332-9448; hiwt@welding.org; www.welding.org.

Preparation and Exam for AWS Certified Welding Supervisor. One-week-long course begins May 3 and Oct. 18. Contact Hobart Institute of Welding Technology, Troy, Ohio; (800) 332-9448; hiwt@welding.org; www.welding.org.


AWS Certification Schedule
Certification Seminars, Code Clinics and Examinations

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

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>Houston, TX</td>
<td>Mar. 7-12</td>
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<td>Sacramento, CA</td>
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Certified Robotic Arc Welding (CRAW)

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<td>Miami, FL</td>
<td>Nov. 29-Dec. 4</td>
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For current CWIs and SCWIs needing to meet education requirements without taking the exam. If needed, recertification exam can be taken at any site listed under Certified Welding Inspector.

Certified Radiographic Interpreter (CRI)

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<td>Apr. 19-23</td>
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<td>Allentown, PA</td>
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Certified Welding Supervisor (CWS)

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<td>Miami, FL</td>
<td>Sept. 13-17</td>
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<td>Norfolk, VA</td>
<td>Oct. 4-8</td>
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Certified Welding Sales Representative (CWSR)

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<td>Houston, TX</td>
<td>Mar. 31-Apr. 2</td>
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<td>Miami, FL</td>
<td>May 5-7</td>
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<td>Chicago, IL</td>
<td>Jun. 9-11</td>
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<td>Miami, FL</td>
<td>Aug. 25-27</td>
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<tr>
<td>Indianapolis, IN</td>
<td>Sept. 22-24</td>
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<tr>
<td>Atlanta, GA</td>
<td>Nov. 17-19</td>
<td>Nov. 19</td>
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</table>

Certified Welding Educator (CWE)

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

Senior Certified Welding Inspector (SCWI)

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

International CWI Courses and Exams

Please visit http://www.aws.org/certification/inter_contact.html

For information on any of our seminars and certification programs, visit our website at www.aws.org/certification or contact AWS at (800) 443-9353, Ext. 273 for Certification and Ext. 455 for Seminars. Please apply early to save Fast Track fees. This schedule is subject to change without notice. Please verify the dates with the Certification Dept. and confirm your course status before making final travel plans.

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American Welding Society®
Industry Leaders Recognized at the Show

The 2009 class of five AWS Counselors and one AWS Fellow were inducted during the FABTECH International & AWS Welding Show held Nov. 15–18, 2009, in Chicago, Ill.

Yu Ming Zhang was inducted as an AWS Fellow. Dr. Zhang was recognized for being a pioneer and a leader in the development of innovative welding processes, and welding process sensing and control, which directly supports the shipbuilding industry. Also, this year, he was a recipient of the A. F. Davis Silver Medal Award, detailed on the next page.

Counselor James “Rusty” Franklin was recognized for his more than 30 years of contributions to the industry, working both nationally and internationally to promote important safety-related innovation, equipment, and education.

Counselor Douglas D. Kautz was recognized for his work in electron beam and laser beam welding technology and for his achievements as a metallurgical engineer and organizer.

Counselor David J. Landon, District 16 director, was cited for his leadership and expertise, which covers a broad spectrum of the industry from construction to manufacturing to consulting on welding issues.

Counselor Kevin A. Lyttle was cited for making significant technical contributions to the industry in the areas of welding consumables, process development, and development of high-strength steel welding products.

Counselor Glenn Oyler was cited for his long and distinguished career in the welding industry serving in leadership positions and in research and development that impacted the power and pressure vessel sectors and other key industries.
Comfort A. Adams Lecture Award
Innovative Developments in FSW
Wayne Thomas currently is pursuing a PhD in materials research and innovation at Bolton University Centre, UK. In 1959, he began his career at Baldwins, Ltd., as a craft apprentice where he progressed to a boilermaker/fabricator. In 1964, he joined B.S.C., Machynys Works, where he served as project leader for friction welding, and later as planning engineer and estimator for its Fabrication and Welding Departments. He has been with The Welding Institute (TWI) since 1983, where he serves as principal research engineer. Thomas has published numerous technical papers. He has received the Sir William J. Larke Medal, the Japanese Welding Society Welding Process Technology Award for inventing and developing a friction stir welding method, the Samuel Wylie Miller Memorial Medal Award, the IIW Evgenij Paton Medal, and the American Society of Manufacturing Engineers Award.

Adams Memorial Membership Award
Horst Cerjak served as head of the Institute for Materials Science and Welding at Graz University of Technology, Austria, from 1982 until 2008. He received his PhD from the Technical University, Hanover, Germany. In 1967, he joined Siemens AG Nuclear Power, where he became general manager, materials and welding. He has authored more than 350 scientific papers and 13 books in the fields of nuclear materials, materials development, weldability, modeling approaches, and creep-resistant steels. Cerjak introduced the IWE education at his university, served from 2004 to 2007 as vice rector of the university, and is founder and chairman of the IWE international seminar, Numerical Analysis of Weldability. He has received the IIW Wossenheimer Software Innovation Award, IIW Yoshiaki Arata Award, and the Dr. Wolfgang-Houska Prize Award for research.

Howard E. Adkins Memorial Instructor Membership Award
Darryl K. Main holds a master’s degree in education. He began his teaching career in 1988 at Stanwood High School, Stanwood, Wash., as an agriculture science teacher with an emphasis in agricultural mechanics. His welding curriculum at Stanwood includes gas metal arc, oxy-acetylene, gas tungsten arc, and arc welding courses. In 2005, the Stanwood High School AWS Student Chapter was chartered. With the support of the District 19 Puget Sound Section, Stanwood’s welding program continues to reach new heights. Main received the Washington Vocational Agriculture Teachers Association’s District 1 Rookie Teacher of the Year; National Vocational Agriculture Teachers Association Outstanding Young Member Candidate; Washington State Teacher of the Year Candidate; Stanwood School District Teacher of the Year; Washington Association of Agricultural Educators Agriculture Teacher of the Year; and the Washington Assn. of Agricultural Educators Outstanding Agriculture Program Award.

Robert J. Conkling Memorial Award
2009 SkillsUSA Championships
Gold Medalist Schools
First Place — High School
Shelby County School of Technology
Columbiana, Ala.

A. F. Davis Silver Medal Award
Machine Design
Consumable Double-Electrode GMAW Part II: Monitoring, Modeling, and Control
Kehai Li received his PhD in electrical engineering from the University of Kentucky in 2007. Currently, he is a product engineer with ESAB. His major research interests include high-speed and high-production welding, laser hybrid welding, and welding and cutting process control, machine vision, and plasma cutting. Li has published 20 peer-reviewed journal articles and conference publications. He has received the IWE Henry Granjon Prize, The Welding Institute Sir William J. Larke Medal, and the Outstanding Young Manufacturing Engineer Award from the Society of Manufacturing Engineers.

Yu Ming Zhang, inducted as an AWS Fellow this year, received his PhD in mechanical engineering/welding from Harbin Institute of Technology, Harbin, China. From 1984 to 1991, he was a Harbin faculty member in the State Key Laboratory for Advanced Welding Production Technology. In 1991, he joined the University of Kentucky where he holds the James R. Boyd Professorship, Department of Electrical and Computer Engineering. He is also director of the Welding Research Laboratory and Applied Sensing and Control Laboratory, and the director of Graduate Studies. His research interests lie in applied machine vision and control systems with applications to manufacturing processes and robotic welding. Zhang has received the Donald Julius Groen Prize, A. F. Davis Silver Medal Award, Adams Memorial Membership Award; 15th IFAC Triennial World Congress Best Poster Paper Prize; and the Application Paper Honorable Mention from the International Federation of Automatic Control. He is a Senior Member of IEEE and SME, and a member of ASME.

Maintenance and Surfacing
Cladding in Marine Applications
Using Direct-Diode Lasers
Valdemar Malin, an AWS Fellow, received his PhD in welding/metalurgical engineering from Leningrad Polytechnic Institute, then became involved in production and research in welding automation, processes, and metallurgy. He was one of the developers of the air plasma arc cutting process and was the first to introduce it to industry in 1970. In 1971, he discovered the variable-polarity arc welding technology. Since 1979, Malin has continued his research at Siemens, Northwestern University, and, currently, at Alion Science and Technology. His focus is on new welding processes, metallurgy, utilization of lasers for surfacing, fabrication, automation, and consulting for industry and the U.S. government.

He has published more than 60 articles and two books. He serves or has served on various technical committees, including Commission XII of the American Council of IIW; the AWS D15 Committee on Railway Welding; Welding Journal Peer Review Committee; Joint ASTM, ASME, and Metal Properties Council Committee (Dissimilar Metal Welding Task Group); and Welding Research Council’s Reduced Gap Welding Committee on Weldability. He has re-
received several awards from the J. F. Lincoln Arc Welding Foundation, R&D Magazine RD 100 Awards, and the Arctic American Maritime Award.

Federico Sciammarella received his PhD degree from the Illinois Institute of Technology in metallurgy and materials engineering in 2003, then went to work for Alion Science & Technology’s Manufacturing Technology Center in Rockford, Ill. There, he developed the visualization system for the automated laser cell (ALC) that enables real-time remote observation of the welding process. In 2004, the group received an R&D 100 award for the ALC. The following year, the group won the R&D 100 award in Electronics for Power Measurement Calorimetric System. The article, “Controlling Heat Input by Measuring Net Power,” published in the July 2006 Welding Journal, details the work done by Sciammarella and Val Malin on the system. In 2007, Sciammarella received a TMS Young Leader Professional Development Award from the Materials Processing and Manufacturing Div. In 2007, he joined the College of Engineering and Engineering Technology at Northern Illinois University where he is an assistant professor in the mechanical engineering department.

Dalton E. Hamilton Memorial CWI of the Year Award

Phil Zammit began his welding career in 1975 in London, UK, where he worked as a gas tungsten arc welder/fitter. In 1978, he moved to the United States where he worked for 11 years using the flux core and shielded metal arc processes for welding custom, specialized canal-digging equipment, mobile conveyors, and similar heavy mining and earth-moving machinery. In 1985, he became an AWS Certified Welding Inspector. He is also Level 2 certified in UT, MT, and PT as well as a National Association of Corrosion Engineers (NACE) Level 3 Coatings Inspector. Currently, he works as QA manager at Brooklyn Iron Works Inc. in Spokane, Wash. Zammit has been an active member of the AWS Spokane Section since it was chartered in 1982. He has held every position on the Section’s executive committee and is known throughout District 19 for his strong support and involvement in AWS. He credits his growth in the welding industry to his participation, encouragement, and networking with AWS members. In 2000, he served as a member of the AWS board of directors and was elected District 19 director for six years. He participated in several committees during his terms — the latest being the Welding Handbook Committee that reviewed and published the ninth edition Volume 3 — Welding Processes, Part 2.

W. H. Hobart Memorial Award

Characterization of High-Strength Steel Weld Metals: Chemical Composition, Microstructure, and Nonmetallic Inclusions

Jose E. Ramirez received his PhD degree in metallurgical and materials engineering from the Colorado School of Mines. He has more than 20 years of experience in welding and corrosion technologies. He has worked for Edison Welding Institute, Columbus, Ohio, since 1999, where as a principal engineer he has researched the welding of high-strength steels, corrosion- and heat-resistant alloys, stainless steels, nickel-based alloys, and dissimilar metal welding. His areas of expertise include phase transformations of engineering materials, microstructure-property relationships of welded joints; and the weldability of ferrous and nonferrous materials. Ramirez has authored more than 40 technical papers and presentations. He is an active member of the American Welding Society peer review panel, the Welding Research Council, and the International Institute of Welding. He also participates in several NACE International technical committees where he is recognized as a corrosion specialist.

Honorary Membership Award

Jack Dammann received his degree in physical science from Colorado State University. He worked 37 years in a welding supply distributorship until 1998. He recently retired as owner and president of J. Hudson Ltd., where he served as an industrial distribution consultant. Dammann is a past member of the Colorado State VICA Board and a past member and chair of numerous Colorado welding and vocational advisory boards. He has served on the Linde (Praxair), Lincoln Electric, and Matheson Gas Products distributor advisory boards. In 1994, he served as president of the National Welding Supply Association (now GAWDA) and was a board member for 13 years. He was an AWS Foundation Trustee from 1994 to 2002, and continues to support several educational scholarship and grant awards. A Life Member of AWS, Dammann has served as chairman of the Southern Colorado Section and as its secretary and treasurer for several years. Dammann is an AWS Counselor, and a recipient of the District 20 Meritorious Certificate Award and the National Meritorious Certificate Award.

Lee G. Kvidahl, a graduate of Stevens Institute of Technology, is the sector manager of welding engineering for Northrop Grumman Shipbuilding, Gulf Coast. He is responsible for all welding engineering activities at the Pascagoula and Gulfport, Miss., and the New Orleans and Tallulah, La., sites. Kvidahl is an AWS past president (1993–1994). He has served as the AWS Pascagoula Section chair and District 9 director. He has chaired several AWS standing committees, including the Executive, Role and Missions, Compensation, National Nominating, and Honorary Meritorious Award Committees, Technical Activities, Technical Papers, and Conference Committees, and several special study committees. Presently, he chairs the AWS Membership Committee, and is a member of the Counselors Committee, D3 Committee on Welding in Marine Construction, and the AS Committee on Filler Metals and Allied Materials. He has also been a trustee of the AWS Foundation, serving as vice chairman from 1992 to 2004. Kvidahl chairs the National Shipbuilding Research Program Welding Technology Panel. He also is the chair of the Navy Joining Center (NJC) Steering Committee and a member of the NJC Technical Advisory Board. Kvidahl is a member of the American Bureau of Shipping Special Committee on Materials and Welding and a member of ASM International and SNAME.

Int’l Meritorious Certificate Award

Douglas R. Luciani received his MBA from the Richard Ivey School of Business, University of Western Ontario, Canada. He holds a diploma as a welder/fitter and is currently enrolled in the Directors Ed-
William Irgang Memorial Award
Chandra Bhushan C. Girotra received his master's in welding technology from Cranfield University, UK. He has more than 35 years of experience with Indian Nuclear Power Corp. and ESAB India. He is currently president of the Indian Institute of Welding. Girotra's company, Girotral Engineering Pvt. Ltd., based in Mumbai, markets welding consumables and equipment manufactured worldwide to AWS specifications. His company's client base includes major chemical, petrochemical, mechanical engineering industries, fabricators, project contractors, and retailers. Girotra has presented numerous technical papers. He also represents Edison Welding Institute, USA, and is actively working with the AWS to improve the transfer of welding technology between the United States and India.

Charles H. Jennings Memorial Award
Maria Carolina Payares-Asprino is a full professor in the Mechanical Department of Universidad Simon Bolivar, Caracas, Venezuela. She received her PhD from the University of Wales, Swansea, UK. She has been conducting and involved in welding engineering research and education for more than 24 years. She was a visiting professor at the Colorado School of Mines, Metallurgical and Materials Department, and in the Engineering Division in 1995 and 2008-2009. She also has carried out collaborative projects in South America. Payares-Asprino's research includes welding process development for any material, modeling techniques for the analysis of welding geometry and mechanical properties, welding metallurgy, weldability of duplex stainless steel, and robotic welding. Her publications have appeared in a number of research journals and conference proceedings.

James F. Lincoln Gold Medal Award
A Gleeble®-Based Method for Ranking the Strain-Age Cracking Susceptibility of Ni-Based Superalloys
David A. Metzler received his master's in engineering degree from the University of Pittsburgh, Pa. Prior to joining Haynes International in 2006, he spent 29 years involved in industrial metallurgy and manufacturing engineering in seawater-resistant stainless steel, nickel-based superalloys, production of high-performance EDM electrode wire, design of corrosion-resistant insulation systems for winding wires, and implementation of in-line inspection systems for high-speed
**NEW PRIZES. NEW 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 2009-2010 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.

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

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

**President's Roundtable:** Recruit 9-19 new Individual Members and receive an AWS polo shirt, hat and an AWS key chain.

**President's Guild:** Recruit 20 or more new Individual Members and receive an AWS watch, an AWS polo 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 FABTECH International & AWS Welding Show.

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**SPECIAL PRIZES**

Participants will also be eligible to win prizes in specialized categories. Prizes will be awarded at the close of the campaign (June 2010).

**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 2010 FABTECH International & AWS Welding 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 key chain.

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

**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.

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**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 2009, as well as in February and June 2010.

**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 2010 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.

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*The 2009-2010 MGM Campaign runs from June 1, 2009 to May 31, 2010. Prizes are awarded at the close of the campaign.*

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American Welding Society
Visit www.aws.org
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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](http://www.aws.org/membership)

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Last Name:  
First Name:  
Title:  
Birthdate  

Were you ever an AWS Member?  
- YES  
- NO  
If "YES," give year and Member #  

Primary Phone (  )  
Secondary Phone (  )  
FAX (  )  
E-Mail  

Did you learn of the Society through an AWS Member?  
- YES  
- NO  
If "YES," who referred you?  

**ADDRESS**  

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

Company (if applicable)  
Address  
Address Cont'd.  

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 degree  
- Bachelor's degree  
- Master's degree  
- Doctoral degree  

**PAYMENT INFORMATION (Required)**  

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<td>TWO-YEAR AWS INDIVIDUAL MEMBERSHIP</td>
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New Member?  

If "YES," give member's #  

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

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

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

**TOTAL PAYMENT**  

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<td>AWS STUDENT MEMBERSHIP</td>
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<td>$50</td>
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NOTE: Dues include $18.70 for Welding Journal subscription and $4.00 for the AWS Foundation.

Payment can be made by check or money order, payable to the American Welding Society, or by charge card  

Check | Money Order | Bill Me  
American Express | Dinners Club | Carte Blanche | MasterCard | Visa | Discover | Other  

Your Account Number  
Expiration Date (mm/yy)  

Signature of Applicant:  

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

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- Jefferson's *Welding Encyclopedia (CD-ROM)*  
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- Welding Metallurgy  
- *Welding Handbook* (9th Ed., Vol. 3)  
- Welding Handbook (9th Ed., Vol. 2)  
- *Welding Handbook* (9th Ed., Vol. 1)  

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

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

- Contract construction  
- Chemicals & allied products  
- Petroleum & coal industries  
- Primary metal industries  
- Fabricated metal products  
- Machinery except elect. (incl. gas welding)  
- Electrical equip., supplies, electrodes  
- Transportation equip. - air, aerospace  
- Transportation equip. - rail  
- Automotive  
- 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  
- Aluminum  
- Nonferrous metals except aluminum  
- Advanced materials/Intermetallics  
- Ceramics  
- High energy beam processes  
- Arc welding  
- Brazing and soldering  
- Resistance welding  
- Thermal spray  
- Cutting  
- LNT  
- Safety and health  
- Bending and shearing  
- Roll forming  
- Stamping and punching  
- Aerospace  
- Automotive  
- Machinery  
- Marine  
- Piping and tubing  
- Pressure vessels and tanks  
- Sheet metal  
- Structures  
- Other  
- Automation  
- Robotics  
- Computerization of Welding  

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In 2006, he joined the Research & Technology department of Haynes International where he is currently senior mechanical metallurgist. His current activities include test method development for strain-age cracking in nickel-based superalloys, and computer modeling of alloy manufacturing. He has written several papers in a variety of areas and authored the ultrafine wire-drawing chapter in the WAI Non-Ferrous Wire Handbook. Metzler is also a GE six-sigma green belt.

**McKay-Helm Award**

**Effect of GMAW Process and Material Conditions on DP780 and TRIP 780 Welds**

**Nick Kapustka** received his master's in welding engineering from The Ohio State University. His main interests are in arc welding processes, titanium, and advanced high-strength steels. While completing his bachelor's degree, he conducted fume characterization research at the Edison Welding Institute, joining the company in 2004 as a junior technician in the Resistance and Solid-State Welding group. Currently, he is an applications engineer in the Arc Welding group conducting extensive work on the gas metal arc welding (GMAW) of titanium sheet metal, as well as evaluating the feasibility of precision GMAW for high-alloy build-ups. Kapustka has authored several papers on GMAW of advanced high-strength steels and the fabrication of titanium and nickel-based components. He is coinventor of several shielding devices for GMAW and gas tungsten arc welding of reactive metals.

**Chris Conrardy** received his MS degree in welding engineering from The Ohio State University. He is currently chief technology officer and vice president for Technology and Innovation at Edison Welding Institute (EWI). His responsibilities include managing EWI’s technology investments to develop high-impact technical capabilities to meet the changing needs of industry. He previously held the position of technology leader in Arc Welding and Automation. His areas of technical expertise include advanced arc welding processes, automated systems, development, quality-tracking software, and distortion-control techniques. He developed and commercialized software to manage a variety of welding information, including weld inspection data, welding procedure data, and real-time weld process monitoring data. Prior to joining EWI, Conrardy was a founder and owner of WeldQC, Inc., a provider of quality-control software and systems. He was also a senior engineer with Babcock and Wilcox Division of McDermott. Conrardy is a member of the American Welding Society and is EWI’s representative as a sponsor of the American Council of the International Institute of Welding (IIW).

**Sudarsanam Suresh Babu**, an AWS Fellow, received his PhD in materials science and metallurgy from the University of Cambridge, UK. From 1992 to 1993, he worked as a research associate at Tohoku University, Japan. He joined Oak Ridge National Laboratory in 1993 as a postdoctoral research scholar then joined the research staff in 1997. From 2005 to 2007, Babu worked as technology leader in the engineering and materials area at Edison Welding Institute (EWI). He then joined The Ohio State University (OSU) as a faculty member in the welding engineering program. In 1995, he pioneered the development of online computational models for welding. In 2007, he and his team at EWI developed and deployed an online computational weld mechanics tool (EWeldPredictor) to the EWI member industries. His research at OSU involves three major areas: nonequilibrium phase transformations; physical processes during solid-state joining including ultrasonic additive manufacturing and friction stir welding; and material degradation in lithium ion batteries. Babu has authored more than 100 publications. His many recognitions include the Professor Koichi Masubuchi Award and the Lidstone Medal Award from the Welding Institute.

**C. E. Charley Albright** is a professor in the Welding Engineering group at The Ohio State University (OSU) where he teaches welding processes and materials. Albright joined the OSU Welding Engineering Group in 1979 serving as head of the group from 1994 through 1998. He also served as an adjunct professor at the University of Stuttgart in the early 1990s, and has advised 45 students to advanced degrees. His research areas include laser beam and solid-state welding, and, more recently, directing arcs with low-power lasers, and deformation resistance welding. He received his PhD in material science from the University of New Mexico while a member of the Sandia National Laboratories technical staff. He has received the Adams Memorial Membership Award and the Charles H. Jennings Memorial Award.

**Prof. Koichi Masubuchi Award**

**Yutaka Sato** received his PhD in material processing from the Tohoku University, Japan, in 2001. He served as a visiting researcher in the Mechanical Engineering Department, College of Engineering and Technology, Brigham Young University from 2003 to 2004; and as an assistant professor at the Department of Materials Processing, Graduate School of Engineering, Tohoku University, from 2006 to 2008. Currently, he is an associate professor, Department of Materials Processing, Graduate School of Engineering, Tohoku University. Sato has authored more than 40 publications and proceedings. He is a member of several professional and technical societies, and has received numerous awards from the Japan Institute of Metals, Iron Steel Institute Japan, Aoba Foundation, Japan Welding Society, Honda Memorial Foundation, and the Welding and Joining Engineering Foundation.

**Samuel Wylie Miller Memorial Medal Award**

**Robert L. ‘Bob’ Peaslee** was an AWS Fellow, a Life Member, and world-renowned nickel brazing expert affiliated with Wall Colmonoy Corp. (WCC) until his death March 5, 2009. He earned a degree in chemical engineering at the University of Cincinnati in 1940. During WWII, he worked at Curtiss Wright Corp. as a metallurgist where he became welding engineer in charge of fabrication development on jet engines. It was there Peaslee invented a high-temperature furnace process to braze jet engine parts using Colmonoy 6, a nickel alloy. The process he developed is now known as diffusion brazing. In 1950, he joined WCC where he further developed high-temperature and high-quality structural brazing techniques for use throughout the
jet engine industry. Peaslee and the AWS C3 Committee on Brazing and Soldering initiated the first annual Int’l Brazing Conference at the 1970 AWS Welding Show. In 1999, the International Brazing and Soldering Conference (IBSC) became a stand-alone event held every third year. In 1970, Peaslee established the Wall Colmonoy Modern Furnace Brazing course and served as the main instructor for more than 35 years. He also taught the ASM Brazing Technology course from 1973 to 1996. Peaslee was well known for his Brazing Q & A column that ran bimonthly in the Welding Journal for many years. He initiated the work on Brazing Handbook and was a major contributor to all five editions. He also initiated work on the Soldering Handbook in the 1950s. He served as chair of the C3 Committee, and was a member of A2 Committee on Definitions and Symbols, A5 Committee on Filler Metals and Allied Materials, A5X Executive Committee, A5H Subcommittee on Filler Metals and Fluxes for Brazing, B2A Subcommittee on Brazing Qualifications, and committee groups with American Society of Mechanical Engineers and the American Chemical Society. In 1991, he received the AWS Comfort A. Adams Lecture Award. In 2004, the Robert L. Peaslee Scholarship Fund was established by Peaslee and the Detroit Brazing and Soldering Division.

**National Meritorious Award**

**Alfred B. Crichton** received his master’s in metallurgy from Stevens Institute of Technology and a MBA from Pace University. In 1969, he joined the Union Carbide Corp.-Linde Division where he worked for 17 years. From 1986 to 1988, he served Moore Bros., Inc., as vice-president and general manager, then joined Airgas, Inc. From 1988 to 1992, he held the position of president, Sierra Airgas and from 1991 to 1993, regional vice-president of Airgas, Inc., in Sacramento, Calif. In 1993 he was named president-western division, Folsom, Calif. As western division president, he worked with all Airgas Region companies east of the Mississippi until his retirement in 2006. He received Airgas’ Scott Melman Award and served as AWS Sacramento Section chairman from 1990 to 1991.

**Jay Leno** enthusiastically promoted his admiration for welders and support for welding as a career in the video *Hot Bikes, Fast Cars, Cool Careers* developed with the assistance of The Lincoln Electric Co. He was honored with a star on the Hollywood Walk of Fame for his many years as host of the *The Tonight Show*. Leno is well known as an avid car and motorcycle collector, enthusiast, and restorer of vehicles. He works with the Automobile Restoration Department at McPherson College. After receiving his degree from Emerson College, Leno entered show business as a stand-up comedian. He made his first appearance on the Tonight Show in 1977 and during the 1980s, he served as guest host of the show. He became the permanent host in 1992 and held this position until May 2009.

**Robert L. Peaslee Brazing Award**

**Characterization of Titanium/Steel Joints Brazed in Vacuum**

**Ahmed Elrefaey** received his PhD in engineering from Osaka University, Japan. His research interests include materials welding and welding processes for joining dissimilar materials. From 1994 to 1999, he worked for the Central Metallurgical Research and Development Institute (CMRDI), Egypt, as an assistant researcher and lecture assistant. In 2000, he entered Osaka University, Japan, as a research student and PhD candidate. In 2005, Elrefaey returned to CMRDI as a lecturer, and in 2006, he joined the Institute of Materials Engineering, Dortmund University, Germany, as a Postdoctoral Fellow, where he currently works as a researcher. He is a co-holder of a patent from the Egypt Scientific Research Academy for new postweld heat treatment regimes for welding carbon steel to Monel® 400.

**Wolfgang Tillmann** received his Dr.-Ing degree in mechanical engineering from Aachen University of Technology. From 1988 to 1996, he was with Aachen University of Technology, Materials Science Institute (MSI) of Brazing Technology as a research engineer, group leader, and chief engineer. In 1996, he joined Hilti Corp. Technical Center in Liechtenstein. In 2001, he was managing director of the diamond tools business unit of Hilti Germany Ltd. Since 2002, Tillmann has been a professor at the Institute of Materials Engineering, Technische Universität Dortmund. His research includes the joining of materials, brazing technology, heat treatment, powder metallurgy, thermal spraying PVD-technology, and materials development and characterization. He received the Borchers Pinkett Award, Aachen University of Technology and the Bennigsen-Foerder-Preis of North Rhine-Westfalia Award.

**Plummer Memorial Education Lecture Award**

**Teaching Human Development Skills to Welders — Twenty Years Later**

**Jack D. Compton**, an AWS Distinguished Member and a Life Member, became interested in welding through his father, who was a sheet metal welder. Following service during the Vietnam War in the U.S. Army, he earned his teaching degree from California State University. He worked in industry with stainless steel products, followed by full-time teaching positions at the College of the Canyons and William S. Hart High School. He has devoted more than 30 years training welders, and has served as an expert witness. Throughout his career, he kept his welding skills sharp performing structural welding on a number of buildings in California, as a welder in the motion picture industry, and as a Certified Welding Inspector for a number of welding fabrication shops. Compton has been an active AWS member and leader since 1984. He served as District 21 director (2007–2009) and currently chairs the San Fernando Valley Section. He is an AWS Certified Welding Inspector, a Certified Welding Educator, and the author of the *Guide to Certified Welder Examinations*, which has sold more than 14,000 copies.

**Warren F. Savage Memorial Award**

**Liquation of Mg Alloys in Friction Stir Spot Welding**

**Youngki Yang** received his PhD degree in materials science and engineering from the University of Wisconsin–Madison. He is currently a research associate in the Department of Engineering Physics at the university. His research interests include corrosion, irradiation damage, welding of Mg alloys, and creep-resistant Mg-alloy development for structural applications.
in automobiles, power plants, nuclear reactors, aircraft, and marine facilities.

Honggang Dong received his PhD degree in materials processing engineering from the Harbin Institute of Technology. Currently, he is an associate professor in the Department of Materials Processing Engineering at Dalian University of Technology, Dalian, China, where he teaches joining of advanced materials. From 2005 to 2007, he worked as a research associate in the Department of Materials Science and Engineering at the University of Wisconsin-Madison. Dong’s research interests include the joining of similar and dissimilar materials, welding metallurgy, composition design of filler materials, modeling, and simulation of heat transfer and fluid flow in welding processes. He has been a member of the computer-aided welding commission of the Chinese Welding Society since 2007.

Hongbo Cao joined General Electric Global Research Center in 1999 where he is currently a materials scientist at the Ceramic and Metallurgy Technologies Organization, Niskayuna, New York. He is conducting research and development in the field of solid oxide fuel cells and thin-film solar cells. He received his PhD in materials science and engineering from the University of Wisconsin—Madison, in 2008. His dissertation is titled, Application of Computational Thermodynamics in the Study of Multicomponent Magnesium Alloys and Bulk Metallic Glasses. Cao has authored more than 20 publications, holds one U.S. patent, and is active in many professional organizations.

Y. Austin Chang received his PhD in metallurgy from University of California—Berkeley. He has served as a professor in the Department of Material Science and Engineering, University of Wisconsin-Madison (UW-Madison), since 1980. He held the post of Wisconsin Distinguished Professor from 1988 until 2006, when he was named Wisconsin Distinguished Professor Emeritus. Chang served as chairman of two academic departments at UW-Milwaukee, and later at UW-Madison, for a total of 15 years. He has performed research in the thermodynamics and kinetics of chemical materials early in his career, followed by contributions to thermodynamic modeling and phase diagram calculations, and studies of structural, electronic, and magnetic materials in bulk and nanoscale forms. Chang is a Fellow of the Minerals, Metals and Materials Society (TMS) and a Fellow of ASM International (1978). He served as a visiting professor at Tohoku University in 1987 and Massachusetts Institute of Technology in 1990, and was a summer faculty member at the Quantum Structure Research Initiative Group, Hewlett-Packard Labs, in 1999. He was Honorary Chair Professor at National Tsing Hua University. Chang received an Outstanding Instructor Award from UW-Milwaukee, Educator Award from TMS, Albert E. White Distinguished Teacher Award from ASM International (1994), and named a Wisconsin Idea Fellow. He has played leadership roles as a board member, vice president, and president of TMS (2000), and as a trustee of ASM International (1981–84), a trustee of AIME (1999–2001), and national president of Alpha Sigma Mu (1984). He has authored more than 500 publications and holds three patents with another pending. He is a member of the National Academy of Engineering, and is a foreign member of the Chinese Academy of Sciences.


William Spraragen Memorial Award

The Mechanism of Ductility Dip Cracking in Nickel-Chromium Alloys

George A. Young received his PhD degree in materials science from the University of Virginia. He is an advisory scientist at Knolls Atomic Power Laboratory and an adjunct professor at the Union Graduate College in Schenectady, N.Y. Young’s research and teaching interests include welding metallurgy, physical metallurgy, diffusion in solids, fracture mechanics, computational materials science, and environmentally assisted cracking. He has authored more than 30 peer-reviewed papers, co-authored book chapters on welds for nuclear systems and hydrogen embrittlement of nickel alloys, and serves as a peer reviewer for the Welding Journal.

Thomas Capobianco received his BS degree in materials engineering from the University of Colorado, Boulder. From 1982 to 1992, he was a mechanical engineer at the National Institute of Standards and Technology Superconductor and Magnetic Measurements Group, Gaithersburg, Md. His work concerned designing and building apparatus for low-temperature (cryogenic) physics experiments and directing projects in electromagnetic nondestructive testing. Capobianco joined the Knolls Atomic Power Laboratory (upstate New York), Nondestructive Testing and Evaluation Group, where his initial work focused on eddy current research and testing for heat exchanger tubing. Currently, he is actively involved in welding and materials process development and conducting research on cause and mitigation of ductility dip cracking in nickel-chromium alloys.

Michael A. Penik is manager of the Materials Development Operation Laboratory, and earlier served as manager of the Welding & Materials Process Development group at Knolls Atomic Power Laboratory in Schenectady, N.Y. Penik is a graduate of Clarkson University and Rensselaer Polytechnic Institute with master’s degrees in both mechanical and
materials engineering. His research expertise includes the metallurgy of low-alloy steels and the weldability of alloys used in nuclear power systems.

Brian W. Morris received his MS degree in mechanical engineering from Union College, and MS degree in material science and engineering from Rensselaer Polytechnic Institute in 1985, 1991, and 2000, respectively. Since 1985, Morris has worked at the Knolls Atomic Power Laboratory, initially in the field of nuclear power plant operations and maintenance. He subsequently moved into the power plant design area where he concentrated on structural analysis of plant components, reactor core design, and computational material science. He is currently working on developing alternate energy conversion technologies. He is an active member of the American Society of Mechanical Engineers and the American Nuclear Society.

James J. McGee received his master’s degree in geochemistry/geology from the State University of New York–Stony Brook. For 18 years, he was employed with the U.S. Geological Survey in Reston, Va., where he performed geochemical and mineralogical studies on lunar rocks. He also directed an electron beam instrumentation laboratory, overseeing the use and application of microanalytical techniques to research a wide variety of geological materials and the processes that affect them. McGee spent four years as a research associate at the University of South Carolina Department of Geological Sciences where he pursued microanalytical studies of lunar and terrestrial igneous rocks and their thermal histories, in addition to managing the department's Microbeam Laboratory. He has published more than 100 papers. For the past nine years, he has been employed with Lockheed Martin, and now Bechtel, performing microcharacterization studies of materials using a variety of electron microscopic techniques. He has served in various roles on the leadership councils of the national Microbeam Analysis Society and the local Capital District Microscopy and Microanalysis Society.

R. D. Thomas Memorial Award

Warren Miglietti received his PhD from the University of Pretoria. He is a principal engineer in the Reconditioning Department at PSM, a wholly owned subsidiary of Alstom. He joined PSM in 2008 after working five years at General Electric. His primary responsibility is the development of novel repair techniques and processes for components, operating in advanced land-based gas turbine engines. He has 21 years of experience and expertise in the welding, brazing, and heat treatment of nickel- and cobalt-based superalloys, as well as titanium, aluminum, and stainless steels. Miglietti continues to support the industry as chair of the International Institute of Welding Commission XVII, Brazing and Diffusion Bonding. He has authored 39 technical papers, has two repair technology patents granted, and seven patents pending.

Elilhu Thomoson

Resistance Welding Award

Larry E. Moss is president and CEO of Automation International, Inc., Danville, Ill. The company was established in 1991 with the merger of three resistance and arc welding companies: Federal Welder and Machine, Berkeley-Davis, Inc., and Swift-Ohio. During his career, Moss has worked in engineering, field services, weld lab, arc and resistance welding applications, sales engineering, and product manager of flash welding systems. In 1969, he joined Berkeley-Davis/Federal part time while attending college, and became a full-time electrical engineer in 1973. In 1992, he served as sales and marketing manager of Automation International, Inc., and in 1996 became co-owner of the company. Although an expert in resistance welding, he has concentrated much of his work in the development of the flash and upset welding processes. Moss has presented at the AWS Sheet Metal Welding Conference and written numerous articles on resistance welding for the Welding Journal and other publications. He is a past chairman of the AWS Welding Handbook, Chapter 3, ninth edition, chapter on Flash and Upset Welding, and holds a patent on an adaptive data-acquisition system. Since 1986, Moss has held various leadership positions in the Resistance Welding Manufacturing Alliance (RWMA). He was a RWMA welding instructor for ten years and served two terms as chair of its Welding School Committee. He was president during its reorganization and establishment as an AWS Standing Committee. From 2004 to 2006, he served as its chairman and continues to serve RWMA as a member of the Governing Committee and a contributor to the RWMA newsletter.

George E. Willis Award

Thomas M. Mustaleski Jr. received his degree in metallurgical engineering from Rensselaer Polytechnic Institute, and has completed graduate work in metallurgical engineering at the University of Wisconsin — Milwaukee, and the University of Tennessee. Currently, he is chairman of the American Council of the IIW. Within IIW, he is a member of the Technical Management Board and chaired the Select Committee on Welding for Aircraft and Aerospace Applications (SC AIR) for seven years. He has served as the U.S. Delegate to IIW Commission V, Delegate to Commission IV, and as Lead U.S. Representative to SC AIR. He also serves as a Representative to SC QUAL, and has participated in other IIW commissions and select committees as an expert or observer. He has also participated in several ISO TC 44 meetings. Mustaleski was a member of the AWS board of directors from 1994 until 2006. He served two terms as a director-at-large, three terms as a national vice president, and one term as president (2003–2004). He also served as an officer of the Milwaukee and the Northeast Tennessee Sections. He chaired the Northeast Tennessee Section for several terms. He has led several technically based committees of the Society. An AWS Life Member, he was inducted as an AWS Fellow and has received the William Irrgang Memorial Award, Honorary Membership Award, R. D. Thomas Memorial Award, and Davis Silver Medal. He was recognized as a Distinguished Member in 1989. Mustaleski is retired from BWXT Y-12 L.L.C., Oak Ridge, Tenn., where he was employed from 1974 until 2006. He served as a staff member and group leader in the Technology Development Organization, where he was involved in welding metallurgy and process and procedure development.
Standards for ANSI Public Review

**B2.1-22:015:20XX, Standard Welding Procedure Specification (SWPS) for Gas Tungsten Arc Welding of Aluminum (MP-22 to M/P-22), ER4043 or R4043, 18 through 10 Gauge, in the As-Welded Condition, with or without Backing. Revised — $25. 1/25/10**

**B2.1-1-019-94 (AMD1), Standard Welding Procedure Specification (WPS) for CO2 Shielded Flux Cored Arc Welding of Carbon Steel (M-1P-1/S-1, Group 1 or 2), % through 1/2 Inch Thick, E70T-1 and E71T-1, As-Welded Condition. Amendment — $25. 1/25/10**

**B2.1-1-020-94 (AMD1), Standard Welding Procedure Specification (WPS) for 75% Ar/25% CO2 Shielded Flux Cored Arc Welding of Carbon Steel (M-1P-1/S-1, Group 1 or 2), % through 1/2 Inch Thick, E70T-1 and E71T-1, As-Welded or PWHT Condition. Amendment — $25. 1/25/10**

**B2.1-1-027:20XX, Standard Welding Procedure Specification (SWPS) for Self-Shielded Flux Cored Arc Welding of Carbon Steel (M-1 or P-1), Groups 1 and 2, % through 1/2 Inch Thick, E71T-11, As-Welded Condition, Primarily Plate and Structural Applications. Revised — $25. 1/25/10**


AWS was approved as an accredited standards-preparing body 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. The above documents were open for public review before the dates shown. Draft copies may be ordered from R. O’Neill, ext. 451, roneill@aws.org.

**Technical Committee Meetings**

March 9, 10, C3 Committee on Brazing and Soldering and its subcommittees, Phoenix, Ariz. Contact: S. Borrero, ext. 334.

March 12, 11 Committee on Resistance Welding Equipment, Palm Beach Gardens, Fla. Contact: A. Alonso, ext. 299.

March 23, A5 Committee on Filler Metals and Allied Materials, Orlando, Fla. Contact: Rakesh Gupta, ext. 301.

March 23–26, D1 Committee on Structural Welding, Kansas City, Mo. Contact: S. Morales, ext. 313.

**Welding Sales Representatives**

AWS established a new certification program for welding sales representatives in 2009. Volunteers are invited to be part of the technical subcommittee responsible for setting the qualification requirements. **AWS B5.14, Specification for the Qualification of Welding Sales Representatives**, that this program is based on. Contact John Gayler, gayler@aws.org, (800/305) 443-9353, ext. 472; or visit www.aws.org/1UQ4.

**Robotic and Automatic Welding**

Volunteers are sought to participate on the D16 Committee on Robotic and Automatic Welding. Its documents include **D16.1, Specification for Robotic Arc Welding Safety; D16.2, Guide for Components of Robotic and Automatic Arc Welding Installations; D16.3, Risk Assessment Guide for Robotic Arc Welding; D16.4, Specification for Qualification of Robotic Arc Welding Personnel.** Persons engaged in robotic welding operations and suppliers of equipment who want to contribute their expertise to the preparation of one or more of these documents are urged to contact Matthew Rubin, mrubin@aws.org; (800/305) 443-9353, ext. 215, or visit www.aws.org/1UQ4 to submit your member application online.
Districts Council News

On Nov. 15, 2009, AWS Districts Council approved the Section charter for the Auburn-Opelika Section, District 9. Student Chapter charters were approved for Bethlehem Area Vocational Technical School, District 3; Wake Tech Community College, District 4; Aiken, S.C., District 5; Kankakee River Valley, District 13; Lincoln College of Technology, District 17; FHS Welding, District 18; and Lee High School, District 18.

Raffle Winners Named

Those who joined or renewed their memberships for two years or more at the recent FABTECH International and AWS Welding Show received an American Welder jacket and were entered in a raffle. The raffle winners were Jack Lilley, MetalTek International ($150); Mat O. Hutson Jr., FBS Group ($100); Dale Osmanson, Naval Sea Systems Command ($50); and Donald R. McMaster, VersaGate (an AWS Challenger jacket). More than 70 people participated in the event.

Membership Counts

<table>
<thead>
<tr>
<th>Member Grades</th>
<th>As of 01/01/10</th>
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<tr>
<td>Sustaining</td>
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<tr>
<td>Supporting</td>
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<td>Student + transitional members</td>
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<tr>
<td>Total members</td>
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</table>

AWS Participates at 2009 Essen Welding Fair

Pictured at a reception held during the 2009 Essen Welding Fair by the show organizers are members of the foreign delegations that sponsored national pavilions at the show. The United States Pavilion included 28 exhibitors. The AWS representatives included President Vic Matthews, Treasurer Earl Lipphardt, Executive Director Ray Shook, and Associate Executive Director Jeff Weber.
Listed below are those who participated in the 2009–2010 campaign. See page 67 in this Welding Journal or visit www.aws.org/mgm for rules and prize list. These standings are as of December 15, 2009. Call the AWS Membership Dept. (800/305) 443-9353, ext. 480, for information on your proposer status.

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

- J. Compton, San Fernando Valley
- E. Ezell, Mobile
- J. Merzthal, Peru
- G. Taylor, Pascagoula
- L. Taylor, Pascagoula
- S. Esders, Detroit
- B. Mikeska, Houston
- W. Shreve, Fox Valley
- J. Compton, San Fernando Valley
- J. Hope, Puget Sound
- J. Ciaramitaro, N. Central Florida
- M. Anderson, Indiana
- D. Saunders, Lakeshore
- J. Carney, Western Michigan
- D. Kowalski, Pittsburgh
- S. Miner, San Francisco
- S. Siviski, Maine
- A. Baughman, Stark Central
- T. Gerber, Allegheny
- D. Kowalski, Pittsburgh
- R. Wahrman, Triangle
- S. Burdge, Stark Central
- A. Duron, New Orleans
- R. Evans, Siouxland
- E. Norman, Ozark
- G. Marx, Tri-River
- C. Donnell, NW Ohio
- J. Durbin, Tri-River
- V. Facchiano, Lehigh Valley
- J. Theberge, Boston
- M. Arand, Louisville
- J. Boyer, Lancaster
- K. Rawlins, Columbia
- K. Carter, Tri-River
- G. Smith, Lehigh Valley
- G. Seese, Johnstown-Altoona
- D. Zabel, SE Nebraska
- J. Stallsmith, South Carolina
- R. Madrigal, LA/Inland Empire
- J. Ciaramitaro, N. Central Florida
- R. Munas, Utah
- D. Vranich, N. Florida

**3+ Student Member Sponsors**

- C. Rogers, San Antonio
- D. Berger, New Orleans
- H. Hughes, Mahoning Valley
- D. Kowalski, Pittsburgh
- M. Anderson, Indiana
- D. Saunders, Lakeshore
- J. Carney, Western Michigan
- D. Kowalski, Pittsburgh
- S. Miner, San Francisco
- S. Siviski, Maine
- A. Baughman, Stark Central
- T. Gerber, Allegheny
- D. Kowalski, Pittsburgh
- R. Wahrman, Triangle
- S. Burdge, Stark Central
- A. Duron, New Orleans
- R. Evans, Siouxland
- E. Norman, Ozark
- G. Marx, Tri-River
- C. Donnell, NW Ohio
- J. Durbin, Tri-River
- V. Facchiano, Lehigh Valley
- J. Theberge, Boston
- M. Arand, Louisville
- J. Boyer, Lancaster
- K. Rawlins, Columbia
- K. Carter, Tri-River
- G. Smith, Lehigh Valley
- G. Seese, Johnstown-Altoona
- D. Zabel, SE Nebraska
- J. Stallsmith, South Carolina
- R. Madrigal, LA/Inland Empire
- J. Ciaramitaro, N. Central Florida
- R. Munas, Utah
- D. Vranich, N. Florida

**President’s Guild**  
*Sponsored 20+ new members.*

- V. Craven, Pascagoula
- B. Chin, Auburn
- A. Sumal, British Columbia
- H. Thompson, New Orleans

**President’s Roundtable**  
*Sponsored 9–19 new members.*

- R. Ellenbecker, Fox Valley
- A. Sumal, British Columbia
- H. Thompson, New Orleans

**President’s Club**  
*Sponsored 3–8 new members.*

- D. Berger, New Orleans
- J. Ciaramitaro, N. Central Florida
- L. Taylor, Pascagoula
- J. Hope, Puget Sound
- S. Keskar, India Int’l
- S. Keskar, India Int’l
- E. Ravelo, International
- C. Schiner, Wyoming
- J. Smith, Greater Huntsville
- R. Davis, Syracuse
- J. Grossman, Central Michigan
- S. Hansen, Southeast Nebraska
- S. Henson, Spokane
- E. Hinojosa, LA/Inland Empire
- A. Kitchens, Olympic Section
- J. Lynn, Idaho/Montana
- S. MacKenzie, Northern Michigan
- M. Stevenson, J.A.K.
- N. Carlson, Idaho/Montana
- B. Chin, Auburn
- J. Compton, San Fernando Valley
- W. Davis, Syracuse
- C. Gilbertson, Northern Plains
- G. Kimbrell, St. Louis
- S. McDaniel, Inland Empire
- R. Madrigal, LA/Inland Empire
- D. Newman, Ozark
- S. Robeson, Cumberland Valley
- J. Smith, Greater Huntsville

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

- J. Barber, Connecticut
- G. Burrion, South Florida
- G. Callender, San Fernando Valley
- K. Carter, Tri-River
- R. Davis, Utah
- M. Haynes, Niagara Frontier
- K. Hurst, Kansas City
- D. Mandina, New Orleans
- V. Matthews, Cleveland
- J. Medina, International
- P. Newhouse, British Columbia
- T. Rowe, Tulsa

AWS Opens India Welding Show

A bird’s eye view of Vic Matthews (blue shirt), AWS president, cutting the ribbon opening the India Welding Show in December. The India Welding Society and AWS cosponsored the event.
AWS Members Convened at the Show to Celebrate Milestone Anniversaries

Life Members were celebrated for 35 years of service to the Society. Shown (from left) are William Rice Jr., Gene Lawson, Kenneth Coryell, Charles Daily, Jack Compton, Dale Harrington, Ronald Smith, and Chon-Liang Tsai with President Vic Matthews. Life Member awardees not shown are Kenneth Jobes, John McGrady, Gary Montgomery, James Osborne, Dana Shatts, Walter Sperko, and Robert Wiswesser.

Silver Members were celebrated for 25 years of service to the Society. Shown (from left) are Wladyslaw Jaxa-Rozen, Andrew Johnson, Eric Krauss, Martin Vondra, Steven Whitney, Jerry Warren, David Landon, Dennis Wright, Stephen Liu, Sean Moran, Thomas McCormack, Evelyn Schneider, Bruce Salonek, President Vic Matthews, and Kenneth Schwerin Jr. Silver Member awardees not shown include Sammy Campo, Albert Moore Jr., and David Nangle.

Shown above at the Section Appreciation Luncheon are the Sections recognized for their Named Scholarships. AWS Foundation Chair Jerry Utracht (far-right in all photos) is shown with District 9 Director George D. Fairbanks Jr. in the Baton Rouge and New Orleans Sections photos; Northwest Section shows Section Secretary Bob Renner (left) with District 15 Director Mace Harris; Ozark Section: Ed Norman (left) with District 17 Director J. Jones; and Puget Sound Section: District 19 Director Nell Shannon (left) with Jerry Hope.
Green & White Mountains Section members are shown at the Campbell Plaster & Iron shop in November.

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

**BOSTON, CENTRAL MASS., RHODE ISLAND**  
**December 7**  
Activity: Members of the three Sections toured V & S Galvanizing to learn its techniques for preparing surfaces and galvanizing. Eamonn McCarthy, plant manager, and Phil Scannell led the walking tour of the plant. Included were stops at the preheating, cleaning, and hot dip galvanizing stations, and a visit to the paint shop to see the application of nonslip coatings to galvanized metals. Kevin DeSousa was presented the District CWI of the Year Award by Russ Norris and Tom Ferri, District 1 director and District 1 director-elect, respectively.

**GREEN & WHITE MOUNTAINS**  
**November 12**  
Activity: The Section members met at Campbell Plaster & Iron in West Rutland, Vt., to study its procedures for casting various metals into detailed art forms. Glenn Campbell, who specializes in bronze castings, conducted the program, detailing the procedures from beginning to end.

Kevin DeSousa (center) receives his CWI of the Year Award from Russ Norris (left), District 1 director, and Tom Ferri, incoming District 1 director.

Plant tour hosts Eamonn McCarthy (left) and Phil Scannell (right) are shown with Tom Ferri, District 1 director-elect, in December.
Shown at the Long Island Section program are (from left) Barry McQuillen, Tom Garland, Rau O’Leary, Chair Brian Cassidy, Jim Danaher, Alex Duschere, and Harland Thompson.

George Benyak demonstrated torch brazing at the Philadelphia Section program (left photo) and is shown chatting with Chairman Gary Atherton at right.

Shown at the South Carolina Section program are (from left) Chairman Ben Magrone, Norm Frasher, and Hugh Dennison.

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

LONG ISLAND
November 12
Speaker: Joe Kane
Topic: Welder licensing requirements in New York City
Activity: The program was held at Nook Restaurant.

PHILADELPHIA
November 11
Speaker: George Benyak
Affiliation: The Harris Product Group
Topic: Brazing various materials
Activity: The Section members met at Local Union #19 training facility in Philadelphia, Pa. Benyak concluded his presentation with demonstrations of his brazing techniques.

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

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

SOUTHWEST VIRGINIA
November 19
Speaker: Bret McIntire, technician
Affiliation: T. J. Snow Co.
Topic: A history of resistance welding
Activity: The program was held in Salem, Va.

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

SOUTH CAROLINA
November 18
Activity: The Section members met at Parker Hannifin Corp. in Moncks Corner, S.C.
Andrew Mugnaini, welding engineer, discussed welding dissimilar metals. Gary O’Neill, NDT manager, made a presentation on filmless radiography techniques. David McIlwain and Leonard Chestnut, team leaders, conducted the plant tours. Section Chair Ben Magrone presented plaques of appreciation to Norm Frasher, plant manager, for hosting the meeting, and Hugh Dennison, manufacturing engineer, for his support of student membership.

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

NORTHERN NEW YORK
November 30
Activity: The Section members met at Dimension Fabricators, Inc., in Schenectady, N.Y., for a tour of the facility that fabricates massive rebar structures using robotically controlled gas metal arc welding. Scott Stevens, company president, made a presentation and conducted the tour.

SYRACUSE
November 11
Activity: The Section members participated in a vendors’ night program held at Haun Welding in Syracuse, N.Y. Several equipment makers displayed plasma cutting and various welding machines for the attendees to use. Davis Brothers Inspection supervised welding trials based on AWS D1.3, Structural Welding Code — Sheet Steel, with several members passing the test. The presenters included Tim Howell, Bill Davis, and Bob Davis.
**District 7**

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

**COLUMBUS**  
**November 19**  
**Speaker:** Joel Mayerson, director of musculoskeletal oncology  
**Affiliation:** Arthur James Cancer Hospital  
**Topic:** Using metal parts to replace diseased joints and bone tissues  
**Activity:** The Section joined members of the local chapters of SWE, ASME, ASM Int'l, IIE, AIIE, ISA, and NACE for this program, held at Arlington Banquets in Columbus, Ohio.

**DAYTON**  
**December 8**  
**Speaker:** Uwe Aschemier, welding engineer  
**Affiliation:** H. C. Nutting  
**Topic:** Making underwater pipeline repairs in the Caribbean Sea  
**Activity:** Don Howard, District 7 director, attended the program, held at Bullwinkle’s in Middletown, Ohio.

**PITTSBURGH**  
**November 13–18**  
**Activity:** Several Section members participated in the FABTECH International & AWS Welding Show in Chicago. Joining them were David McQuaid, a past Section chairman and currently an AWS director-at-large; Dan Ciarlariello, chairman of the AWS D10P Subcommittee on Local Heat Treating of Pipework; Life Member John Hill, a Houston Section member and D10P Subcommittee member; and Ed Yevick, chairman, D11 Committee on Welding Iron Castings, and president of Weld Met Int'l.

**District 8**

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

**GREATER HUNTSVILLE**  
**November 19**  
**Activity:** The Section met at Drash Technologies, Huntsville, Ala., for a tour of its facilities for manufacturing mobile generators for government applications. Keith Marsh, production supervisor, conducted the program.

**District 9**

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

**District 10**

Richard A. Harris, director  
(440) 339-5921  
richaharris@windstream.net

**MOBILE**  
**October 15**  
**Activity:** The Section members toured Faircloth Metallurgical Service in Mobile, Ala. Bill Faircloth conducted the program for 35 attendees.

**November 12**  
**Speaker:** Chris Burge, project manager  
**Affiliation:** AIDT Maritime Center  
**Topic:** Status of the AIDT Maritime Center  
**Activity:** The program was held at Saucy-Q Bar B Que in Mobile, Ala.

**CLEVELAND**  
**November 10**  
**Activity:** Forty Section members participated in a seminar course in cost estimating seminar presented by Harry Sadler, manager, military and shipbuilding sales, for The Lincoln Electric Co.
Members of the Capital Area Career Center welding technology class are shown during their excursion to the FABTECH Intl & AWS Welding Show, sponsored by the Central Michigan Section.

Ferris State University faculty and students pose with past AWS Treasurer Earl Lipphardt at the FABTECH Intl & AWS Welding Show.

Don DeCorte, an AWS director-at-large, said a few words at the Detroit Section holiday party in December.

John Pagel (left) is shown with Chuck Frederick, Lakeshore Section chair.

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

CENTRAL MICHIGAN
November 17
Activity: The Section’s executive board members sponsored a bus trip for 18 welding technology students from Capital Area Career Center, Mason, Mich., to visit the FABTECH Intl & AWS Welding Show in Chicago, Ill. Accompanying them were their instructors Jeff Grossman and Scott Poe.

DETROIT
December
Activity: The Section held its holiday party at the Ukrainian Cultural Center in Warren, Mich., featuring a surprise visit from Santa, himself.

Ferris State University
Student Chapter
November 16
Activity: University faculty members made presentations to the Education Scholarship Committee at the FABTECH Intl & AWS Welding Show in Chicago, Ill. Speakers included Student Chapter Advisor Jeff Carney, Bill England, Jeff Hardesty, Ken Kuk, David Murray, and Paul Kwant. About 90 students attended the event.

District 12
Sean P. Moran, director
(920) 954-3828
sean.moran@hobartbrothers.com

LAKE SHORE
October 15
Activity: The Section members toured Pagel’s Ponderosa Dairy in Kewaunee, Wis. The farm features 3900 cows, a rotary milking parlor, and a processor that produces the methane gas fueling a 1700-hp engine-generator. John Pagel, owner, conducted the tour for 37 attendees.

MILWAUKEE
November 17
Activity: The Section chartered two buses to take 104 members and guests to the FABTECH Intl & AWS Welding Show in Chicago. The travelers included attendees from three tech schools and representatives from 35 local businesses.

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

District 14
Tully C. Parker, director
(618) 667-7795
tparke@millerwelds.com
INDIANA
November 15–17
Activity: Section members helped to conduct the Professional Welding Competition at the FABTECH Int'l & AWS Welding Show in Chicago. Working the event were Chairman Tony Brosio, Treasurer Mike Anderson, Bennie Flynn, Vice Chair Gary Tucker, Gary Dugger, and Secretary Bob Richwine. Working with them were Nichole Bradley, AWS Educational Services, and Dean Droddy with the Louisville Section.

LEXINGTON
November 19
Speaker: Sean Norton
Affiliation: Victor Equipment Co.
Topic: Welding safety
Activity: The program was held at Bluegrass Community College in Lexington, Ky. Holston Gases donated a Lincoln welding machine for the raffle won by Andrew Standiford.

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

ARROWHEAD
November 24
Activity: The Section’s executive committee met at Mesabi Range Community College in Eveleth, Minn. Attending were Chair Loren Kantola; Al Kliwer, vice chair; Doug Mroz, secretary/treasurer; and Tom Baldwin, librarian, consultant, and technical representative.

December 4
Activity: The Section members toured TriTec of Minnesota, Inc., in Virginia, Minn., a full-service steel facility that custom fabricates machined products. Attending were welding students from Virginia High School. Shop foremen Joe Rutchasky and Rich Stevens conducted the tour. Fifty members and guests participated in the event. At a previous meeting, Chairman Loren Kantola presented Ervin Stoch the Section Meritorious Award.
Shown at the Northwest Section tour in December are (from left) Kirby Stellmach, John Barnett, Chair Todd Bridigum, and Jim Trudeau.

Northwest Section members are shown during their tour of Consolidated Precision Products in December.

Guide Tom Anderson (left) is shown with Jay Gerdin, Northwest Section vice chair, during the Olympic Steel tour.

Jason Miles (left), Kansas City Section chair, presents Dennis Wright his Silver Member Certificate.

**NORTHWEST**
**November 11**
Activity: The Section members toured Olympic Steel Co. in Plymouth, Minn., to see the production of plate and sheet steel products. The tour guides were Tom Anderson, Cory DeWitte, Brad Hagg, Chris Merriman, Joe Alrick, and Bill Friedrichs.

**December 9**
Activity: Thirty Northwest Section members toured Consolidated Precision Products Co. in Bloomington, Minn., a producer of large airframe and engine structural castings, and gearbox housings. The guides included John Barnett, Kirby Stellmach, and Jim Trudeau.

**District 16**
David Landon, director  
(612) 621-7476  
dlandon@vermeermfg.com

**KANSAS CITY**
**November 12**
Speaker: Steven Huffman, student  
Affiliation: UMKC School of Engineering  
Topic: The 2010 steel bridge competition  
Activity: The Kansas City Section members met at University of Missouri, Kansas City campus, to learn about previous team bridge competition projects and requirements for the upcoming bridge competition. Chairman Jason Miles presented Dennis Wright his Silver Member Certificate for 25 years of service to the Society.

**District 17**
J. Jones, director  
(913) 368-3130  
jones@thermadyne.com

**CENTRAL ARKANSAS**
**November 16**
Activity: Chair Dennis Pickering presented Grayling V. Hill and Michael Rose their Silver Certificates for 25 years of service to the Society. The presentations took place in Benton, Ark.

**December 8**
Activity: Adam Webb from Lincoln Electric demonstrated the VRTEC 360 virtual reality welder training system. The program was held at Pulaski Technical College in Little Rock, Ark. Mike Porter received the CWI of the Year Award.

**December 10**
Speaker: Monica Pfarr, corporate director  
Affiliation: AWS Solutions Opportunity Squad (SOS)  
Topic: AWS SOS activities  
Activity: The program was held during the Arkansas Welding Expo presented by WELSCO, Inc., Industrial Gases & Welding Supplies, at Verizon Arena in Little Rock, Ark.

**TULSA**
**November 17**
Activity: The Section members toured Sherry Laboratories to study its test equipment and procedures. Don Bunn, project engineer and failure analyst, conducted the program.

**District 18**
John Bray, director  
(281) 997-7273  
sales@affiliatedmachinery.com
Lee High School Student Chapter

November 5
Activity: The Student Chapter held its second meeting at the welding facility at the school. The Chapter officers elected are Diego Duran, Adriana Rojas, Alan Nava, and Johnny Cabrera with Advisor Albert Urbina. District 18 Director John Bray attended the program.

RIO GRANDE VALLEY

May 27
Activity: The Section members participated in the 1st Annual Gold Collar Career Day at South Texas College of Technology in McAllen, Tex. Sam Coulton, advisor to the Arizona Western College Student Chapter, made a presentation titled Welders without Borders.

September 9
Activity: The Rio Grande Valley Section held its awards-presentation program in Palm Aire Best Western in Weslaco, Tex. Barney Burks presented a check for $500 from the Houston Section to assist the new Section with its startup costs. District 18

Shown are the Lee High School Student Chapter members. Far left is John Bray, District 18 director, and far right is Advisor Albert Urbina.

Tour guide Don Bunn (right) chats with Tulsa Section Chair Jamie Pearson.

Shown at the Rio Grande Valley Section activity in May are (from left) Felipe Reyes, speaker Sam Coulton, and Ed Garcia.

Grayling V. Hill (right) receives his Silver Membership Certificate from Dennis Pickering, Central Arkansas Section chairman.

Mike Porter (right) receives the CWI of the Year Award from Dennis Pickering, Central Arkansas Section chair in December.

Adam Webb demonstrated virtual reality welder training at the Central Arkansas Section program in December.

Shown at the Arkansas Welding Expo are (from left) Kevin Sava, Chris Layton, Monica Pfarr, Central Arkansas Section Chair Dennis Pickering, Aaron Campbell, and Angela Harrison, WELSCO owner.
Barney Burks (left) presents a $500 check to Chair George Baldree at the Rio Grande Valley awards program in September.

Chair George Baldree (left) displays his awards presented by District 18 Director John Bray at the Rio Grande Valley program.

Shown at the British Columbia Section program are (from left) James Kutt, Sheldon Frank, and Ron Poole.

AWS President Vic Matthews addressed the joint Spokane and Inland Empire Sections in November.

Shown at the British Columbia Section program are Treasurer Brenda Moe (left) and Mirela Chrihana.

Jim O’Sullivan demonstrated nondestructive examination equipment for the Arizona Western Student Chapter November 6.

Director John Bray presented Chair George Baldree the Section Meritorious and District Director Awards. Richard Solinis received the Section Meritorious Award. Thomas Solano received the Section Private Sector Instructor Award. The Section Educator Award went to Edwin Rivera, and the CWI of the Year Award was presented to Jose Delgado.

District 19

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

ALASKA

November 20
Speaker: Tony Barnard
Topic: Welding health and safety
Activity: Cody Pruitt was awarded full AWS membership for his performance in the Skills-USA competition. The next Alaska-region six-day CWI seminar is scheduled for March. Check the Web site www.aws.org for details. The program was held at Peggy’s Restaurant in Anchorage.

BRITISH COLUMBIA

November 10
Speakers: James Kutt and Ron Poole
Affiliation: Silver City Galvanizing
Topic: Galvanizing history and applications
Activity: Following the dinner and meeting at Twin Bridges Restaurant in Delta, B.C., Canada, the 38 attendees visited Silver City Galvanizing for a tour of the facility.

SPOKANE, INLAND EMPIRE

November 10
Speaker: Victor Matthews, AWS president
Affiliation: The Lincoln Electric Co. (ret.)
Topic: Welding student education
Activity: The two Sections met in the welding shop at Big Bend Community College in Moses Lake, Wash. Following the president’s talk, the 90 attendees visited Norco, Inc., air-separation facility for a plant tour. Shawn Welch conducted the tour and detailed the process used to produce 150 tons of liquefied nitrogen, 150 tons of liquefied oxygen, and 7 tons of liquefied argon daily. District 19 Director Neil Shannon attended the event.

SPOKANE

December 16
Activity: The Section members met at Haskins Steel Co., Inc., in Spokane, Wash., for a tour of the facility. Craig Dias, vice president and general manager, conducted the tour of the three buildings for 38 attendees.
District 20
William A. Komlos, director
(801) 560-2353
bkoz@arctechllc.com

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

Arizona Western College IWT Student Chapter
November 3
Activity: The members of the Arizona Western College Institute of Welding Technology (AWCIWT) Student Chapter met for technical presentations in inverter welding technology with advisory committee members Alex Buatista of Lincoln Electric Co., Chuck Taber of Miller Electric Co., and Jeff Shively of Thermadyne. The focus was on the AWS SENSE program, and the acquisition of new submerged arc welding equipment and a robotic welding system for the institute.

November 6
Activity: The AWCIWT Student Chapter met at the Mandarin Palace in Yuma, Ariz., for a presentation by Larry Lebsack, tech prep director, Arizona Western College, who urged the students to participate in SkillsUSA and to stay in school. Jim O’Sullivan of Olympus NDT Co. displayed a collection of the latest nondestructive examination equipment, including a phased array system and videoscope inspection tools.

December 4
Speaker: Ron Pixley, welding instructor
Affiliation: Yuma Union High School District
Topic: Career opportunities with a college welding degree
Activity: At this AWCIWT Student Chapter program, David Sanchez, an AWS CWI and CWE and president of Arc Dynamics, Inc., donated a welding power source for the door prize that was won by Chris Larson.

WELDING JOURNAL 85
The AWCIWT Student Chapter members and guests are shown at the November 6 program.

Shown at the December AWCIWT Student Chapter program are (from left) Chris Larson, Isabella Larson, and David Sanchez.

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

SAN FRANCISCO
December 2
Activity: The Section held its holiday banquet at Spenger’s Restaurant in Berkeley, Calif. Sixty-six members and guests attended the program. The team of metalworkers and artists John C. Rogers, J. Todd Blair, and Alexandra Ismerio discussed their roles in the reconstruction of the 12th Street bridge at Lake Merritt, detailing the artistic enhancements they made.

Candidate Sought to Receive the Prof. Masubuchi Award

The deadline for submitting nominations for the 2011 Prof. Koichi Masubuchi Award is Nov. 2, 2010. The award, including a $5000 honorarium, is presented each year to one person who has made significant contributions to the advancement of materials joining through research and development. The candidate must be 40 years old or younger, may live anywhere in the world, and need not be an AWS member. The nomination package should include the candidate’s résumé listing background, experience, publications, honors, and awards, plus at least three letters of recommendation from fellow researchers.

The award, sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology, was established to honor Prof. Koichi Masubuchi for his numerous contributions to the advancement of the science and technology of welding in the fields of fabricating marine and outer space structures. E-mail your nominations to Prof. John DuPont at jnd1@lehigh.edu.

AWS Mission Statement

The mission of the American Welding Society is to advance the science, technology, and application of welding and allied processes, including joining, brazing, soldering, cutting, and thermal spraying.

AWS Publications Sales

Purchase AWS standards, books, and other publications from WEX (World Engineering Xchange, Ltd.); orders@awspubs.com; www.awspubs.com. Call toll-free (888) 935-3463 (U.S. and Canada); (305) 824-1177; FAX (305) 826-6195.

Copies of Welding Journal articles may be purchased from Ruben Lara, (800/305) 443-9353, ext. 288; rlara@aws.org.

Custom reprints of Welding Journal articles, in quantities of 100 or more, may be purchased from FosteReprints, Claudia Stachowiak, (866) 879-9144, ext. 121; claudia@fostereprints.com.
Welding Test Positions for Groove Welds in Pipe

Welder, welding operator, and tack welder qualification tests determine the ability of the persons tested to produce acceptably sound welds with the process, materials, and procedure called for in the tests.

Following are descriptions of the various test positions for groove welds in pipe.

1G. A welding test position designation for a circumferential groove weld applied to a joint in pipe, in which the weld is made in the flat welding position by rotating the pipe about its axis — Fig. 1A.

2G. A welding test position designation for a circumferential groove weld applied to a joint in pipe, with its axis approximately vertical, in which the weld is made in the horizontal welding position — Fig. 1B.

5G. A welding test position designation for a circumferential groove weld applied to a joint in a pipe, with its axis approximately horizontal, in which the weld is made in the flat, vertical, and overhead welding positions. The pipe remains fixed until the welding of the joint is complete — Fig. 1C.

6G. A welding test position designation for a circumferential groove weld applied to a joint in pipe, with its axis approximately 45 deg from horizontal, in which the weld is made in the flat, vertical, and overhead welding positions. The pipe remains fixed until welding is complete — Fig. 1D.

6GR. A welding test position designation for a circumferential groove weld applied to a joint in pipe, with its axis approximately 45 deg from horizontal, in which the weld is made in the flat, vertical, and overhead welding positions. A restriction ring is added, adjacent to the joint, to restrict access to the weld. The pipe remains fixed until welding is complete — Fig. 1E.

Fig. 1 — Welding test positions and their designations for groove welds in pipe.

What defines excellence in welding sales?

The American Welding Society announces the certification program for welding sales representatives.

If you are among the best and most successful sales professionals in the welding industry, it’s because you provide value-added expertise to your customers.

The AWS Certified Welding Sales Representative program tells the industry that you have what it takes to add value to every sale.

If you meet the program’s requirements, you can take a two-hour exam to establish your credentials.

AWS offers three-day preparation seminars that can be taken at certain AWS-scheduled sites or at your workplace for groups of sales personnel.

The examination will establish your level of knowledge concerning five arc welding processes, brazing and soldering, cutting, safety in processes 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.

For more information and application forms, visit www.aws.org/CWSR or call 1-800-443-9353 ext. 273.

• Give your company and yourself a competitive advantage.

• Receive hundreds of dollars’ worth of reference books that will be a lifelong asset.

• Learn or refresh yourself on key skills that can help you assist your customers.

• Taking the seminar qualifies you to test with just two years of documented industry experience.

• Gain the respect you deserve for the professionalism you provide.

• Group seminars and examinations can be offered at your business location.

Here’s what a recent candidate said about the program:

“This is not just a cert for your territory. It’s for the whole welding industry, no matter where you are. I use the books all the time. The week after the seminar, a customer brought in some drawings with symbols their shop foreman didn’t understand. It was cool that I could do some digging and help him out. The more I know, the more valuable I am to WESCO.

“The course was a real eye-opener! I wish I’d had a chance to do this years ago. The certification gives me an edge over my competitors.”

Timothy Howard, WESCO Gas and Welding Supply

You are among the elite in welding sales. Now you can prove it, as an AWS Certified Welding Sales Representative.

American Welding Society

Certified Welding Sales Representative

John Doe

Has complied with the requirements of Section 7.1 of the AWS Specification for the Certification of Welding Sales Representatives, QC14-2009

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Certificate Number
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www.aws.org/CWSR
PROFESSIONAL PROGRAM ABSTRACT SUBMITTAL
Annual FABTECH International & AWS Welding Show
Atlanta, GA - November 2 – 4, 2010
Submission Deadline: March 31, 2010
(Complete a separate submittal for each paper to be presented.)

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Affiliation:
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Co-Author(s):
Name (Full Name):
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Answer the following about this paper
Original submittal? Yes ☐ No ☐
Progress report? Yes ☐ No ☐
Review paper? Yes ☐ No ☐
Tutorial? Yes ☐ No ☐

What are the welding/Joining processes used?
What are the materials used?
What is the main emphasis of this paper? Process Oriented ☐ Materials Oriented ☐ Modeling ☐
To what industry segments is this paper most applicable?
Has material in this paper ever been published or presented previously? Yes ☐ No ☐
If “Yes”, when and where?
Is this a graduate study related research? Yes ☐ No ☐
If accepted, will the author(s) present this paper in person? Yes ☐ Maybe ☐ No ☐

Keywords: Please indicate the top four keywords associated with your research below

Guidelines for abstract submittal and selection criteria:
- Only those abstracts submitted on this form will be considered. Follow the guidelines and word limits indicated.
- Complete this form using MSWord. Submit electronically via email to techpapers@aws.org

**Technical/Research Oriented**
- New science or research.
- Selection based on technical merit.
- Emphasis is on previously unpublished work in science or engineering relevant to welding, joining and allied processes.
- Preference will be given to submittals with clearly communicated benefit to the welding industry.

**Applied Technology**
- New or unique applications.
- Selection based on technical merit.
- Emphasis is on previously unpublished work that applies known principles of joining science or engineering in unique ways.
- Preference will be given to submittals with clearly communicated benefit to the welding industry.

**Education**
- Innovation in welding education at all levels.
- Emphasis is on education/training methods and their successes.
- Papers should address overall relevance to the welding industry.

☐ Check the category that best applies:
- Technical/Research Oriented
- Applied Technology
- Education
Abstract:
Introduction (100 words max.) – Describe the subject of the presentation, problem/issue being addressed and its practical implications for the welding industry. Describe the basic value to the welding community with reference to specific communities or industry sectors.

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

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

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

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

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

Return this form, completed on both sides, to

AWS Education Services
Professional Program 2010
550 NW LeJeune Road
Miami FL 33126
FAX 305-648-1655

MUST BE RECEIVED NO LATER THAN MARCH 31, 2010
Guide for Welding and Weld Inspection Released

A Quick Guide to Welding and Weld Inspection is described as an accessible guide to the knowledge required to fulfill the role of a welding inspector. In covering both European- and U.S.-based codes, the book offers a basic all-around understanding of the subject. The key topics include terminology and symbols, duties of welding inspectors, analysis of fusion weld joint preparation, materials and weldability, classification of alloy steels, welding processes, nondestructive testing and inspection methods, welding defects and fracture modes, codes and welding standards, procedure qualification documentation, and health and safety. The hardcover text is priced at $58 plus shipping and handling. Search “Quick Guide Welding” on the Web site for more information or to order.

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

Full-Line Catalog Lists New Products for 2010

The company’s 100-page, full-color, 2010 full-line catalog features photographs, specifications, and comparison charts to assist in product selection. Featured are nine new products, and new resources available on the Web site are showcased. Shown are gas metal arc and tungsten arc welding machines, plasma arc cutting machines, welding helmets, and safety gear. Three new product categories include respirators, fume extractors, and welding workstations. Additional product information is provided for other brands, including Bernard, Hobart Brothers, Smith Equipment, Tregaskiss, and Weldcraft. The catalog may be ordered by phone or downloaded from the Web site.

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

Welding Products Catalog Updated

The 136-page, full-color 2010 Product Catalog illustrates and describes the company’s extensive line of products. It is available in hard copy and online in a fast-flip eBook version. Included are 108 new products.
products and accessories introduced during the past year. The profusely illustrated catalog pictures a wide selection of power sources, welding consumables, accessories, automated solutions, and environmental systems. Some of the new products include a line of Viking™ welding helmets, Bulldog® commercial engine-driven welding machines, and Magnum® PRO, Cougar™, and Panther™ welding guns, and new items in the UltraCore® consumables line, and additional automated welding cell products. To order, request Bulletin No. E1.10.

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

Brazing Web Site Enhanced

The Global Brazing Solutions Web site has been launched with the goal of providing customers access to information that will help them better understand brazing technology and ultimately make informed purchase decisions. Added is a new Knowledge Base section that provides insight on the fundamentals of brazing, proper brazing procedures, and joint design. Case studies are provided to illust-
The 16-page, full-color M-BRAD™ Abrasive Filament Power Brushes catalog presents a comprehensive description of the company’s Advance Brush product line that offers longer brush life, better conformance to irregular surfaces, useful for deburring and surface conditioning, with a more consistent finish. One page offers a useful selection and troubleshooting guide for determining the best brush for each job based on the parameters of desired finish, brush diameter, rev/min, trim length, filament size, grit size, and density. Detailed illustrations and dimensions are provided for composite wheel and disc brushes, cup and end brushes, and tube and tube end brushes. The brochure can be downloaded as a PDF from the Web site or ordered by phone.

Pferd, Inc.  
www.pferdusa.com  
(978) 840-6420

Weider Safety Products Catalog Updated

The eight-page Welding and Safety Products Auto-Darkening Program catalog — continued on page 103

For info go to www.aws.org/ad-index
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For The World Class Members of AWS

There is a crisis in health care and AWS has done something about it. We are proud to introduce an outstanding package of benefits for our members, a single source with more than fifty insurance companies, offering value-priced health, dental, vision, disability, accident, cancer and life insurance. Simply visit www.worldclassbenefits.com/aws or call 800-955-0418 to learn more.

Managed By:

www.worldclassbenefits.com/aws
Wall Colmonoy Hires Corporate Controller

Wall Colmonoy, Madison Heights, Mich., has appointed Randy Buoy corporate controller. Buoy most recently worked 23 years with an automotive supplier serving as vice president and chief financial officer. The company operates two FAA repair station facilities and is a supplier of nickel-coated and iron-based brazing and coating alloys.

Orbitform Appoints Applications Engineer

Orbitform Group, Jackson, Mich., an assembly automation manufacturer specializing in forming, fastening, and joining, has appointed Greg Stoia an applications engineer. Stoia has 23 years of experience in the fastening, forming, machine design, and sales business.

OK Int’l Names Southwest Sales Manager

OK International, Garden Grove, Calif., a provider of production soldering and assembly equipment and fume-extraction equipment, has appointed Delia Orvañanos territory sales manager for the southwestern United States, including southern California and Arizona and the Mexican border markets in those states. Orvañanos has more than 20 years of sales experience in the southern California electronics assembly marketplace.

Fronius USA Fills Two Manager Posts

Fronius USA, Brighton, Mich., has named Michael J. Ludwig market segment manager for shipbuilding, platform, and power generation for its welding division; and Howard Lunt its northeast area sales manager for the welding division. Ludwig, with 27 years of experience in welding engineering, most recently served as corporate welding engineer for Cianbro Companies working with refinery modules. Lunt most recently worked for ITW, Hobart Brothers filler metals division, as district manager for accounts in the New England and New York area.

Obituaries

Richard Keen

Richard Keen, 67, died Dec. 4 in Newark, Del., following a long illness. A graduate of DuPont High School, Wilmington, Del., he was employed with Keen Compressed Gas Co. for 49 years. He is survived by a daughter, a son, five sisters, four grandchildren, and 18 nieces and nephews.

Carl E. Walter

Carl E. Walter, 65, died Nov. 16 in Georgetown, Tex. An AWS member from 1982 to 1999, he was affiliated with the Cleveland Section. Walter held many positions in the welding industry starting as a welder at the Puget Sound Naval Shipyard before serving in the U.S. Air Force. He graduated from The Ohio State University with a degree in welding engineering in 1975. His professional career began on the Prudhoe Bay Project, then he moved to research work at Lawrence Livermore Laboratory. Later he worked in the nuclear industry and supported Brown and Root’s automatic welding program for two Texas nuclear power plants. He served in engineering management positions, including positions at Triten Corp., and Firstech, as well as nondestructive evaluation management work for Law Engineering in Saudi Arabia. He also had considerable executive management experience as the European Operations manager of Teledyne McKay in Wiesbaden, Germany, and later as vice president and general manager of Cronatron Welding Systems in Charlotte, N.C.

In 2000, Walter initiated a new career in the offshore deep water industry as a senior welding engineer at Acute Technological Services in Houston, Tex., where he worked on many critical multibillion dollar projects such as BP’s Thunder Horse and Atlantis up to the last few days of his life. Walter is survived by his wife, Linda, a daughter, and three stepchildren, seven grandchildren, and one great-grandchild. His hobbies included world travel, and he had a passion for golf.

Giovanni Paolo Peloso

Giovanni Paolo Peloso, 76, died Nov. 4 in Genoa, Italy. He received two degrees in electrotechnical engineering from Genoa University and a degree in chemical engineering. His specialty was welding technology and metallurgy. He served both in industry as well as at the university with research projects, study, and design of welded constructions, particularly in the field of steam boilers and turbine fabrication and nuclear reactors welding tubes to tube-plates.

Dr. Peloso, an AWS member since 1971, authored several books and more than 120 scientific and technical publications. In 1969, he was elected a Fellow of The Welding Institute, UK, and in 1993 he became a member of its Welding and Joining Society. AWS awarded him his Life Member Certificate for 35 years of service to the Society in 2006. In 1991, he was named secretary of the Engineers Geinoese Order, and admitted to the Ligurian Academy of Sciences and Letters in 1978 where he served as treasurer, and later as general secretary.

Change of Address?

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Get ready to emerge from the recession at the forefront of the welding industry.

WIGMCO      RWMA
Welding Equipment Manufacturers Committee
2010 co-located Annual Meeting
Palm Beach Gardens, Florida
March 11-13, 2010

Join the Welding Equipment Manufactures Committee (WEMCO), and the Resistance Welding Manufacturing Alliance (RWMA) at their first-ever co-located annual meeting at the award-winning PGA National Resort and Spa in Palm Beach Gardens, Florida.

The 3-day event will cover today’s pressing issues with highly respected speakers featuring:

Emily Stover DeRocco, President, Manufacturing Institute, speaking about the challenges manufacturers are facing today during the economic recovery and how to succeed in a post-recession business environment.

Dr. David E. Cole, Chairman of the Center for Automotive Research, sharing his knowledge on the challenges facing the global automotive industry today, as well as its future direction through his presentation: “Today’s Turbulence: A Foundation for Future Success.”

Martin Quinn, President of Thermadyne Holdings Corporation, speaking about how Thermadyne Holdings has taken significant strides toward key goals during the sharp economic downturn that has depressed sales throughout the industry and also the company’s key goals including: supporting the brand strategy, improving customer service and introducing innovative new products.

Alan Beaulieu, President and Economist for the Institute for Trend Research, presenting his highly acclaimed economic forecast. Topics include: short-term and long-term forecasts, leading economic indicators we should be watching and what impact the current or future Administration has on the economy.

Register by February 12, 2010, to be entered in a raffle for a special prize!
A limited number of rooms are now available for a discounted room rate of $189.00 per night for meeting attendees.

Cost to attend:
RWMA/WEMCO members $585 / non-Members $785
Spouse $225/ Child $75

For more information or to register contact:
Susan Hopkins at susan@aws.org or 800-443-9353, ext. 295
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**Poster Requirements and Selection Criteria:**
- Only those abstracts submitted on this form will be considered. Follow the guidelines and word limits indicated.
- Complete this form using MSWord. Submit electronically via email to techpapers@aws.org or print and mail.
- Any technical topic relevant to the welding industry is acceptable (e.g. welding processes & controls, welding procedures, welding design, structural integrity related to welding, weld inspection, welding metallurgy, etc.).
- Submittals that are incomplete and that do not satisfy these basic guidelines will not be considered for competition.

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

Criteria by category as follows:

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

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

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

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

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

- (A) Student 2-yr. or Certificate Program
- (B) Student 4-yr. Undergraduate
- (C) Graduate Student
- (D) Professional
- (E) High School Certificate Program

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

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

**Abstract:**

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

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

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

Return this form, completed on both sides, via email to techpapers@aws.org

*MUST BE RECEIVED NO LATER THAN April 16, 2010*
Friends and Colleagues:

The American Welding Society established the honor of Counselor to recognize individual members for a career of distinguished organizational leadership that has enhanced the image and impact of the welding industry. Election as a Counselor shall be based on an individual’s career of outstanding accomplishment.

To be eligible for appointment, an individual shall have demonstrated his or her leadership in the welding industry by one or more of the following:

- Leadership of or within an organization that has made a substantial contribution to the welding industry. The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employees in industry activities.

- Leadership of or within an organization that has made a substantial contribution to training and vocational education in the welding industry. The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employee in industry activities.

For specifics on the nomination requirements, please contact Wendy Sue Reeve at AWS headquarters in Miami, or simply follow the instructions on the Counselor nomination form in this issue of the Welding Journal. The deadline for submission is July 1, 2010. The committee looks forward to receiving these nominations for 2011 consideration.

Sincerely,

Alfred F. Fleury
Chair, Counselor Selection Committee
Nomination of AWS Counselor

I. HISTORY AND BACKGROUND

In 1999, the American Welding Society established the honor of Counselor to recognize individual members for a career of distinguished organizational leadership that has enhanced the image and impact of the welding industry. Election as a Counselor shall be based on an individual’s career of outstanding accomplishment.

To be eligible for appointment, an individual shall have demonstrated his or her leadership in the welding industry by one or more of the following:

- Leadership of or within an organization that has made a substantial contribution to the welding industry. (The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employees in industry activities such as AWS, IIW, WRC, SkillsUSA, NEMA, NSRP SP7 or other similar groups.)
- Leadership of or within an organization that has made substantial contribution to training and vocational education in the welding industry. (The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employees in industry activities such as AWS, IIW, WRC, SkillsUSA, NEMA, NSRP SP7 or other similar groups.)

II. RULES

A. Candidates for Counselor shall have at least 10 years of membership in AWS.
B. Each candidate for Counselor shall be nominated by at least five members of the Society.
C. Nominations shall be submitted on the official form available from AWS headquarters.
D. Nominations must be submitted to AWS headquarters no later than July 1 of the year prior to that in which the award is to be presented.
E. Nominations shall remain valid for three years.
F. All information on nominees will be held in strict confidence.
G. Candidates who have been elected as Fellows of AWS shall not be eligible for election as Counselors. Candidates may not be nominated for both of these awards at the same time.

III. NUMBER OF COUNSELORS TO BE SELECTED

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**MOST IMPORTANT**

The Counselor Selection Committee criteria are strongly based on and extracted from the categories identified below. All information and support material provided by the candidate's Counselor Proposer, Nominating Members and peers are considered.

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PROPOSER ____________________________
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The proposer will serve as the contact if the Selection Committee requires further information. The proposer is encouraged to include a detailed biography of the candidate and letters of recommendation from individuals describing the specific accomplishments of the candidate. Signatures on this nominating form, or supporting letters from each nominator, are required from four AWS members in addition to the proposer. Signatures may be acquired by photocopying the original and transmitting to each nominating member. Once the signatures are secured, the total package should be submitted.

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Characterization of Welding Fume Generated by High-Mn Consumables

Fume particle size and mass distribution, phase identification, and composition for high-Mn welding consumables are reported


ABSTRACT

The welding fume generated by two high-Mn hardfacing welding electrodes was evaluated using a range of fume collection and characterization techniques. This study included a shielded metal arc welding (SMAW) electrode and a flux-cored arc welding (FCAW) electrode both manufactured by Lincoln Electric Co. Data collected previously using an E6010 SMAW electrode were used for comparison. The fume generation rates under nominal welding conditions were relatively high, averaging 0.84 and 3.1 g/min for the SMAW and FCAW electrodes, respectively. Fume particle size and mass distribution were determined using an electrical low-pressure impactor (ELPI). Fume particles contained high levels of Fe and Mn and suggested that Mn substitution for Fe in the FeO lattice, resulting in Mn:FeO (Mn doped magnetite) having the same crystal structure as magnetite.

Analysis of individual fume particles and agglomerates using X-ray energy-dispersive spectroscopy (XEDS) in conjunction with transmission electron microscopy (TEM) revealed that the SMAW fume contained Fe, Mn, Mg, Si, Na, F, and O. The only phase that was unequivocally identified by selected area diffraction (SAD) in the TEM was Mn:FeO. Agglomerates consisting of many small particles (10 to 30 nm) analyzed by SAD were shown to have an Fe-rich Mn:FeO crystalline structure. TEM analysis of the FCAW fume revealed two basic types of fume particles. Most of the particles were roughly spherical with diameters ranging from 100 to 200 nm, while some were in the form of agglomerates of very small particles (FeO) with diameters from 10 to 50 nm. SAD was used to identify individual square particles (~150 nm) as Mn:FeO. X-ray photoelectron spectroscopy (XPS) was used to analyze the fume particle surface chemistry and generate compositional depth profiles by a sputter etching technique. These results showed an increase in Fe and Mn concentration upon etching, suggesting that a thin shell of different composition than the bulk particle is present on the particle surface.

KEYWORDS

Hardfacing Consumable
High-Mn Electrodes
Welding Fume
Fume Generation
FCAW
SMAW

Introduction

Recently, the American Conference of Governmental Industrial Hygienists (ACGIH) reduced the threshold limit value (TLV) for Mn particulate matter from 1 to 0.2 mg/m³. The TLV reduction arose out of concern that increased Mn exposure may play a role in certain neurodegenerative diseases. Much debate surrounds the effect of Mn (or Mn compounds) in welding fume on the human body. The following statement has been issued by the International Institute of Welding (IIW) on Mn in welding fume: “There is no convincing evidence that exposure to manganese-containing fume during employment as a welder can result in an increased risk of developing neurobehavioral deficiencies and loss of motor skills. There is, however, insufficient evidence to the contrary to dismiss the possibility with absolute certainty.” (Ref. 1). The goal of this investigation is to provide basic information on the nature of fume in two high-Mn, hardfacing consumables. While previous researchers have used a few selected techniques to study manganese in welding fume, this investigation has relied on a combination of fume collection and analytical techniques to provide a better “global” picture of the nature of welding fume. The details of these techniques and how they are applied to the study of welding fume were published previously by Sowards et al. (Refs. 2, 3).

A previous study has shown that high-Mn consumables may produce fume that contains between 1 and 15 percentage by weight (wt-%) of the total welding fume, compared to 6 wt-% Mn in mild steel consumables (Ref. 4). It has been shown that manganese in respirable fume particles is in the form of complex oxides (spinel), sometimes with a core-shell morphology where the particle core is surrounded by a silicon oxide shell (Ref. 5). The core is typically an Fe-rich oxide (FeO) containing Mn, K, Cr, and O in...
different ratios. The shell consists of silicon oxide and other compounds (fluorides) that result from additions to the SMAW electrode coating. In mild steel weld fume the predominant compound is magnetite — Fe₃O₄ (Ref. 6). Transition metals may substitute for iron in the magnetite lattice, but do not form in the pure oxide state (such as MnO₂) (Refs. 3, 7). In SMAW electrodes, Mn is the most common substitution due to its high concentration in the electrode coating. Minni et al. (Ref. 8) used XRD and XPS to determine that the oxidation state of Mn is primarily Mn²⁺ and Mn³⁺ for GMAW and SMAW, respectively. In the same study, XRD analysis of the SMAW fume showed that Mn was present in the fume as MnFe₂O₄ and KMnO₂.

Experimental Procedures

A “global” procedure for the evaluation of welding fume has previously been developed by Sowards et al. for the analysis of a wide range of welding consumables. The procedures used here are similar to those described in detail in a previous paper (Ref. 2).

Consumables

Two high-Mn hardfacing electrodes manufactured by The Lincoln Electric Co. were evaluated in this study. The consumables selected for this study were produced under the trademarks Wearshield Mangjet® (SMAW) and Lincore M® (FCAW). These electrodes are used to deposit weld metal that is highly resistant to wear and abrasion. The deposited weld metals are austenitic and can be work hardened by transformation to martensite to hardness levels in the range HRC 30–48. The nominal and actual deposit compositions of these consumables are listed in Table 1 along with the composition of the mild steel electrode E6010 that was used for comparison in this study.

Welding Procedures and Fume Collection

Nominal welding parameters were selected based on the manufacturer’s rec-

Table 1 — Nominal and Actual Weld Metal Deposit Compositions

<table>
<thead>
<tr>
<th>Elements (wt-%)</th>
<th>High-Mn SMAW(1)</th>
<th>High-Mn FCAW(2)</th>
<th>E6010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal</td>
<td>Actual</td>
<td>Nominal</td>
</tr>
<tr>
<td>Fe</td>
<td>Bal</td>
<td>Bal</td>
<td>Bal</td>
</tr>
<tr>
<td>Mn</td>
<td>14.5</td>
<td>10.2</td>
<td>13.0</td>
</tr>
<tr>
<td>Ni</td>
<td>0.077</td>
<td>0.5</td>
<td>0.56</td>
</tr>
<tr>
<td>Ti</td>
<td>0.013</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Mo</td>
<td>1.15</td>
<td>1.1</td>
<td>—</td>
</tr>
<tr>
<td>Si</td>
<td>0.18</td>
<td>0.18</td>
<td>4.9</td>
</tr>
<tr>
<td>Cr</td>
<td>0.084</td>
<td>0.084</td>
<td>0.6</td>
</tr>
<tr>
<td>C</td>
<td>0.012</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>P</td>
<td>0.01</td>
<td>0.015</td>
<td>0.017</td>
</tr>
<tr>
<td>S</td>
<td>0.18</td>
<td>0.15</td>
<td>0.026</td>
</tr>
<tr>
<td>Cu</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>W</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Al</td>
<td>—</td>
<td>—</td>
<td>0.032</td>
</tr>
</tbody>
</table>

(1) Lincoln Electric Wearshield Mangjet®, (2) Lincoln Electric Lincore M®
ommendation and represented the median parameters for the range provided. The actual welding parameters used in this investigation are provided in Table 2. All welds were deposited on plain carbon A36 steel plate. Fume was collected using both a modified AWS F1.2:1999 type fume hood and an electrical low-pressure impactor (ELPI). The ELPI sorts fume particles into 13 size ranges from 0.03 to >10 μm. Number and mass distribution analysis of the fume was conducted using the ELPI, while fume generation rates were determined using the AWS procedure. Fume collection procedure details are provided in Table 3. A minimum of three runs were conducted for each consumable in order to develop statistically valid data for fume generation rates, and particle number and size distributions.

### Table 2 — Welding Parameters

<table>
<thead>
<tr>
<th>Welding Parameters</th>
<th>High-Mn FCAW</th>
<th>High-Mn SMAW</th>
<th>E6010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average current, A</td>
<td>269</td>
<td>157</td>
<td>115</td>
</tr>
<tr>
<td>Average voltage, V</td>
<td>26.2</td>
<td>18.8</td>
<td>30.8</td>
</tr>
<tr>
<td>Wire feed speed, in./min (mm/s)</td>
<td>170 (72)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Travel speed, in./min (mm/s)</td>
<td>10.6 (4.5)</td>
<td>10.25 (4.3)</td>
<td>11.1 (4.7)</td>
</tr>
<tr>
<td>Calculated heat input, kJ/in. (kJ/mm)</td>
<td>40 (1.6)</td>
<td>17.2 (0.68)</td>
<td>19.1 (0.75)</td>
</tr>
<tr>
<td>Electrode diameter, in. (mm)</td>
<td>5/64 (2)</td>
<td>5/32 (4)</td>
<td>1/8 (3.2)</td>
</tr>
<tr>
<td>Contact tip-to-work distance, in. (mm)</td>
<td>1.25 (32)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

### Fume Generation Rate

The fume hood was used to collect bulk fume used in the determination of fume generation rate in Table 2. All welds were deposited on plain carbon A36 steel plate. Fume was collected using both a modified AWS F1.2:1999 type fume hood and an electrical low-pressure impactor (ELPI). The ELPI sorts fume particles into 13 size ranges from 0.03 to >10 μm. Number and mass distribution analysis of the fume was conducted using the ELPI, while fume generation rates were determined using the AWS procedure. Fume collection procedure details are provided in Table 3. A minimum of three runs were conducted for each consumable in order to develop statistically valid data for fume generation rates, and particle number and size distributions.

### Table 3 — Details of Welding Fume Collection

<table>
<thead>
<tr>
<th>Analysis Technique</th>
<th>SMAW Collection Time, s</th>
<th>FCAW Collection Time, s</th>
<th>Collection Medium</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Distribution</td>
<td>20</td>
<td>15</td>
<td>ELPI, greased Al substrates</td>
<td>Inlet pressure of 100 mbar. Charger activated. Current range of 400,000 fA. Charger had to operate in the 5 kV range. The charger current was typically in the 1 μA range. Gravimetric balance used to measure fume before and after number distribution.</td>
</tr>
<tr>
<td>Mass Distribution</td>
<td>20</td>
<td>15</td>
<td>ELPI, greased Al substrates</td>
<td>12 collection stages used for fume collection on aluminum substrates. SEM, XPS sample collection was done without charger. Inlet pressure of 100 mbar was used during fume collection.</td>
</tr>
<tr>
<td>SEM/XEDS</td>
<td>20</td>
<td>20</td>
<td>ELPI, Al substrate Stage 2, 4, 8, 10</td>
<td>AWS F1.2:1999 type. 40 ft³ initial flow rate. Manometer used to detect pressure drop across filter. 0.3 μm glass fiber filter used for sample collection. Welding stopped when the pressure dropped to 10 ft³/min. The remaining fume would be extracted for 30 s.</td>
</tr>
<tr>
<td>XPS</td>
<td>20</td>
<td>20</td>
<td>ELPI, Al substrate Stage 3</td>
<td></td>
</tr>
<tr>
<td>FGR</td>
<td>45</td>
<td>10</td>
<td>0.3 μm glass filter in fume hood</td>
<td></td>
</tr>
<tr>
<td>XRD</td>
<td>50</td>
<td>20</td>
<td>0.3 μm glass filter in fume hood</td>
<td></td>
</tr>
<tr>
<td>TEM (XEDS/SAD)</td>
<td>5</td>
<td>5</td>
<td>C-coated, Cu grid above arc</td>
<td>TEM grids were held at 3 and 6 in. above the arc. Collection times were approximately 5 s.</td>
</tr>
</tbody>
</table>
generation rate and for X-ray diffraction studies. The construction of the fume hood and fume generation tests were variants of the AWS F1.2:1999 specification. Instead of using a 4 \( \mu \)m cellulose fiber filter, glass fiber filters with an average pore size of 0.3 \( \mu \)m were used as a collection substrate in the fume hood. The smaller pore size was used to prevent any fume particle losses through the filter. (The backside of the filter was clean following testing.) Due to the smaller pore size, a 40 ft\(^3\)/min flow rate was required to get adequate flow through the filter. An automated rotary table was used to traverse the A36 steel plate under the electrode. A high-volume air sampling system (Model TFIA-F) was connected to the top port of the fume hood with a vinyl hose. The fume hood was equipped with a digital manometer so the pressure drop across the filter could be monitored. Fume was collected on the filter until the flow rate decreased to approximately 10 ft\(^3\)/min, after which the air pump would remain on for another 30 s. The filters for FGR and XRD analyses were stored in antistatic storage bags to avoid loss of fume from the substrate. Fume generation rate was determined by weighing the final weight of the filter and dividing by the test time.

**Particle Number and Size Distributions**

A Dekati electrical low-pressure impactor (ELPI) was used to sample the welding fume. Similar to the FGR collection, a plate was traversed under the welding gun. Aluminum substrates were placed onto the individual impactor stages for fume collection. A 6-in.-diameter glass funnel was positioned 6 in. above the arc and attached to a 30-in. length of Tygon\(^\text{\textregistered}\) tubing, with the other end of the tube connected to the inlet of the impactor column. The Tygon tubing had an outer diameter of ½ in., an inner diameter of ¼ in. Once the charger and impactor column were assembled within the ELPI, a pressure of 100 mbar was applied using a Sogevac SV-25 vacuum pump with the flush pump on the ELPI activated. The flush pump was deactivated allowing the particles to be drawn toward the funnel, through the Tygon tubing, and into the unipolar charger. The charged particles then pass into a low-pressure impactor having electrically isolated collection stages. The particles collected on a specific impaction stage produce an electrical current that was recorded, in real time, by the appropriate electrometer channel. The ELPI classifies particles on 13 separate stages according to their aerodynamic diameter in the range of 0.03 to 10 \( \mu \)m. Number distribution of the fume was determined using the ELPIV1 software. Dekati collection substrate grease was applied to the surface of the substrates prior to being placed on the collection stages. This grease helps the particles to “stick” to the substrate during the collections process. Greased aluminum substrates were placed on the collection stages inside the ELPI. The current range used was 400,000 fA. Also, the charger was operated in the 5-kV range as this was the manufacturer’s recommended charger voltage. The charger current was typically in the 1-\( \mu \)A range. Once the flush, pump, and charger were on, an “All-zero” calibration was performed to effectively zero the electrometers. This was done for each test run. Once the “All-zero” calibration had been completed, the flush would be turned off and the welding would be initiated using a remote control. Mass distributions were determined by weighing the aluminum collection substrates before and after testing using a gravimetric balance with precision of ±0.0001 g.

**Characterization Techniques**

Characterization techniques used in this study included X-ray diffraction (XRD), scanning electron microscopy (SEM), X-ray energy-dispersive spectroscopy (XEDS), X-ray photoelectron spectroscopy (XPS), transmission electron microscopy (TEM), and selected area diffraction (SAD). Details of these characterization techniques are listed in Table 4.

**Table 4 — Fume Characterization Details**

<table>
<thead>
<tr>
<th>Technique</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>XRD</td>
<td>Cu X-ray source running at 45 kV and 20 mA. Scan from 15–70 deg 2θ angle. Rate of 0.2–0.5 deg/min.</td>
</tr>
<tr>
<td>SEM</td>
<td>15 kV, working distance of 5 mm. Collection time of 100 s for XEDS. Dead time in the range of 20–40%.</td>
</tr>
<tr>
<td>XPS</td>
<td>Pre-etch condition used to determine elements at surface of particles. Ar(^+) ion etching reveals elements present at 5 nm depth in the particles.</td>
</tr>
<tr>
<td>TEM</td>
<td>300 kV. Collection time of 400 s for XEDS. SAD patterns.</td>
</tr>
</tbody>
</table>

Fig. 3 — X-ray diffraction spectrum of high-Mn FCAW fume.
Sample distance of 5 mm. Secondary electron images were collected of particles and agglomerates to determine the morphology of the fume. For the XEDS analysis, a spectrum collection time of 100 s was used. Dead time between 20 and 40% was utilized for composition analysis. Approximately 50 particles and agglomerates from each consumable were analyzed using XEDS. In addition, bulk fume pile composition was measured.

The XPS system used was a Kratos Ultra Axis XPS and UPS system with depth profiling capabilities using Ar+ ion etching. In XPS, an X-ray is absorbed and a photoelectron is emitted. By subtracting both the energy of the impinging X-ray (which is known) and the energy of the electron (which is measured), the binding energy of the electron can be determined. Based on this information, the composition and valence states of various elements can be determined. Fume collected on stage 3 of the ELPI was used for XPS analysis. This stage represents a mean particle diameter of 0.095 μm. The charger inside the ELPI was deactivated during the collection of the fume for this analysis. Also, the aluminum substrate used in this test was not covered with collection grease.

The TEM samples were collected on carbon-coated 400 mesh TEM copper grids placed directly in the weld plume at approximately 3 in. above the arc. The TEM analysis was performed at the Brazilian synchrotron light laboratory (LNLS), using a JEOL HRTEM JEM 3010 URP instrument coupled with chemical nano-analysis by XEDS equipped with a Si(Li) detector. A double-tilt beryllium sample holder was used for crystallographic and low background chemical analysis. TEM analysis was performed at 300 kV. For the microanalysis, probe sizes of 5 to 25 nm in diameter were used. The XEDS spectra were obtained with a dead time lower than 25%. In order to provide reliable statistics on the spectra collection, 400 s of collection time was used. Particles with sizes in the range of 10 to 300 nm were analyzed in the TEM. Bright field images were taken of the fume particles, while SAD was used to determine the crystal structure of the fume particles. Composition of the fume particles was determined using XEDS.

Results and Discussion

Fume Generation Rate

The fume generation rates for the high-Mn SMAW and FCAW consumables were 0.84 and 3.1 g/min, respectively. The FGR for the E6010 consumable was 0.60 g/min.
The high-Mn SMAW consumable had an FGR similar to that of E6010, but the FCAW had a significantly higher FGR, owing to the large quantity of the welding wire consumed. The higher fume generation rate of the high-Mn FCAW consumable is due to both the relatively high current levels (~270 A) at which this wire operates, and the fact that it is a self-shielded electrode.

### Fume Particle Number Distribution

The results of the fume particle number distribution tests from the ELPI are provided in Fig. 1A. The majority of the fume particles were located in the fine (0.1-2.5 μm) and ultrafine (< 0.1 μm) particle size regimes. This distribution is similar to E6010, except that E6010 had a slightly higher percentage of particles in the fine regime.

### Mass Distribution

The results for the mass distribution tests are provided in Fig. 1B. The analysis shows that the majority of the mass of the particles for both the SMAW and FCAW electrodes is in the fine regime. This distribution is similar to other consumables that have been evaluated.

### X-Ray Diffraction

The XRD spectrum for the high-Mn SMAW consumable is shown in Fig. 2A. Strong peaks were identified for Fe₃O₄ (magnetite) and MnFe₂O₄ (jacobsite). The iron dimanganese (III) oxide, FeMn₂O₄, was also detected. A reference spectrum for E6010 is shown in Fig. 2B. For this mild steel electrode, the only detectable compound is magnetite, Fe₃O₄. The XRD spectrum for the FCAW consumable is shown in Fig. 3. This fume exhibited strong peaks for Fe₃O₄, MnFe₂O₄, and smaller peaks for CaF₂ (fluorite) and NaF (villiaumite). Based on SEM and TEM analyses presented in the following sections, some Mn substitutes for Fe in the Fe₃O₄ compound, resulting in Mn-doped magnetite (MnFe₂O₄). This results in a slight shift in the peak relative to the Fe₃O₄ peak, but it still indexes as magnetite. In contrast, the E6010 bulk fume only exhibits peaks for Fe₃O₄ with small peak shifts suggesting the substitution of other elements (Mn, Si, and Na) for Fe (based on SEM and TEM results).
Fig. 9 — Small particle agglomerate from high-Mn FCAW fume that shows Fe$_3$O$_4$ type crystal structure. Oxygen was not included in this analysis.

Fig. 10 — Large, square Mn:Fe$_3$O$_4$ fume particle from high-Mn FCAW [013] zone axis.

Scanning Electron Microscopy

Morphological analysis revealed that the two high-Mn consumables produce similar fume types. The fume particles were typically spherical, either as individual particles or multiparticle agglomerates. Agglomerates collected on Stage 2 (0.06 μm) and 4 (0.16 μm) of the ELPI consisted of spherical particles. Agglomerates collected on Stage 8 (0.96 μm) consisted of larger spherical particles. The number of particles in the agglomerates on Stage 8 was considerably less than Stages 2 and 4. Stage 10 (2.4 μm) contained almost all individual spherical particles, which ranged in size from 0.5 to 3 μm in diameter. Very few agglomerates were collected on Stage 10 for both high-Mn consumables. The composition of the bulk fume piles collected in the ELPI for the three consumables is shown in Fig. 4. The Mn and Fe contents are shown in Fig. 4A, while Na and Si contents are shown in Fig. 4B.

The bulk fume analysis also revealed the presence of Mg, Mo, Ca, Ti, and Cu in the high-Mn SMAW fume, and Mg, Ca, Ti, and Cr in the high-Mn FCAW fume. The E6010 fume contained traces of Mg and Ti. Oxygen was detected in all of the fume particles, but was not quantified. Fluorine was detected in the high-Mn FCAW fume. This is consistent with the XRD results that showed the FCAW fume particles are comprised of metallic oxides and fluorides. The largest fraction of the composition for all of the fume particles consisted of Fe and Mn, with Na, Mg, Si, Ca, Ti, and Mo making up the difference. Table 5 shows the composition of the individual particles and agglomerates analyzed with XEDS in the SEM. These data present the average in atomic percent (at.-%) and standard deviation of the fume particle composition analyses.

The high-Mn SMAW fume exhibited an inverse compositional relationship between the Fe and Mn composition. When the Mn content was high, the Fe content was low. Conversely, when the Fe content was high, the Mn content was low. Nearly all of the fume particles, a total of nearly 50 individual particle analyses from the

<table>
<thead>
<tr>
<th>Table 5 — Composition of Individual Fume Particles and Agglomerates for High-Mn and E6010 Fumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements (at.-%)</td>
</tr>
<tr>
<td>&lt;0.1 μm</td>
</tr>
<tr>
<td>Value  Fe  Mn  Mo  Ti  Si  Na  Mg  Ca</td>
</tr>
<tr>
<td>High-Mn SMAW AVG  50.4  26.5  3.2  —  4.8  8.8  6.4  —</td>
</tr>
<tr>
<td>σ         10.8  11.6  2.2  —  2.0  5.6  3.8  —</td>
</tr>
<tr>
<td>High-Mn FCAW AVG  34.7  24.6  4.9  3.3  1.9  17.3  14.8  2.2</td>
</tr>
<tr>
<td>σ         11.7  11.7  4.1  2.4  0.9  5.5  5.0  1.0</td>
</tr>
<tr>
<td>E6010 AVG  76.7  11.6  —  6.5  4.8  —  —</td>
</tr>
<tr>
<td>0.1–1 μm</td>
</tr>
<tr>
<td>Value  Fe  Mn  Mo  Ti  Si  Na  Mg  Ca</td>
</tr>
<tr>
<td>High-Mn SMAW AVG  51.0  32.3  1.7  0.6  0.7  9.5  5.4  0.8</td>
</tr>
<tr>
<td>σ         29.4  23.1  0.9  —  0.8  5.5  3.3  —</td>
</tr>
<tr>
<td>High-Mn FCAW AVG  20.1  47.1  3.0  1.5  1.1  12.6  14.5  1.2</td>
</tr>
<tr>
<td>σ         17.3  19.7  2.4  0.8  0.9  3.1  9.3  0.7</td>
</tr>
<tr>
<td>E6010 AVG  71.6  19.7  —  15.1  3.6  0.4  0.5</td>
</tr>
<tr>
<td>&gt;1 μm</td>
</tr>
<tr>
<td>Value  Fe  Mn  Mo  Ti  Si  Na  Mg  Ca</td>
</tr>
<tr>
<td>High-Mn SMAW AVG  51.2  32.4  0.5  1.3  2.4  9.8  5.8  1.0</td>
</tr>
<tr>
<td>σ         28.9  23.8  0.3  1.7  1.5  5.8  0.9  0.9</td>
</tr>
<tr>
<td>High-Mn FCAW AVG  47.3  32.4  2.9  2.2  1.0  7.5  3.7  1.1</td>
</tr>
<tr>
<td>σ         23.4  19.9  1.5  0.7  0.5  4.9  2.7  0.4</td>
</tr>
<tr>
<td>E6010 AVG  58.1  19.7  0.5  12.5  14.2  2.3  —  2.1</td>
</tr>
</tbody>
</table>

Data are presented as average (AVG) and standard deviation (σ). Oxygen was detected, but not quantified in this analysis. Only AVG values were calculated for the E6010 consumable. Values are given in atomic percent (at.-%).
high-Mn-SMAW exhibited this type of behavior. For the high-Mn SMAW fume, Ca and Ti increased with particle diameter. Mo decreased with particle diameter. Na, Mg, Si, Mn, and Fe remained relatively constant with particle diameter. The high-Mn FCAW consumable contained about 6 at.% Ni in some of the coarse (Dp > 1 μm) particles. Also, all of the size ranges for this consumable contained an average of 2 at.% Cr. For the high-Mn FCAW consumable, Na, Mg, Si, and Ca appeared to decrease with particle diameter. However, this correlation takes into account the average composition of this size regime, and is not representative of all fume particles. The standard deviation values show that there is a wide variation in composition among these fume particles. Also, some of the fume particles that were analyzed were contained in agglomerates. An example of a high-Mn FCAW agglomerate is shown in Fig. 5.

The behavior of the E6010 consumable was different with respect to the Fe-Mn relationship. The Mn content of the E6010 electrode is fairly low compared to that of the high-Mn consumables, thus there is not as much Mn present in the fume. The E6010 particles were primarily Fe-rich oxides with Mn in the range from 8 to 12 at.% and Si in the range from 5 to 20 at.%. Some of the coarse particles contained about 12 at.% potassium. When the Fe content of the E6010 fume particles decreases, there is no subsequent increase in Mn.

Transmission Electron Microscopy

Magnetite (Fe₃O₄), jacobsite (MnFe₂O₄), and iron dimanganese (III) oxide (FeMn₂O₄) have the same FCC crystal structure (space group 227) with slightly different lattice parameters. Therefore, differentiating between these three phases by SAD analysis is not possible. Thus, for simplicity, these three phases have been identified by SAD as Mn-doped magnetite, Mn:Fe₃O₄.

SMAW Particles

The elements detected by XEDS in the TEM analyses of the high-Mn SMAW fume particles were Fe, Mn, Mg, Si, Na, F, and O. Fe, Mn, and O were the predominant elements detected in most particles. The only phase that was unequivocally identified by SAD in the TEM was Mn:Fe₃O₄ — Fig. 6. However, the presence of other compounds identified by XRD analysis, such as Mn-oxides, NaF and CaF₂, is suggested by the TEM analysis due to the observation of Mn-rich particles with low Fe and some F and Na revealed by the XEDS analyses. Some Si was also observed. Si was present in the form of an amorphous Si-rich oxide (SiO₂) forming as a “shell” on the particle surface. Small particle (10 to 30 nm) agglomerates analyzed by SAD were identified as Fe-rich Mn:Fe₃O₄. This fume also exhibited some medium size (30–70 nm) high-Mn oxides with a Fe₃O₄-like crystal structure. The presence of Na and the large Fe Lα peak observed suggested that F is present on these particles. It should be noted that the F Kα and Fe Lα peaks overlap, thus the F content is difficult to quantify by XEDS.

Not all the analyzed medium-size particles had a high Mn content. Some medium size and large particles (80–120 nm) had a high Fe content. A comparison of a range of particles in terms of Fe and Mn content as determined by XEDS is shown in Fig. 7. These crystalline oxides have been identified through SAD and high resolution TEM images as being Mn:Fe₃O₄. Some of the medium-size Mn-rich particles exhibited a very thin (1–2 nm) amorphous shell as shown in Fig. 8. This shell is a Si-rich oxide, as suggested by the large Si content at the particle surface. Among the analyzed medium-size and large Mn-rich particles, most of them were identified by SAD as Mn:Fe₃O₄. However, the identification of some of these high-Mn oxides was not possible.

FCAW Particles

The TEM analysis of the FCAW welding fume revealed two basic types of fume particles. Most of the particles were roughly spherical with diameters between 100 and 200 nm. The second type consisted of agglomerates of very small particles with diameters between 10 and 50 nm. An agglomerate of spherical particles along with a corresponding SAD pattern and XEDS analysis is shown in Fig. 9. Some of the larger spherical particles show a very high Mn concentration at its core. SAD was used to identify individual square particles (~150 nm) as Mn:Fe₃O₄. Figure 10 shows a Mn:Fe₃O₄ particle with SAD pattern at the [013] zone axis. The larger fume particles contained mostly Fe, Mn, and O. However, Cr, Ca, Ti, F, Mg, and Si were also detected in some particles or regions of such particles (such as the outer shell). XRD and TEM-based chemical analyses detected the presence of fluorine compounds CaF₂ and NaF.

A large variation in the relative amounts of Mn and Fe was observed among the particles analyzed. For example, spherical particles, exhibited a 2:1 ratio of Mn to Fe. However, particles mostly consisting of Fe (with little Mn) or Mn (with little Fe) were also observed. On the other hand, most of the small-particle agglomerates that were analyzed were found to be Fe rich. In general, the small-particle agglomerates were Fe rich, with approximately 70–80 wt-% Fe and 15–20...
were enriched in Na. The crystal structure of these agglomerated particles corresponded to Fe₃O₄, as determined by SAD.

The TEM analysis of the E6010 fume particles also showed evidence of a core-shell type morphology. Where the core was identified as MnFe₂O₄ and the shell an amorphous Si-rich oxide. Therefore, this result is similar to the high-Mn SMAW fume presented here. X-Ray Photoelectron Spectroscopy

XPS analysis was conducted both before and after etching using Ar-ion sputtering. The pre-etch condition detects elements present on the surface of the particles, while the post-etch condition reveals elements below the outer layer of the fume particles. Since many particles are evaluated simultaneously, the XPS results represent an average composition profile over many particles. The area of the intensity for elements of interest is plotted as counts per second (CPS). These intensities are normalized from the sum of the intensities for all elements for both the pre-etch and post-etch conditions. Figure 11 shows XPS results for the high-Mn consumables and the reference E6010 fume. The XPS results from the high-Mn SMAW fume show that the metallic species Si, Mn, Fe, and Na increase in intensity below the surface. The results for the high-Mn FCAW fume also shows that Si, Mn, and Fe intensity increase below the surface of the particles. For the FCAW fume, the particle surface was enriched in Fe. Based on the XRD analysis (Fig. 3), it is probably present as a NaF or CaF₂ compound. Manganese was present as complex oxides, while the XPS data show that Fe was present, in part, as elemental Fe. For E6010, metallic species Fe, Mn, and Si increase as the surface layer is removed. The outer region of the E6010 particles were enriched in Na. For all of the fume types, oxygen intensity decreased by nearly half following Ar⁺ etching. This suggests that the particle surfaces are heavily oxidized, in some cases due to the presence of a SiO₂ shell. The XPS analysis also suggested that the Mn oxidation states are Mn⁴⁺ and Mn⁶⁺ based on the energies of the observed 2p peaks.

Conclusions

1) The fume generation rates for the three consumables are as follows: high-Mn SMAW: 0.84 g/min, high-Mn FCAW: 3.1 g/min, and E6010: 0.60 g/min.
2) The fume particle number distribution revealed that more than 95% of the particles are in the fine (0.1–2.5 μm) and ultrafine (less than 100 nm) size regimes. The peak in fume particle mass is in the fine regime.
3) The XRD analysis of high-Mn SMAW fume showed strong diffraction peaks for magnetite (Fe₃O₄), most likely with Mn substituted for some of the iron in the magnetite, MnFe₂O₄, and FeMn₂O₄. The high-Mn FCAW fume contained a Fe₃O₄-type compound in addition to MnFe₂O₄. The fluoride compounds NaF and CaF₂ were also identified for the high-Mn FCAW fume.
4) The XEDS analysis in the SEM showed a wide composition range for the fume particles with most particles consisting of Fe, Mn, Na, Mg, and Si. Elements in the fume particles could be traced back to the consumable composition. For instance, the high-Mn FCAW consumable produced fume that contained Cr and Ni, while the other consumables did not.
5) The XEDS analysis of the high-Mn SMAW fume in the TEM showed that Fe, Mn, Si, Na, and Mg were the predominant elements observed in most particles. The only phase unequivocally identified by SAD in the TEM was MnFe₂O₄.
6) The TEM analysis of the high-Mn FCAW fume shows that the large particles are generally Mn-rich and exhibited the MnFe₂O₄ structure.
7) The XPS results from the high-Mn SMAW fume show that Si, Mn, Fe, and Na increase in intensity below the surface of the particles. The results for the high-Mn FCAW fume show that Si, Mn, and Fe intensity increase below the surface of the particles. The FCAW particle surfaces are rich in Fe.
8) Based on the combined characterization results, it can be concluded that Mn is present in either the Mn⁴⁺ or Mn⁶⁺ valence state. No free Mn or Mn-oxides were identified in any of the analyzed fumes.

Acknowledgments

This project was supported by D&L Welding Fume Analysis, LLC, that represents a consortium of past and present welding consumable manufacturers.

References

5. McMillan, G. 2005. Is electric arc welding linked to manganism or Parkinson’s disease?
Welding of Hydrogen-Charged Steel for Modification or Repair

The effect of hydrogen in base metal is confirmed, and advice is provided on welding C-Mn and Cr-Mo steel that contains hydrogen

BY R. J. PARGETER AND M. D. WRIGHT

ABSTRACT

Various types of steel equipment, particularly in refinery service, absorb hydrogen during operation. Material selection and design should ensure that this does not cause any damage, but the presence of hydrogen in the steel also needs to be taken into account if modifications or repairs involving welding are required. Hydrogen in the steel will contribute to hydrogen in the weld and may increase the risk of fabrication hydrogen cracking (cold cracking). The usual approach is to impose a hydrogen removal heat treatment, or hydrogen bakeout prior to welding, to ensure that there is no significant hydrogen left in the steel, in which case normal welding precautions can then be taken to avoid cracking. This, however, is a costly and time-consuming process, with the time taken making a direct and particularly significant contribution to the cost if it results in extended downtime of a refinery. The effects of hydrogen in the base steel have been explored in an experimental program of work, and recommendations for safe welding procedures have been made.

Introduction

When faced with a requirement to weld on hydrogen-charged steel, the welding engineer will typically perform some sort of calculation to determine the time and temperature required to remove the hydrogen. For example, the hydrogen removal curves presented in Ref. 1 may be used. Any such calculation will require a knowledge of the coefficient of diffusion of hydrogen for the steel of concern, which is generally not known with any confidence, and some judgment will have to be made with regard to the amount of hydrogen that needs to be removed. One solution to these uncertainties is to employ direct measurement of hydrogen effusion, and successful use of such an approach has been reported (Ref. 2). Nevertheless, both downtime and uncertainty would be removed if the effects of hydrogen in the steel could be accommodated in the welding procedure. Welding conditions that avoid hydrogen cracking can be devised for high-hydrogen consumables, and a similar approach should be possible for a hydrogen-charged steel.

A further advantage of devising welding procedures that accommodate hydrogen in the steel is that trapped hydrogen, which may not be driven out by relatively low-temperature bakeout treatments or, therefore, registered by direct hydrogen flux measurements, would be taken into account. There is some risk associated with assuming that a hydrogen bakeout treatment has been completely effective by calculation or measurement.

Bearing the above considerations in mind, a program of experimental work was carried out at TWI. The aim was to demonstrate and quantify the effect of hydrogen in the steel such that appropriate modifications to welding procedures could be recommended.

KEYWORDS

Controlled Thermal Severity (CTS)
Hydrogen
C-Mn Steel
Cr-Mo Steel
Heat-Affected Zone (HAZ)

Experimental Program

Approach

The issue of hydrogen charging of steels in service arises both in low-temperature corrosive conditions and when handling hot, high-pressure hydrogen. For corrosive conditions, the primary concern is with carbon manganese (C-Mn) steels, particularly when operating in sour (H₂S-containing) environments. For hot, high-pressure hydrogen, chromium molybdenum (Cr-Mo) alloyed steels resistant to hydrogen attack are used. In view of both the significant differences in the materials and the hydrogen charging routes, the work included tests on corrosively charged C-Mn steel and Cr-Mo steel charged in a hydrogen autoclave.

The controlled thermal severity (CTS) test (Ref. 3) was selected as a weldability test to provide a comparison between hydrogen-charged and hydrogen-free steels. Data generated using this test at TWI formed the basis of the guidelines currently in BS EN 1011-2, Appendix C (Ref. 4), and in the TWI book on welding steels without hydrogen cracking (Ref. 1). Thus, it was considered to be an appropriate test that would allow the data to be fed directly into guidelines for avoidance of cracking. It was also possible to carry out hydrogen charging and analysis with only slight modification of the test method. To facilitate hydrogen analysis, extension pieces were included on all test blocks, which were removed for analysis immediately prior to test welding.

Bearing in mind the common constraints on heat input in a repair weld situation, ‘crack: no crack’ boundaries were determined in terms of preheat at a single heat input typical of repair practice.

Materials

The test steels consisted of three C-Mn steels and one Cr-Mo steel. Chemical
compositions are presented in Table 1. Micrographs are also presented — Fig. 1.

Three C-Mn steels were used to investigate the effects of two material variables. The steels selected cover high and low carbon equivalents (CE, see Table 1), the parameter that best describes this class of material’s relative susceptibility to fabrication hydrogen cracking. The selected steels also cover both high and low sulfur contents. The higher sulfur level was selected to allow the effect of hydrogen trapping around inclusions (which might slow diffusion of hydrogen in the steel) to be explored.

A high CE, high sulfur C-Mn steel (A) was chosen as representative of older, dirty (high sulfur and oxygen) steels likely to be encountered in repair welding operations. It conformed to the old British Standard BS 1501-221 Grade 32A and had a CE of 0.43 wt-% and a sulfur content of 0.032 wt-%.

A steel with the same CE (steel B), but with a very low sulfur content of <0.002 wt-%, provided a comparison in terms of steel cleanliness. Furthermore, this was the only Al-treated steel of the three C-Mn steels tested, and it had a low oxygen content of 4 ppm. This steel complied with BS 4360: 1990 Grade 50D. The grain size

---

**Table 1 — Chemical Compositions of Base Materials (wt-%)**

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>S</th>
<th>P</th>
<th>Si</th>
<th>Mn</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>Cu</th>
<th>Nb</th>
<th>Ti</th>
<th>Al</th>
<th>O</th>
<th>N</th>
<th>CE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>High CE, high S C-Mn steel, A</td>
<td>0.21</td>
<td>0.029</td>
<td>0.018</td>
<td>0.22</td>
<td>1.12</td>
<td>0.08</td>
<td>0.07</td>
<td>0.02</td>
<td>&lt;0.002</td>
<td>0.12</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>0.0121</td>
<td>0.0062</td>
<td>0.43</td>
</tr>
<tr>
<td>High CE, low S C-Mn steel, B</td>
<td>0.19</td>
<td>&lt;0.002</td>
<td>0.021</td>
<td>0.28</td>
<td>1.38</td>
<td>0.01</td>
<td>0.02</td>
<td>&lt;0.005</td>
<td>&lt;0.002</td>
<td>0.005</td>
<td>0.024</td>
<td>&lt;0.002</td>
<td>0.047</td>
<td>0.0004</td>
<td>0.0041</td>
<td>0.43</td>
</tr>
<tr>
<td>Low CE, high S C-Mn steel, C</td>
<td>0.14</td>
<td>0.033</td>
<td>0.035</td>
<td>0.20</td>
<td>1.25</td>
<td>0.04</td>
<td>0.03</td>
<td>0.005</td>
<td>&lt;0.002</td>
<td>0.02</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>0.004</td>
<td>0.0100</td>
<td>0.0038</td>
<td>0.36</td>
</tr>
<tr>
<td>2% Cr 1Mo steel, D</td>
<td>0.14</td>
<td>0.002</td>
<td>0.004</td>
<td>0.20</td>
<td>0.43</td>
<td>0.10</td>
<td>2.17</td>
<td>0.96</td>
<td>0.002</td>
<td>0.02</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>0.024</td>
<td>0.0024</td>
<td>0.0034</td>
<td>—</td>
</tr>
</tbody>
</table>

* CE\textsubscript{TW} = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15
was finer than that of steel A, but it was not unusual for a steel of this grade.

Steel C was another high sulfur (0.033 wt-%) steel to BS 1501-121 but with a lower CE of 0.36 wt-%. The grain size was relatively coarse and closer to that of steel A than steel B.

The Cr-Mo steel (B) was a 2.25Cr 1Mo type, with a tempered bainitic microstructure, and low sulfur and oxygen contents. The manual metal arc/shielded metal arc process was selected, and part dried welding consumables were procured that could be conditioned to the desired hydrogen level. For C-Mn steels, AWS E7018 consumables were used. These were dried at 330°C for 1 h to give 9.7 mL/100 g deposited metal hydrogen, which is toward

Table 2 — Test Results, C-Mn Steel, A

<table>
<thead>
<tr>
<th>Weld No.</th>
<th>Heat Input* kJ/mm</th>
<th>Preheat °C</th>
<th>HAZ Hardness HV10 max–min</th>
<th>No. of Faces Showing Cracking</th>
<th>Hydrogen, mL/100 g in Top Block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>mean</td>
<td></td>
<td>Diffusible</td>
</tr>
<tr>
<td>W2</td>
<td>0.83</td>
<td>20</td>
<td>425–390</td>
<td>3/6</td>
<td>Not charged</td>
</tr>
<tr>
<td>W3</td>
<td>0.83</td>
<td>100</td>
<td>376–354</td>
<td>0/6</td>
<td>Not charged</td>
</tr>
<tr>
<td>W4</td>
<td>0.86</td>
<td>50</td>
<td>429–360</td>
<td>0/6</td>
<td>Not charged</td>
</tr>
<tr>
<td>W6</td>
<td>0.82</td>
<td>38</td>
<td>429–401</td>
<td>0/6</td>
<td>Not charged</td>
</tr>
<tr>
<td>W8</td>
<td>0.88</td>
<td>85</td>
<td>383–357</td>
<td>0/6</td>
<td>6.3</td>
</tr>
<tr>
<td>W9</td>
<td>0.88</td>
<td>35</td>
<td>421–401</td>
<td>0/6</td>
<td>Not charged</td>
</tr>
<tr>
<td>W11</td>
<td>0.78</td>
<td>60</td>
<td>394–380</td>
<td>1/6 inclusion cracking</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>394–380</td>
<td>3/6 conventional</td>
<td></td>
</tr>
<tr>
<td>W12</td>
<td>0.81</td>
<td>35</td>
<td>394–376</td>
<td>5/6 inclusion cracking</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>394–376</td>
<td>2/6 conventional</td>
<td></td>
</tr>
<tr>
<td>W13</td>
<td>0.82</td>
<td>77</td>
<td>401–376</td>
<td>6/6 inclusion cracking</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>401–376</td>
<td>0/6 conventional</td>
<td></td>
</tr>
<tr>
<td>W15</td>
<td>0.88</td>
<td>100 top 95 base</td>
<td>376–357</td>
<td>3/6 inclusion cracking</td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>376–357</td>
<td>0/6 conventional</td>
<td></td>
</tr>
<tr>
<td>W17</td>
<td>0.72</td>
<td>120</td>
<td>366–342</td>
<td>5/6 inclusion cracking</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>366–342</td>
<td>0/6 conventional</td>
<td></td>
</tr>
<tr>
<td>Not welded</td>
<td>—</td>
<td>As charged</td>
<td>—</td>
<td>—</td>
<td>14.0</td>
</tr>
<tr>
<td>Not welded</td>
<td>—</td>
<td>150</td>
<td>—</td>
<td>—</td>
<td>9.5</td>
</tr>
</tbody>
</table>

* Using arc efficiency of 0.8.
the upper end of scale C in BS EN 1011-2 (5–10 mL/100 g deposited metal). For the Cr-Mo steel, matching AWS E9018 consumables were used, dried at 250°C for 1 h to give 4.3 mL/100 g hydrogen, which is toward the upper end of scale D (3–5 mL/100 g deposited metal). The aim was to generate cracking conditions with reasonable preheat/heat input combinations so that any effect of base metal hydrogen on these thresholds could be determined.

Hydrogen Charging of C-Mn Steels

Hydrogen charging of the C-Mn steels was achieved by placing the modified CTS top blocks (see below) in acidified (pH3) 5 wt-% NaCl solution saturated with H₂S (standard NACE TM0177 solution A (Ref. 5)), with an exposure time of 96 h. After charging, the blocks were removed from the solution, lightly cleaned, then packed in dry ice and stored in a freezer until required for testing. Results of diffusible and total hydrogen determinations on the tabs from charged CTS top blocks are included in Tables 2–4. Diffusible hydrogen analysis was performed by full evaporation and collection over mercury at ambient temperature and residual hydrogen (to give total hydrogen by addition) by vacuum hot extraction at 650°C.

Hydrogen Charging of Cr-Mo Steel

Hydrogen charging of the Cr-Mo steel was carried out using an autoclave. In this case, CTS top blocks were exposed to a hydrogen atmosphere at a temperature of 450°C and pressure of 10.3 MPa (1500 lb/in.²) for 48 h. This temperature was chosen as it is approximately that at which many vessels operate, and the pressure places this condition just within the safe region of a Nelson curve plot for this material. The exposure time of 48 h was estimated to be sufficient to saturate the material under these conditions. Previous published work (Ref. 6) indicates that a hydrogen content of approximately 4 ppm should be obtained (1 ppm = 1.12 mL/100 g). The same source quotes a calculated hydrogen content of 4.8 ppm for an α iron under similar conditions.

After charging, the Cr-Mo blocks were stored in the same way as the C-Mn blocks. However, in this case some loss of hydrogen is expected between charging and storage because the blocks must cool to 250°C before pressure can be released and the blocks extracted and quenched. This can take up to 1 h.

Results of diffusible and total hydrogen determinations on the tabs from charged CTS top blocks are included in Table 5. Diffusible hydrogen analysis was performed by evolution and collection over mercury at ambient temperature and residual hydrogen (to give total hydrogen by addition) by vacuum hot extraction at 650°C.
Table 3 — Test Results, C-Mn Steel, B

<table>
<thead>
<tr>
<th>Weld No.</th>
<th>Heat Input* kJ/mm</th>
<th>Preheat °C</th>
<th>HAZ Hardness HV10 mean-max/min</th>
<th>No. of Faces Showing Cracking</th>
<th>Hydrogen, mL/100 g in Top Block</th>
<th>Diffusible</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>W27</td>
<td>0.83</td>
<td>45</td>
<td>417-405/412</td>
<td>6/6 conventional</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W28</td>
<td>0.88</td>
<td>110</td>
<td>421-405/414</td>
<td>4/6 conventional</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W29</td>
<td>0.82</td>
<td>125</td>
<td>413-345/376</td>
<td>0/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W31</td>
<td>0.83</td>
<td>125</td>
<td>429-413/419</td>
<td>0/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W32</td>
<td>0.83</td>
<td>160 top</td>
<td>405-366/390</td>
<td>0/6</td>
<td>Not analyzed</td>
<td></td>
<td></td>
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<tr>
<td>W34</td>
<td>0.82</td>
<td>135</td>
<td>405-387/393</td>
<td>0/6</td>
<td>0.8                 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W35</td>
<td>0.85**</td>
<td>135</td>
<td>405-373/395</td>
<td>0/6</td>
<td>1.0                 1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W37</td>
<td>0.88</td>
<td>125</td>
<td>376-357/370</td>
<td>0/6</td>
<td>0.7                 0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W40</td>
<td>0.81</td>
<td>110-115</td>
<td>417-394/403</td>
<td>1/1 conventional</td>
<td>0.9                 1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Using arc efficiency of 0.8.
** Estimated using V = 23 because true voltage reading unavailable.

** CTS Tests **

CTS testing was performed as far as possible to BS EN ISO 17642-2:2005 (Ref. 3), but slightly modified to take account of the special requirements of this work. All welding was performed using 4-mm-diameter electrodes at a nominal heat input of 0.8 kJ/mm (arc energy of 1 kJ/mm), representative of likely practice for repair welds. Specially designed robotic equipment was used, and travel speed and arc length were controlled automatically. Current and voltage were monitored and recorded throughout. Tests were carried out at different preheats to define ‘crack: no crack’ boundaries. The threshold preheat is defined as the highest preheat for which cracking was observed, established to within 25°C of a no crack result and confirmed with a second no crack result.

** Test Block Design **

The test assembly itself was modified so that restraint was provided by four bolts (tightened to 100 Nm torque) rather than by anchor welds — Fig. 2. This was to avoid hydrogen loss from the hydrogen-charged CTS test assemblies during anchor welding. In addition, top blocks that were hydrogen charged were machined with small (10 x 12 x 75 mm) tabs on the face opposite the weld. These were sawed off immediately prior to preheating and used for hydrogen determinations. The modified design was used for all tests to ensure consistent comparisons.

In order to establish the validity of this procedure, including uncharged baseline, hydrogen determinations were performed on tabs from two simultaneously charged blocks (steel A) before and after preheating to 150°C. The results of this trial are reported with the rest of those for steel A below.

** Preheating Procedures **

In order to minimize hydrogen loss during preheating, a procedure for rapidly heating hydrogen-charged top blocks and bolting these to the separately preheated bottom blocks was developed. The larger bottom blocks and bolts were brought to the required temperature by soaking in a furnace (1 h/m, thickness min). The hydrogen-charged top blocks were heated using an electric resistance heating method. The equipment used was a weld thermal simulator which, for the size of specimen used in this work, i.e., 50 mm CTS top block, was found to be capable of heating to a temperature of 180°C in 70 s — Fig. 3. During heating and subsequent assembly of the CTS components, temperature was monitored with a portable digital thermometer and by taking readings from a Chromel-Alumel thermocouple located on the upper face of the top block.

Prior to carrying out the CTS tests, an investigation of temperature variations between this top face and the block center was performed. The results showed that when heating to 180°C, the temperature measured on the top face rose more quickly, exceeding the temperature at the center by up to 20°C. As the current was turned down (as 180°C was approached), the difference decreased. With the current off, a uniform temperature was reached after 10 s. The temperature measured on this upper face was, therefore, taken as being representative of the whole block.

Once at temperature, top blocks were transferred to the welding area and the CTS assembly bolted together ready for welding. This incurred a delay of approximately 7 min. During trials, an assembly heated to 180°C was found to cool to 160°C in this time (obviously heat loss will be less at lower preheat temperatures). The temperature quoted for individual tests is the average temperature of the top and bottom blocks immediately prior to welding measured using a contact thermometer. Following welding, water cooling was applied as per BS EN ISO 17642-2:2005.
Examination of CTS Test Welds

After welding, sectioning and examination of the CTS assemblies was also carried out to BS EN ISO 17642-2:2005 following a delay of at least 72 h. Metallographic sections were taken as required, polished to a 3-μm finish, etched in 2 wt-% nital, and then examined for cracking in the top block heat-affected zone (HAZ) using an optical microscope. Following this, hardness surveys were performed using a Vickers hardness machine with a load of 10 kg.

Results

High-Carbon-Equivalent, High-Sulfur, C-Mn Steel (A)

A 'crack: no crack' preheat threshold of 20°C (room temperature) was established for this steel in the as-received condition (at a heat input of 0.8 kJ/mm and with a weld metal diffusible hydrogen level of 9.7 mL/100 g). CTS test results for this steel are presented together with hardness survey results in Table 2. The threshold is lower than would be expected in light of the other results for this steel. It is not, therefore, thought possible to draw any firm conclusions from this trial.

Results of CTS tests on this material after hydrogen charging are shown in Table 2 and included on a graph — Fig. 4. It can be seen that the hydrogen content (average 8.47 mL/100 g) of the charged base material has increased the preheat threshold by approximately 40°C.

In this work, the 'crack: no crack' preheat threshold for charged material has been defined by the occurrence of conventional HAZ-type cracking. No weld metal cracking was observed. However, cracking associated with blistered inclusions was also observed, a photomicrograph showing typical examples of both types of crack is shown in Fig. 5. Examination of unwelded hydrogen-charged material has shown that such cracking can exist even before preheating and, therefore, although its occurrence has been noted, it has not been used to define 'crack: no crack' thresholds. Nevertheless, this type of inclusion cracking did seem to be exacerbated by preheating when preheated but unwelded blocks were examined, and it was also noticeably worse in the HAZs of welded blocks. Although the preheating in this work was unusually rapid, similar effects principally due to an increase in hydrogen pressure at preheat temperatures would be expected unless heating rates were very slow, as hydrogen escape from voids at such temperatures is very slow.

High-Carbon-Equivalent, Low-Sulfur, C-Mn Steel (B)

Controlled thermal severity results for this steel in the as-received condition and after hydrogen charging are shown in Table 3. Hydrogen determinations on the tabs from charged specimens are also included in Table 3. The results for total hydrogen content show the maximum to be 1.15 mL/100 g, the minimum 0.80 mL/100 g, and the average 0.99 mL/100 g. It can be seen from these results that the level of hydrogen, particularly diffusible hydrogen, in this steel is substantially lower than for the high-sulfur steel A.

All the CTS data for this steel are included in Fig. 4. It can be seen from this graph that preheat thresholds are effectively the same in both conditions, at 110°C, and both are significantly higher than for the high-sulfur steel A that has the same CE. In the as-received condition, this is not unexpected considering the difference in sulfur contents between the two steels.
Table 5 — Test Results, 2%Cr-1Mo Steel, D

<table>
<thead>
<tr>
<th>Weld No.</th>
<th>Heat Input* kJ/mm</th>
<th>Preheat °C</th>
<th>HAZ Hardness HV10 max-min mean</th>
<th>No. of faces Showing Cracking</th>
<th>Hydrogen, mL/100 g in Top Block</th>
<th>Diffusible</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>W5</td>
<td>0.70</td>
<td>20</td>
<td>429–397 410</td>
<td>6/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W7</td>
<td>0.78</td>
<td>115</td>
<td>417–401 411</td>
<td>0/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W10</td>
<td>0.85</td>
<td>90</td>
<td>413–401 405</td>
<td>1/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W14</td>
<td>0.75</td>
<td>65</td>
<td>417–409 413</td>
<td>4/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W16</td>
<td>0.76</td>
<td>115</td>
<td>437–409 422</td>
<td>0/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W18</td>
<td>0.76</td>
<td>50</td>
<td>425–405 411</td>
<td>6/6</td>
<td>Not charged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W30</td>
<td>0.86</td>
<td>150</td>
<td>405–401 403</td>
<td>4/6</td>
<td>0.5</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>W33</td>
<td>0.87</td>
<td>200</td>
<td>413–390 405</td>
<td>2/6</td>
<td>0.1</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>W36</td>
<td>0.96</td>
<td>250</td>
<td>409–401 406</td>
<td>0/6</td>
<td>0.4</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>W39</td>
<td>0.90</td>
<td>225</td>
<td>409–401 404</td>
<td>2/6</td>
<td>0.5</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>W41</td>
<td>0.88</td>
<td>250</td>
<td>409–397 402</td>
<td>0/6</td>
<td>Not analyzed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Using arc efficiency of 0.8.

Table 6 — Summary of Effects of Hydrogen on Necessary Preheat to Prevent Hydrogen Cracking

<table>
<thead>
<tr>
<th>Hydrogen in steel, mL/100 g</th>
<th>Increase in preheat after charging</th>
</tr>
</thead>
<tbody>
<tr>
<td>High CE (0.43) High S (0.029%)</td>
<td>40°C*</td>
</tr>
<tr>
<td>High CE (0.43) Low S (&lt;0.002%)</td>
<td>Zero*</td>
</tr>
<tr>
<td>Low CE (0.36) High S (0.033%)</td>
<td>&gt;25°C*</td>
</tr>
<tr>
<td>2/4 Cr 1Mo</td>
<td>150°C**</td>
</tr>
</tbody>
</table>

* Heat input of 0.8 kJ/mm and 9.7 mL/100 g consumable hydrogen.
** Heat input of 0.8 kJ/mm and 4.3 mL/100 g consumable hydrogen.

Steels and the previously reported observation that high sulfur can reduce relative cracking susceptibility (all other things being equal) (Ref. 8). Critical hardnesses for the two steels are, however, very close in the as-received condition at 425 HV10 for the high-sulfur and 421 HV10 for the low-sulfur steel (Tables 2, 3), consistent with the idea that high-sulfur alleviates cracking risk via its effect on hardenability. As expected, no weld metal cracking and no blistered inclusion-type cracking were observed in this low-sulfur steel.

Low-Carbon-Equivalent, High-Sulfur, C-Mn Steel (C)

Controlled thermal severity test results for this steel, in both the as-received and hydrogen-charged condition, are given in Table 4 and included on Fig. 4. Results of hydrogen determinations after charging are also included in Table 4 showing a variation in total hydrogen content from 6.88 to 11.47 with an average of 9.48 mL/100 g. These results are similar to those for the other high-sulfur steel A.

No cracking was observed in tests carried out at room temperature with the material in the as-received condition. In the hydrogen-charged condition, however, a preheat threshold of 45°C was established. This equates to a shift of >25°C by comparison with the as-received steel.

Blistered inclusion-type cracking was also observed in this steel but not used to define the threshold as with the other high-sulfur steel A. There was no weld metal cracking.

2.25Cr 1Mo Steel (D)

Controlled thermal severity test results for as-received and hydrogen-charged material welded at 0.8 kJ/mm heat input and weld metal hydrogen levels of 4-5 mL/100
\textbf{Discussion}

\textbf{C-Mn Steels}

It was not intended to vary charged hydrogen level in this program. The original intention was to determine any increase in preheat necessary to prevent hydrogen cracking for the three C-Mn steels after hydrogen charging, assuming the hydrogen charging had resulted in a constant material hydrogen level. The results of the program are presented in these terms in Table 6.

For C-Mn steels containing high levels of sulfur, hydrogen charging using the NACE TM0177 solution A (Ref. 5) results in total base material hydrogen contents of approximately 9 mL/100 g, and this in turn increased the preheat necessary to prevent cracking by approximately 25°-40°C. The increases in preheat necessary for both the high and low CE steels equate roughly to what would be expected on increasing consumable hydrogen level to scale B from the scale C level actually used. This indicates that, at this level of hydrogen in base material, the effect of hydrogen introduced by welding cannot be considered in isolation or assumed to swamp any base material hydrogen effects.

The lack of any observed increase in cracking following hydrogen charging of the low-sulfur steel (B) is probably due to the low hydrogen content, this being sufficiently low that any effect it may have is masked by the hydrogen from the consumable.

As noted above, the hydrogen charging did not result in consistent levels for all the C-Mn steels, and in some cases there was less consistency within one steel type than was expected. The scatter in levels attained for the three C-Mn steels makes it possible to plot a graph of total hydrogen content vs. preheat. This graph has been presented in Fig. 4 (note that it has been assumed that as-received materials contain no hydrogen). From this graph, the differences in behavior between the three types of C-Mn steel can be seen more clearly. In addition, the need for data at other hydrogen levels or, in the case of the high-CE low-sulfur steel (B) at a lower consumable hydrogen level, can be seen.

For the low-sulfur steel B, the reported results show considerably lower diffusible hydrogen content than the higher-sulfur steels but a roughly comparable residual hydrogen content. Other unpublished work at TWI (Ref. 9) confirms this trend. In a project looking at the effect of hydrogen on fracture toughness of steels, a C-Mn steel of intermediate sulfur content (0.015 wt-%) was charged in an identical manner. Hydrogen determinations revealed a diffusible hydrogen content of 3.97 mL/100 g and a residual content of 0.1 mL/100 g. Thus, it appears that diffusible hydrogen content rather than residual hydrogen content is a function of sulfur content. This is perhaps surprising as it would be expected that more sulfide inclusions would provide more deep traps and result in a greater residual hydrogen content. It is, however, thought that the split between diffusible and residual hydrogen may be misleading, as it is possible that some hydrogen present in inclusion voids may be able to diffuse out even at room temperature over the time period of the measurements. It is also worth noting that only the low-sulfur steel was aluminum treated.

The effect of hydrogen in causing blistered inclusion-type cracking with these high-sulfur steels must also be considered. Although this form of cracking was seen in two of the unwelded base materials (because of the severity of the corrosive charging medium and the quality of the steels) as well as in HAZs, it was observed that such cracking could also be induced or exacerbated in these steels by both preheating and welding. In view of this, it is thought that a less severe cracking condition that does not result in cracking during charging could be used to elucidate this effect in any future work. It should also be recognized that preheat and/or welding could exacerbate this type of cracking in a repair situation.

In the absence of data over a wider range of consumable and precharged hydrogen levels, it is unsuitable to propose any comprehensive guidelines for the behavior of C-Mn steels in general. Nevertheless, this work has shown that base material hydrogen content does indeed have an exacerbating effect on the risk of fabrication hydrogen cracking, but that the possibility exists to overcome this without the need for preweld hydrogen release heat treatments. Specifically, it has been shown that an increase in preheat of the order of 50°C when welding at scale C (5-10 mL/100 g) consumable hydrogen level is sufficient to prevent cracking at a heat input of ~0.8 kJ/mm if the base steel contains up to 12 mL/100 g hydrogen, as might be encountered following sour service.

\textbf{2.25Cr 1Mo Steel}

The effect of hydrogen charging was the most marked with this steel, although the measured hydrogen level was low (average total 0.68 mL/100 g). However, it is thought that these hydrogen levels will be underestimates of the hydrogen present in the actual top blocks owing to the short diffusion distances in the analysis tab. It has been estimated, using a simple diffusion model, that the hydrogen levels in the main body of the blocks are probably consistent with the hydrogen levels expected (approximately 4 mL/100 g).

The very marked effect of the base material hydrogen content (see Fig. 6) is again indicative of an add-on effect as observed with the high-sulfur C-Mn steels.

In this case, the much greater increase in threshold preheat is a reflection of the difference in behavior between the Cr-Mo steel and C-Mn steels. For the former, preheat only decreases the likelihood of cracking by enhancing hydrogen diffusion, whereas with C-Mn steel preheat also influences HAZ hardness to a certain extent, rendering the HAZ microstructure, in turn, less sensitive to hydrogen. The effect of preheat on maximum HAZ hardness is shown — Fig. 7. With a bulk source of hydrogen available in the steel, hydrogen level control via preheat and hence weld cooling time is difficult, but at least in the size of block tested here, possible.

The implications of these results are twofold. First, although for a real repair situation the possibility does exist of preventing cracking through preheat control of weld cooling times, it is probable that this will be impractical for 2.25Cr 1Mo steel in most cases due to the magnitude of the change in cooling rate required. A more practical solution may be the application of postheat to enhance hydrogen diffusion.

A second implication is that any hydrogen release heat treatments on this type of Cr-Mo steel should be combined with conservative (i.e., high preheat) welding procedures as this work has shown that even a very small amount of hydrogen remaining in the base material will greatly increase the risk of cracking during welding.

\textbf{Summary and Conclusions}

An experimental procedure has been developed for CTS tests on hydrogen
charged base material. Tests have been performed, following this procedure, using a modified test block assembly. Results have enabled threshold preheats to be established for three C-Mn and one 2.25Cr 1Mo steel, at a heat input of 0.8 kJ/mm, both in the as-received and hydrogen-charged conditions.

Specific conclusions are as follows:
1. Hydrogen charging increases the risk of fabrication hydrogen cracking in both C-Mn and Cr-Mo steels. For C-Mn steels, this can be overcome by controlling welding cooling times through the application of preheat, negating the need for preweld hydrogen-release heat treatments.
2. The high-sulfur C-Mn steels of both high- and low-carbon equivalent required an increase in preheat to prevent cracking following charging to give hydrogen levels of up to 12 mL/100 g. This increase was of the order of 40°C for the high-carbon-equivalent steel and equal to or in excess of 25°C for the low-carbon equivalent steel when welded using a scale C consumable hydrogen level (5–10 mL/100 g deposed metal) at ~0.8 kJ/mm heat input.
3. For the high-sulfur steels, both conventional HAZ cracking and blistered inclusion cracking were observed to occur after welding in the hydrogen-charged condition. There is some indication that preheat and welding exacerbates blistered inclusion cracking.
4. No change in the preheat required to prevent cracking was observed for the low-sulfur, high-carbon-equivalent C-Mn steel following hydrogen charging under the same conditions as used for the high-sulfur steels. For the low-sulfur steel, the charged hydrogen levels were, however, significantly lower.
5. A significant increase of 130°C in preheat was required to prevent cracking in the 2.25Cr 1Mo steel following hydrogen charging in an autoclave at 450°C and 10.3 MPa pressure for 48 h.

Recommendations

General Recommendations for Welding Steels Containing Hydrogen

When welding either C-Mn or Cr-Mo steels containing or suspected of containing hydrogen, it should be assumed that this will result in an increased risk of fabrication hydrogen cracking during repair or alterations.

Recommendation for Welding C-Mn Steels Containing Hydrogen

For C-Mn steels that have been in sour service, the possibility exists of overcoming the increased risk of cracking in many circumstances by raising the preheat temperature.

In particular, if the steel to be welded has an IIW carbon equivalent of ≤ 0.45 wt-% and is to be welded at a heat input of ~0.8 kJ/mm with consumables of scale C, i.e., 10 mLH2/100 g deposited metal (or lower) hydrogen content, then the increased tendency to crack can be compensated for by specifying a preheat of at least 50°C or 50°C in excess of that recommended in BS EN 1011-2 for a comparable hydrogen-free situation, whichever is the higher.

The use of consumables of scale D or lower is strongly recommended, but an assumed consumable hydrogen level of scale C should still be used when deciding upon an initial (hydrogen free) level of preheat. In situations where a heat input in excess of ~0.8 kJ/mm is to be used, it is recommended that the level of preheat be decided upon the heat input of ~0.8 kJ/mm. If it is not possible to use a heat input of greater than or equal to ~0.8 kJ/mm, then the recommendations set out above cannot be fully relied upon to prevent cracking.

Recommendations for Welding Cr-Mo Steels Containing Hydrogen

For these types of steels, it appears unlikely that the increased risk of cracking can reliably be negated by the use of increased preheat, at least for those steels that have been in typical high-temperature hydrogen service.

In view of this, it is recommended that where such welding operations are to be undertaken, a preweld hydrogen-release heat treatment is performed and that this should be combined with conservative welding procedures, i.e., high preheat and low consumable hydrogen levels. Consideration should also be given to the use of a postheat to further reduce welding hydrogen levels.

Acknowledgment

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References

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