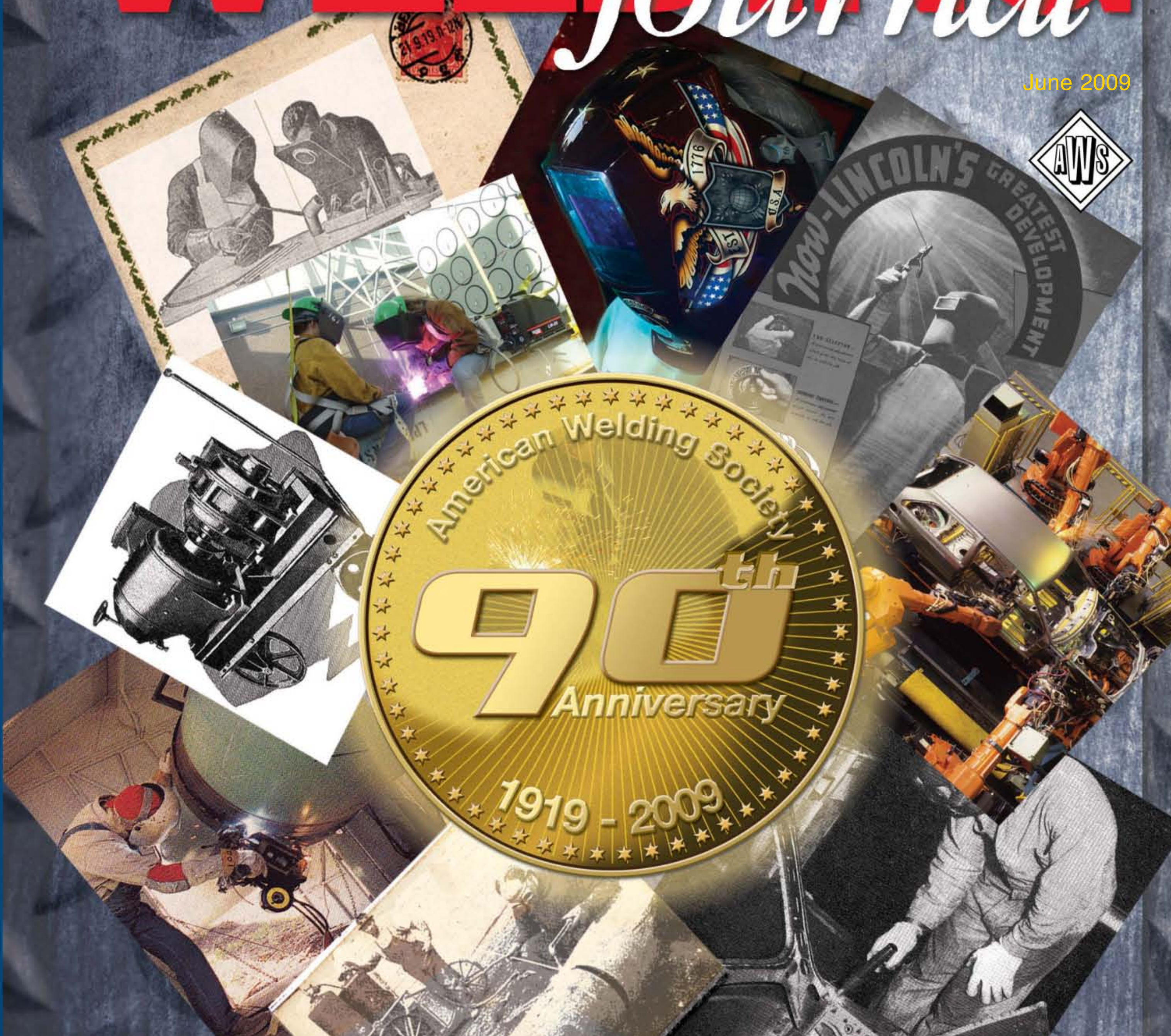
WELDING Journal

June 2009

WELDING JOURNAL • VOLUME 88 NUMBER 6 • JUNE 2009



- AWS Celebrates its 90th Birthday
- Avoid Shock with SMAW
- Evaluating SMAW Electrodes for Pressure Vessels

PUBLISHED BY THE AMERICAN WELDING SOCIETY TO ADVANCE THE SCIENCE, TECHNOLOGY, AND APPLICATION OF WELDING AND ALLIED JOINING AND CUTTING PROCESSES, INCLUDING BRAZING, SOLDERING, AND THERMAL SPRAYING

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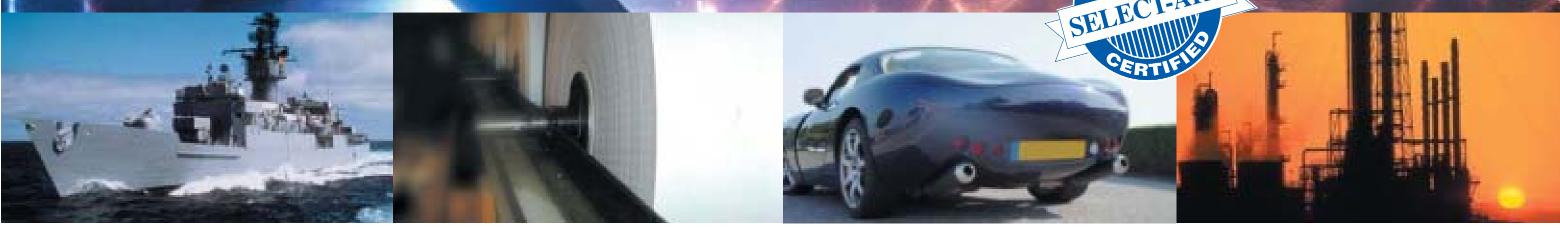
One Word Defines Select-Arc's New Electrode Line and Reputation for Quality...



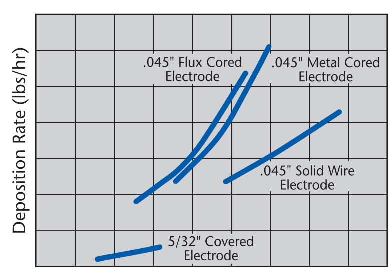
Stainless.

Select-Arc, Inc. has earned an outstanding reputation in the industry as a manufacturer of premium quality tubular welding electrodes for carbon and low alloy steel welding.

Now Select-Arc has expanded its range of exceptional products with the introduction of a complete line of austenitic, martensitic and ferritic stainless steel electrodes. Both the new SelectAlloy and Select stainless steel wires deliver the superior feedability, superb welding characteristics, consistent deposit chemistry and excellent overall performance you have come to expect from Select-Arc.

The chart below shows that SelectAlloy flux cored electrodes' higher deposition rates improve productivity and reduce welding costs.

Typical Deposition Rates for Various Stainless Steel Consumables



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CONGRATULATIONS TO AWS ON ITS 90TH ANNIVERSARY

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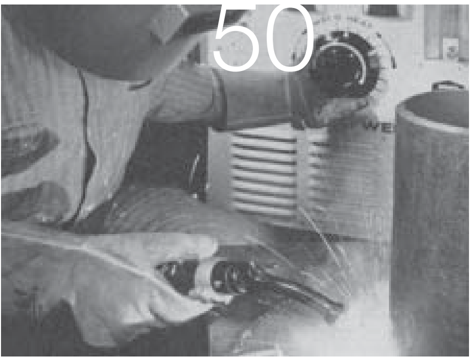

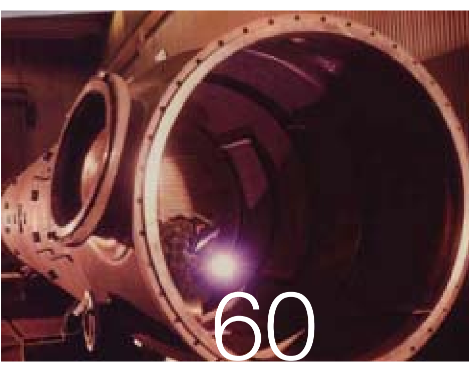

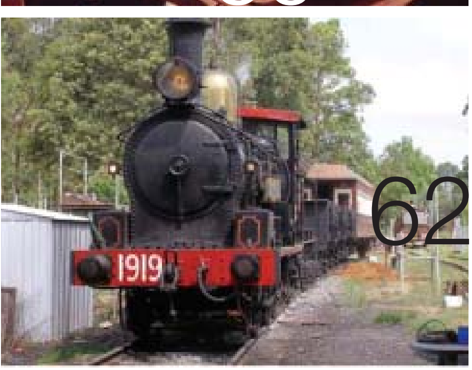

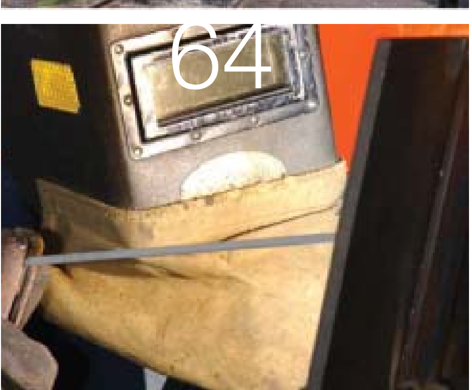

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Welding Research Supplement

Cover design by Brenda Flores

AWS Web site *www.aws.org*

Departments

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WASHINGTON WATCHWORD

BY HUGH K. WEBSTER
AWS WASHINGTON GOVERNMENT AFFAIRS OFFICE

SECTORS Legislation Introduced

The "Strengthening Employment Clusters to Organize Regional Success (SECTORS) Act of 2009," introduced in the Senate and House earlier this year, seeks to create a new federal grant program for industry or sector partnerships. These partnerships organize stakeholders connected to an industry — multiple firms, unions, education and training providers, and local workforce and education system administrators among others — to develop plans for growing (or saving) that industry, with a particular focus on building new workforce pipelines where skilled worker shortages exist and transforming the ways existing workers are utilized, retrained, and compensated.

This legislation envisions one-year planning grants of up to $250,000 and three-year implementation grants of up to $2.5 million.

Green Career and Technical Education Funding Proposed

The Grants for Renewable Energy Education for the Nation (GREEN) Act would provide $100 million in competitive grants for the development of career and technical training in the field of renewable energy. It is expected that postsecondary institutions and career and technical schools would use these grants to enter into public-private partnerships to develop the training programs. Priority would be given to grant applications that 1) use online learning or other innovative methods to deliver a program of study to individuals outside the partnership; and 2) focus on low-performing students and special populations.

Along with developing training programs of study, grants could also be used to develop career and technical educational facilities that are energy efficient and use renewable energy practices.

President Endorses Increased Science Agency Funding

In a recent speech before the National Academy of Sciences, President Obama committed to finishing the ten-year doubling of funding for three science agencies — the National Science Foundation, the Department of Energy Office of Science, and the National Institute of Standards and Technology. Between 2009 and 2016, the Administration's enacted and proposed budgets would add $42.6 billion to the 2008 budgets for these basic research agencies, with a special emphasis on encouraging high-risk, high-return research and supporting researchers at the beginning of their careers.

Energy Program to Be Funded

Created by Congress in 2007, the Advanced Research Projects Agency for Energy (ARPA-E) is only now being funded, in the amount of $400 million via the American Recovery and Reinvestment Act. Modeled after the Defense Advanced Research Projects Agency (DARPA), ARPA-E will award grants to advanced energy technology projects, particularly those that seek to reduce the need for consumption of foreign oil, reduce energy-related emissions, and improve energy efficiency.

Federal Freedom of Information Act Policy Reversed

The U.S. Department of Justice has reversed an 8-year-old policy with respect to disclosure of materials by all federal agencies under the Freedom of Information Act. The official stance of the federal government since 2001 has been that records should be disclosed only if there is a clear legal requirement to do so. The new policy takes a somewhat opposite approach, which is to disclose information unless there is a clear legal requirement not to do so. In addition, even in instances in which there is such a nondisclosure mandate, agencies are now encouraged to make partial disclosures if at all possible.

Government Accountability Office Urges Reporting of Recovery Project Fraud

As billions of dollars are distributed under the American Recovery and Reinvestment Act, the U.S. Government Accountability Office (GAO) is urging anyone who suspects waste, fraud, abuse, or mismanagement of those funds to report their suspicions via GAO's FraudNet system. FraudNet processes allegations about federal agencies and federally funded programs. The Web site is *www.gao.gov/fraudnet/fraudnet.htm*.

OSHA Publishes Respirator Selection Guidance

The U.S. Occupational Safety and Health Administration (OSHA) has issued a new guidance document regarding mandatory respirator selection. The OSHA revised its existing Respiratory Protection standard in 2006 to add Assigned Protection Factors (APFs). These APFs represent the workplace level of respiratory protection that a respirator or class of respirators is able to provide to workers. The higher the APF number (5 to 10,000), the greater the level of protection provided to the user.

The new guidance, *Assigned Protection Factors*, is a 50-page document available on the OSHA Web site, *www.osha.gov*.

H-1B Visa Use Declines

The number of foreign workers entering the U.S. using the H-1B visa declined by 11% in fiscal year 2008, the first decline in several years. The U.S. Citizenship and Immigration Services also reports that applications for such visas for fiscal year 2009 are down sharply, with slots still available. These circumstances are being attributed to the weak economy.♦

Contact the AWS Washington Government Affairs Office at 1747 Pennsylvania Ave. NW, Washington, DC 20006; e-mail hwebster@wc-b.com*; FAX (202) 835-0243.*

PRESS TIME NEWS

AWS Foundation to Award Welder Workforce Development Grants

The AWS Foundation has welder workforce development funds available as a result of gifts from donors with the motivation to immediately impact and increase the welder workforce. The focus of this program is to recruit and train entry-level welders or provide welders with specific specialized training to assist workforce needs for a particular company(s). Also, this program will require a joint application through a partnership between a company(s) and an education and training institution(s).

The industry partner(s) must specify the type of education and/or training program required. In addition, the partnering education and training institution must commit to offering the program as defined by the participating industry partner(s). All education and training curriculum must be based on the participating industry/business needs; safety and welder workforce issues must be stressed, too. The partnering companies must commit to hiring graduates of the institution's program.

The company and education institution partner will submit a joint application to the AWS Foundation including specific activities that will be implemented to address the company's workforce needs.

Applications will be reviewed by a jury and selected based on the proposal's clarity in stating the project goals, expected outcomes, and measures of success; the strategy for achieving these; and the application's relevance to the AWS Foundation's areas of interest. Preference will be given to companies with the largest impact in reducing welder workforce shortages. For more information and the application, visit *www.aws.org* under the Foundation heading.

Welding Comes to Bismarck State College This Fall

Bismarck State College (BSC) is adding an instructional site for its welding technology program in Halliday, N.Dak., through an affiliation with the Halliday Public Schools. Students can earn a program certificate or an associate in applied science degree.

"The demand for welders in the oil fields and the rest of the energy industry remains strong despite a weaker national economy," said Drake Carter, BSC provost and vice president for academic affairs.

The college's program will begin in the fall, but the workforce-training component the public schools system has conducted for three years will be ongoing this summer.

According to Ron Biberdorf, program administrator for Halliday Public Schools, the school has 27 welding stations, and over the past three years, 125 welders who received training there have been placed in jobs.

Nominations Sought for AWS Image of Welding Awards

The American Welding Society (AWS), Miami, Fla., has issued a call for entries in the 7th Annual Image of Welding Awards program. The submission deadline is July 10.

Outstanding achievement will be recognized in the following seven categories: Individual (you or other individual); Section (AWS local chapter); Small Business (less than 200 employees); Large Business (200 or more employees); Distributor (welding products); Educator (welding teacher at an institution, facility, etc.); and Educational Facility (any organization that conducts welding education or training).

These awards are presented by AWS and the Welding Equipment Manufacturers Committee (WEMCO). Nominations will also be judged by WEMCO.

All individuals, organizations, and groups may be nominated for multiple categories. Self nominations are welcome as well. Winners will be honored at an awards ceremony to be held during the FABTECH International & AWS Welding Show scheduled for Nov. 15–18 at McCormick Place, Chicago, Ill.

To see previous Image of Welding Award winners and download the PDF nomination form, visit *www.aws.org/awards/image.html*. Completely fill out and return the form via e-mail to *image@aws.org*, FAX to (305) 443-1552, or mail to AWS Image of Welding Awards, 550 NW LeJeune Rd., Miami, FL 33126.

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EDITORIAL

AWS Is Fine in 2009

Throughout my tenure as treasurer of the American Welding Society, I have been able to give glowing reports regarding its strong cash position. The first reports showed only small growth; however, that soon changed and the growth rate made some dramatic increases. Since we made some necessary changes to the operation of the organization, we have had a long period of continued good growth. I wish it could all be attributed to the great leadership of the treasurer, but that is not the case. We grew and are still growing because the officers and the staff put forth a directed effort and utilized skilled management tools to make it happen. The leadership of the Society has taken the steps necessary to ensure that AWS will enjoy a prosperous future and achieve good financial gains for several years to come. The officers need to continue leading us in a manner that will develop a strong future for the Society.

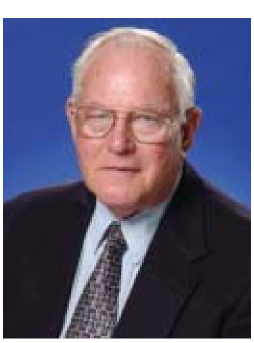
All the leadership must make the effort to keep us growing. It must be the top priority of the board of directors, and they must provide the staff with the tools and direction needed to keep us moving forward. The officers set the standards by which they and the rest of the organization are evaluated by our members and customers. The standards must reflect the conditions the rest of the world is experiencing, even if the Society is not experiencing the same degree of downturn our constituency is going through at the present time. Financially AWS is still very strong, and with the economy in the state that it has been for the past months, it is good to be in this position. The Society has a number of important initiatives, and it has the financial resources to proceed with them.

At the last Welding Equipment Manufacturers Committee (WEMCO) meeting, I had the pleasure of hearing Alan Beaulieu of *Trends Research* speak. For those of you who are not familiar with Mr. Beaulieu, I can tell you he is the most accurate financial forecaster I know. He has spoken at the last several WEMCO meetings I have attended. His discussions on the economy are both enjoyable and informative, and his forecasts of the economic trends have proven very accurate. Beaulieu feels this downturn will slowly come to an end midyear, and we should see a stabilizing of the marketplace but not a lot of growth for the balance of 2009. In 2010, things should look better but we will experience a slow period of recovery over the next few years. He expects full recovery will not occur before 2020 — one prediction in which I hope he is wrong.

It will be good to see the recession end and a recovery begin. Even if it is a slow recovery, at least the downward slide will stop and an upturn no matter how slight will be greatly appreciated and encouraging. AWS has new programs in the final stages of development that will increase its revenue stream and grow its cash position. The AWS Foundation is working to strengthen its Workforce Development Initiative, and we believe this will make AWS a more attractive organization to its present members and its ability to gain additional support from new sources will be enhanced. The Society also has a major building project set to begin that will make its headquarters facility more serviceable for well into the future.

As you have learned over these past few years, I never could just write about the money in my editorials because Frank Tarafa, our chief financial officer, does a far better job than I would ever do so I let him put together all those details and explanations. You can view the full financial report beginning on page 34 of this issue of the *Welding Journal*.

I am enjoying this year of 2009 and look forward to the completion of a number of initiatives under development for the marketplace and the value they will bring to our Society. I am also looking forward to this year ending with a strong driving start to 2010.



Earl C. Lipphardt
AWS Treasurer

NEWS OF THE INDUSTRY

Lockheed Martin Friction Stir Weld Currently Under Way on *Orion* Test Article

Lockheed Martin weld engineers visually monitor the Universal Weld System II weld head as it completes the five-minute initial Orion *friction stir weld. (Photos courtesy of Lockheed Martin.)*

Once this weld is completed, the tool rotates to reveal the welded Aluminum-Lithium (AL) 2195 cone panel and AL 2219 longeron components.

At the NASA Michoud Assembly Facility in New Orleans, La., Lockheed Martin recently began its first friction stir weld process on an *Orion* crew module ground test article that will serve as a production pathfinder to validate the flight vehicle production processes and tools.

When completed, this first full-sized, flight-like crew module will be tested on the ground in equivalent flight-like environments including static vibration, acoustics, and water landing loads. Results will also be used to correlate sizing models for all subsystems on the vehicle.

The initial weld joined an Aluminum-Lithium (AL) 2195 cone panel and AL 2219 longeron using friction stir welding. This process will be used for all crew module welds. Weld operations on the test article will continue for approximately three months. Then, the structure will undergo mechanical assembly, integration, and testing in New Orleans and Denver.

"*Orion* is applying the latest materials and manufacturing technologies, and most efficient processes to produce the lightest weight structure possible," said Blaine Brown, *Orion* Crew Module Integrated Product Team director for Lockheed Martin.

Weld operations occur on a Universal Weld System II (UWS II) featuring a 22-ft-diameter turntable, self-reacting friction stir weld head, and modular t-grid floor. The system provides virtually unlimited five-axis welding on fixture-mounted hardware. In addition, the UWS II is part of the National Center for Advanced Manufacturing, managed by the University of New Orleans Foundation in partnership with NASA and the state of Louisiana.

"The *Orion* team is excited to build NASA's next-generation spacecraft. This is the beginning of a new era in human space flight and America's space program," said Derek Townsend, *Orion* Crew Module senior manager.

Lockheed Martin is the prime contractor to NASA for the *Orion* crew exploration vehicle. Its first manned flight is scheduled in 2015.

Energy Manufacturing Center to Be Established at Edison Welding Institute

Ohio Senator Sherrod Brown recently announced nearly $1 million in new federal funds he secured with Senator George Voinovich to create the Ohio Advanced Energy Manufacturing Center. Edison Welding Institute (EWI), Columbus, Ohio, has been chosen for this center's site. Also, Brown joined EWI President and CEO Henry Cialone to discuss how this center, combined with federal stimulus resources, will help make Ohio a Silicon Valley for clean energy manufacturing.

"The center rallies Ohio's assets in product development, process engineering, and manufacturing technology development, and brings them to bear on these vital new business opportunities," said Cialone.

EWI will be able to reach out to companies interested in advanced energy manufacturing because of this federal money, and the center will identify what they should do to get into the field and make up plans to help them go ahead, Cialone added.

It is expected the federal funding will create one or two jobs initially, but the organization is requesting $6 million a year in state funding for the new center in each of the next three years and is pursuing more federal funds. Over time, Cialone said, the center has the potential to employ 50–100 people.

Siemens Plans to Hire Welders Soon

At Siemens Transportation Systems' facility in Sacramento, Calif., as many as 40 welding and other positions are to be filled in September. These will help to make up part of 200 people the company expects to hire over the next three to five years in a $26 million, 122,000-sq-ft expansion of its light-rail construction facility. Also, this increase will allow insourcing one major component — trucks/bogies for under the vehicle — that are currently manufactured overseas.

Through Aerotek, a skilled temp agency, temporary-to-per-

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A Siemens Transportation Systems' employee welds together car shells that will ultimately become light rail vehicles. The company supplies one in every three light rail vehicles in North America, manufactured at its plant in south Sacramento.

manent employees will be hired. Welders have the opportunity to join Siemens after six months depending on performance. Applicants must apply in person at Aerotek's Rancho Cordova, Calif., offices at 3101 Zinfandel Dr., Ste. 350; they should ask for/fill out the Siemens application. The agency will continue to accept these as positions will be opened throughout the coming years.

According to Siemens spokeswoman Becky Sabin, the company wants only experienced, certified welders with extensive experience in heavy-duty fabrication who have passed qualification tests through a local welding lab.

Kimberly-Clark Obtains Jackson Products

Kimberly-Clark Corp., Dallas, Tex., recently acquired Jackson Products, Inc., Fenton, Mo. This privately held company, also known as Jackson Safety, provides welding safety products, personal protective equipment, and work zone safety products. It was founded in 1933 and has approximately 400 employees.

"Jackson Safety is an excellent fit with Kimberly-Clark Professional, as our products are complementary to Kimberly-Clark's current safety business," said Tom Burns, current president and CEO of Jackson Safety. "I'm excited about this combination because it improves our prospects for growth in the U.S., Europe, and emerging markets around the world." Burns will continue to lead this business as a division of Kimberly-Clark Professional.

The primary focus of this acquisition is to add capabilities and expertise that will accelerate combined growth. The experience and know-how of people in the Jackson Safety organization will be leveraged as well. Initial expectations include an integration team formed with participants from both organizations. A new global organization structure has already been outlined.

World's Second-Largest Solar Plant to Be Built in Florida

Lauren Engineers Constructors, Abilene, Tex., recently signed a contract with Florida Power & Light Co. (FPL) as the engineering, procurement, and construction contractor for a new 75-MW, Concentrated Solar Power Plant near Indiantown, Fla.

The Martin Next Generation Solar Energy Center will achieve milestones as the second-largest solar thermal power plant in the world, the largest solar thermal plant outside of California, and the first hybrid solar facility in the world to connect to an existing combined-cycle power plant.

The project will be located on 500 acres of land adjacent to FPL's Martin Plant. Using Parabolic Trough Technology to capture heat from the sun, it will include approximately 200,000 parabolic mirrors. Total power produced by this solar plant will be 155,000 MW hours annually — enough for 11,000 homes.

Korean Welding Show Commended by AWS

Welding Korea 2009, the 13th Korea International Welding Technology Show, recently attracted 120 companies from 10 countries. The event took place in the Changwon Exhibition Convention Center April 21–24. At its banquet, attended by more than 400 people, Chon-Liang Tsai (right), a professor of welding engineering at The Ohio State University, read a message in English from Ray Shook, the American Welding Society's (AWS) executive director. Seung-Kwan Kang (left), executive director of the Korea Welding Industry Cooperative (KWIC), translated Shook's message. The AWS offered congratulations to the show's organizers, KWIC and The Korean Welding & Joining Society (KWJS); recognized the event would generate strong interest in the area of Changwon, home of Korea's largest industrial complex for the construction of ships, railways, and other heavy industries; applauded its approach to promoting welding and cutting products during the present global economic recession; and hoped members of KWIC and KWJS will visit the FABTECH International & AWS Welding Show including METALFORM to be held Nov. 15–18 in Chicago, Ill.

USNS Carl Brashear Sets Sail

Moving smoothly past downtown San Diego, Calif., USNS Carl Brashear *(T-AKE 7) goes en route to sea trials. (Photo courtesy of Ken Wright, General Dynamics NASSCO.)*

General Dynamics NASSCO, San Diego, Calif., recently delivered *USNS Carl Brashear* (T-AKE 7) to the U.S. Navy. This ship, named in honor of the first African-American to qualify and serve as a master diver and whose life story is also portrayed in the movie *Men of Honor*, began construction in May 2007.

NASSCO has incorporated international marine technologies and commercial ship-design features into T-AKE-class ships, including an integrated electric-drive propulsion system, to minimize operating costs during their projected 40-year service life. The primary mission of these vessels is to deliver food, ammunition, fuel, and other provisions from shore stations to combat ships at sea. Their cargo capacity is more than 10,000 tons.

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Divers Hone Welding Skills at New Facility

A high-tech facility for wet and dry habitat welding training has been installed at the Oceaneering International, Inc., Siracusa Road location in Morgan City, La. Divers and welders using the site can be qualified at 40-ft water depths. A tank allows up to four divers to simulate underwater conditions for performing welding procedures used offshore during platform or ship-repair operations. In addition, it features a self-supporting personnel access platform. (Photo courtesy of Oceaneering International, Inc.)

Hobart Exhibits Gallery of Welding History

The Hobart Institute of Welding Technology, Troy, Ohio, has established a Gallery of Welding History. Its welcome sign (as shown above) provides an overview of how welding began and continues to improve the world. "The gallery displays major milestones in the joining of metals from antiquity to the present time," said André Odermatt, president of Hobart Institute. "We are incorporating antique welding machines, as well as pictorial displays of photographs and collages." Archives with books of early welding-related documents from Hobart companies and the Institute are also featured. The gallery is housed in the former John H. Blankenbuehler Memorial Library.

Davis Calibration Opens Laboratory

Davis Calibration has opened a new calibration lab in Timonium, Md. Shown above are staff members. It replaces a previous Baltimore location, and compared to that site, contains 12,000 sq ft of additional space including 1500 sq ft for a controlled-environment area. Designed by company engineers, the lab features calibration testing equipment, a streamlined work flow layout, and better logistics. The location improves access for employees, clients, freight deliveries, and pick-up. Also, it is adjacent to the company's recently opened headquarters. "As we move forward, our new Timonium calibration lab will serve as a prototype for labs throughout our entire network," said Mark Rohde, Davis Calibration's CEO.

Neptune Marine Services Receives Subsea Fabrication Order

Link Weld Engineering, the specialist fabrication business unit of Neptune Marine Services, has been awarded a contract by Acergy Australia to fabricate subsea tie-in spools for the Pluto LNG Project, a joint venture including Woodside as its operator.

The work, valued at approximately $10 million, involves fabricating 31 spools for both deep and shallow water application, ranging in sizes from 2 to 36 in. The fabrication and assembly of associated spreader beams is included.

Link Weld will assume responsibility for overall project management with all aspects of engineering and fabrication encompassing welding, nondestructive examination, gauging, cleaning, hydrotesting, coating, dimensional control surveying, and final assembly in preparation for loadout.

Jet Edge Celebrates 25th Anniversary

Jet Edge, Inc., is celebrating its 25th anniversary in the waterjet industry this year. The St. Michael, Minn., headquarters (pictured) features a 100,000-sq-ft manufacturing facility. The company entered the waterjet industry in 1984 as a manufacturer of 55,000 lb/in.^{2} intensifier pumps for precision cutting and 36,000 lb/in.^{2} pumps and portable equipment for mobile cutting, cleaning, and surface-preparation applications. It began manufacturing precision waterjet cutting tables in 1998, and in 2007, offered a 90,000 lb/in.^{2} waterjet intensifier pump. The company's systems are used worldwide by many industries.

American Welding Society

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, 2009. The Committee looks forward to receiving numerous Fellow nominations for 2010 consideration.

Sincerely,

Nancy C. Cole
Chair, AWS Fellows Selection Committee

(please type or print in black ink)

CLASS OF 2010

FELLOW NOMINATION FORM

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__________________________ Print Name__________________________
AWS Member No.____________ AWS Member No.____________

NOMINATING MEMBER:__________________________ NOMINATING MEMBER:__________________________
Print Name__________________________ Print Name__________________________
AWS Member No.____________ AWS Member No.____________

SUBMISSION DEADLINE July 1, 2009

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.

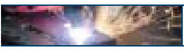
<u>Return completed Fellow nomination package to:</u>

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

Telephone: 800-443-9353, extension 2933

SUBMISSION DEADLINE: July 1, 2009

ALUMINUM Q&A



BY TONY ANDERSON

Q: I am about to become involved in the design of an aluminum welded structure. I have a question about the design strength of welded aluminum. I have been informed there are some considerations relating to the strength of aluminum welded structures that are somewhat unique to this material. If this is indeed correct can you explain what they are?

A: I would agree with the fact there are some characteristics associated with the design strength of welded aluminum structures that do require special consideration — perhaps the two most common being the reduction in strength of the base material after welding and the effect of filler alloy selection on the strength of fillet welds. We will consider each of these topics individually.

The Reduction in Strength of the Base Material after Welding

In order to appreciate this occurrence, we must first recognize the majority of welded aluminum structures are manufactured from aluminum base alloys that are in one of two prescribed metallurgical conditions. They are either in the strain hardened condition, which is generally the case with the nonheat-treatable alloys, such as the 5xxx and 3xxx series; or they are in the solution heat-treated and precipitation-hardened condition, which is generally the case with the heat-treatable alloys, such as the 6xxx, 2xxx, and 7xxx series. Aluminum alloys that are in either of the above-mentioned conditions, if subjected to adequate elevated temperature from any source, are susceptible to loss of strength through changes to their metallurgical structure. When we arc weld aluminum alloys, we certainly subject the base material immediately adjacent to the weld (known as the heat-affected zone or HAZ) to very high temperatures that are more than adequate to change the metallurgical structure and consequently reduce strength. Under most circumstances the heat of the welding operation is sufficient to reduce the strength of the base material in the HAZ of the nonheat-treatable aluminum alloys to their annealed condition. In the case of the heat-treatable alloys, the heat from welding is usually not sustained for a sufficient period of time in order to produce a fully annealed structure within the alloy; however, it is commonly adequate to facilitate an overaging and partial annealing process to transpire in the HAZ. Both of these metallurgical changes reduce the strength of the base material in the HAZ.

So, yes, during the design process it is necessary to consider the change (reduction) in strength that is typically associated with the arc welding process.

One of the most obvious examples of this consideration is seen in the welding procedure qualification requirements of any welding code or standard prescribed for the welding of aluminum structures. The minimum allowable tensile strength required when performing reduced section transverse tensile tests as stipulated by the code is not the material's original strength before welding; it is substantially lower. It is in fact the annealed strength for the nonheat-treatable alloys and a strength value based on the partially annealed condition for the heat-treatable alloys. The welding engineer should understand these reductions in strength to appreciate the mechanical test requirements involved during procedure qualification. The design engineer should understand these reductions in strength to appreciate the necessary allowances to be made in load-carrying capability of an aluminum welded structure. The Aluminum Association's *Aluminum Design Manual*, Part I, Section 7, provides methods for determining the strength of welded aluminum members, which account for the strength reduction from welding. Table 1 shows the unwelded and welded minimum ultimate tensile strength values of some nonheat-treatable and heat-treatable aluminum base alloys.

The Effect of Filler Metal Selection on the Strength of Fillet Welds

The strength of a fillet weld made in aluminum is determined by its throat size and the shear strength of the filler metal used to deposit the weld. This is the same principle that is used for calculating the strength of fillet welds made in other materials. The difference with fillet welds made in aluminum, however, is that it is not unusual to have a situation where we are able to select one of a number of different filler alloys that may be available to weld a particular aluminum base material. For example, many 6xxx series base materials and some 5xxx series base materials can be welded with 4043, 4047, 4643, 5183, 5356, 5554, 5556, and 5654 filler metals. From a design

Base Alloy & Temper	Tensile Strength Before Welding (KSI)	Tensile Strength After Welding (KSI)
1100-H16	19	11
1350-H16	16	8
3003-H18	27	14
5005-H16	24	15
5052-H32	31	25
5083-H116	44	40
5086-H34	44	35
2219-T87	64	35
6061-T6	42	24

Table 1 — Unwelded and welded minimum ultimate tensile strength values of some non-heat treatable and heat treatable aluminum base alloys.

Filler Alloy	Shear Strength (KSI)
1100	7.5
2319	16.0
4043	11.5
4047	13
4643	13.5
5183	21.0
5356	17.0
5554	17.0
5556	20.0
5654	12.0

Table 2 — Minimum shear strength values for aluminum filler alloys. (These values are minimum values and are not intended to be used for design calculations; values used for design have a safety factor incorporated and are therefore much lower.)

standpoint it should be realized that in making the selection of the most appropriate filler metal, the shear strength of that particular filler metal is an important variable to consider. There are significant differences between various aluminum filler alloys. In almost all cases, the strength of a fillet weld is dictated by the strength of the filler metal selected and the weld size. (The opposite holds for groove welds: For groove welds, the strength is usually dictated by the base metal.) See Table 2, which shows the minimum shear strength values for aluminum filler alloys.

Conclusion

When designing arc welded aluminum structures, we should make allowances for the fact that the heat of the welding operation can reduce the strength of the aluminum base material in the HAZ to a strength substantially lower than that of the original base material. We should also recognize that filler alloy selection is a more complex subject for aluminum than it is for most other materials. In aluminum welding, filler alloy selection can influence a number of weld performance characteristics, one of which is the strength of fillet welds. Therefore, from a strength standpoint, we should give serious consideration to filler alloy selection when designing welded aluminum structures.

The Aluminum Association's publication *Aluminum Design Manual — Specification & Guidelines for Aluminum Structures* is the industry's accepted guide for the design of welded aluminum structures and is available from *www.aluminum.org*.

For assistance with filler metal selection for aluminum welding, a filler metal selection chart can be used. There is a selection chart available online at *www.alcotec.com/us/en/support/Alloy-Selection-Chart.cfm*, or if you contact me, I will send you one by mail free of charge. ♦

TONY ANDERSON is corporate technical training manager for ESAB North America and coordinates specialized training in aluminum welding technology for AlcoTec Wire Corporation. He is a Registered Chartered Engineer 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 Tony Anderson c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126, or via e-mail at* tanderson@esab.com.

BRAZING Q&A

BY ALEXANDER E. SHAPIRO

Q: From time to time questions about brazing titanium in air come up from the industry. Generally, they sound like this: We have an application to braze titanium tubing to a copper (or stainless, or Inconel®, or nickel-plated bronze) part, or how to braze a titanium pin to Monel® alloy dental tool, or how to braze cemented carbide insert to a titanium shank. We don't need to braze many parts, therefore we cannot optimally buy a vacuum furnace for this purpose. What process and brazing materials do you recommend?

A: Torch or induction brazing of titanium to titanium, or titanium to other metals subject to air, is possible, but not easy. Brazing should be done with a special flux, but even the flux application cannot always guarantee good quality of joints.

The main problem to braze titanium in air is the nature and chemical specific of titanium oxide (TiO_2), which always occurs when heating titanium in any oxygen-containing atmospheres. Flux brazing of aluminum, steel, or copper in air is based on the ability of appropriate metal oxides to form lightweight chemical compounds (slag) with flux components. The slag floats in the molten brazing filler metal and readily opens the access of the brazing filler metal to the base metal surface. Titanium oxide does not react completely with fluxes at the brazing temperature, and besides, the melting point of titanium-containing slag is above 1400°C (2550°F). Therefore, the titanium surface is accessed by the brazing alloy a very short time after the flux melting.

In order to improve activity of the flux, all titanium brazing fluxes contain a significant amount (from 30 to 50%) of potassium bifluoride (KHF_2), which is decomposed during heating with the formation of hydrofluoric acid (HF). The HF acts as the etching agent on the titanium surface. Other regular components of these fluxes are potassium chloride (KCl) and lithium fluoride (LiF), which form a ternary salt eutectic with KHF_2, and this eutectic being liquid in the temperature range of 600° to 900°C (1110° to 1650°F) protects the titanium surface from oxidation during brazing. Expensive LiF is substituted by cheaper components in some fluxes; however, all components of titanium fluxes belong to the class of reactive chlorides or fluorides.

Partial evaporation of hazardous hydrogen fluoride during brazing is a side effect of application of the said reactive brazing fluxes. Therefore, flux brazing of titanium in air must be done under the hood or at least with a powerful local ventilation system.

Two groups of brazing filler metals (BFM) are used for joining titanium in air: silver-based BFM and aluminum-based BFM. Such silver BFM as BAg-5, BAg-24, and BAg-34 possess satisfactory wetting and flow along the titanium surface to be brazed. These BFM are also suitable for brazing titanium to copper, nickel-plated bronze, or steel. The brazing temperature with this BFM is in the range of 700°–850°C (1290°–1560°F). The expected strength of brazed joints is in the range of 15–26 ksi (105–176 MPa).

Pure aluminum wire is the best among aluminum BFM considering wetting and flow, but the shear strength of joints would be the lowest — in the range of 9.5–13.5 ksi (65–93 MPa). Better strength of joints 12–21 ksi (85–150 MPa) can be reached by using BAl-4 (AWS 5.8-2004, Table 3). The wire or rods made of wrought aluminum Alloy A3003 also are suitable as brazing filler metal, providing joint strength in the range of 15–22 ksi (104–152 MPa). A new brazing filler metal TiBraze®Al-665, providing the same range of joint strength and containing 2.5% magnesium, is being tested now.

Aluminum BFM are used at slight overheating above the melting point; the recommended brazing temperature is 670°–700°C (1240°–1290°F). Another feature of brazing with aluminum filler metals is delayed wetting of the titanium surface (so called "retardation time"). Aluminum alloys are spreading along the titanium surface in 4 to 5 s after the melting. Therefore, brazing with aluminum is recommended in the horizontal position unless the BFM is not fixed in the capillary joint clearance between parts to be joined. Otherwise, aluminum droplets just roll out before reacting with the titanium surface.

Joint design is very important, because we have to provide a small joint clearance and place the filler metal inside the joint clearance before heating. When joining dissimilar metals, the titanium tube should be outside (closer to the heating source) and the copper or steel tube — inside in titanium-copper/steel tubing design, because of lower thermal conductivity of titanium. The titanium tube should be heated up better than copper or steel before filler alloy melting. The recommended position of filler metal and flux before brazing is inside the tubing, e.g., in grooves or narrowing of the tube edge.

No special cleaning procedure before brazing is needed. Fine sandpaper, then rubbing with acetone and alcohol before assembling is sufficient.

Below is a general description of torch brazing titanium tubing. If you did not place the wire filler metal inside the joint clearance, you have to prepare a ring from silver or aluminum braze wire. Assemble your tubing, then deposit the flux into and above the joint clearance. Fix the wire ring over the joint area. Deposit the flux above the wire. Start heating the tubing below the wire in order to heat tubing enough before brazing. When the flux begins to melt, heat the brazing area until the braze melts. The molten braze will go down into the joint clearance between the tubing parts. Both silver and aluminum BFM spread on titanium very fast; therefore, there is no holding time at brazing temperature. Stop heating at that moment but continue to hold tubing parts in the same position. After 20 to 30 s, you can release the brazed tubing and rinse it with hot water, then clean using a metal or other rigid brush. If some places have voids, place additional braze wire over them, cover with the flux, and repeat the procedure carefully. Finally, remove black flux residues from the surface of brazed parts using a steel brush and hot water.

Due to all the specifics in the brazing operation, I strongly recommend that operators begin training themselves on practice pieces before working on production parts.

The last, but probably the most important, technical recommendation is to prebraze the titanium surfaces to be joined by coating with the brazing filler metal using the same flux. Then, assemble the parts, add filler metal and flux, and braze parts together. This approach is especially useful when brazing dissimilar metals with titanium.♦

ALEXANDER E. SHAPIRO has been a member of the C3 Committee on Brazing and Soldering since 2003, and a member of its Subcommittees on Brazing Handbook, Soldering, Brazing Specifications, and Brazing Conferences. He also serves on the A5H Subcommittee on Filler Metals and Fluxes for Brazing, and is a coauthor of the 5th Edition of AWS Brazing Handbook, *2007. He has been engaged in brazing and soldering applications engineering for his entire career.*

Readers are requested to post their questions for Dr. Shapiro on the Brazing Forum section of the Brazing and Soldering Manufacturers Committee Web site www.brazingandsoldering.com.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LETTERS TO THE EDITOR

Reader Comments on Aluminum Pipe Open Root Welding

This letter is in response to a recent Aluminum Q&A article. Tony Anderson, who authors the column, responds below.

I read the article in the April 2009 *Welding Journal* about the open root welding of aluminum pipe, and I think the author missed a few things. To give you my history, I have been an aluminum welder for 23 years at Chart E&C making brazed aluminum heat exchangers, and I have welded open root pipe.

A couple things I think that were missed were with the joint design. They have to remember that when welding in position either a 5G or 6G, the bottom of the root wants to fall or suck back. I found running with a pulse for the root or moving the foot pedal to simulate a pulse works okay, but welders have to be quick on the bottom. If they move too slow it won't help anything. Also, we are finding that depending on X-ray quality and the thickness of the pipe, the 1.5% lanthanated tungsten works best; you have better arc starting, and it holds up at the higher amperages if you need them.

I did like the article; it was very informational. But like I said, having done this, I thought I would pass on to you some things I have found to work for me.

Kevin Bigley
Weld Engineer Technician, CWI/CWE
Chart Energy & Chemicals Inc.
La Crosse, Wis.

Thank you very much for pointing out some practical aspects on open root welding of aluminum pipe of which you obviously have first-hand knowledge.

I mentioned the zirconiated tungsten in the article because I believed that it is probably the most popular of the rare earth tungsten's used for aluminum. However, you are completely correct, tungsten with lanthanum may be a very good choice. I have also come across some welders who really like to use tungsten with cerium additions and feel that they provide the most superior arc characteristics for their applications.

The point that you make about the root collapse or suck back of the root in the overhead position is an excellent one. The technique/method that you describe to overcome this phenomena is very valuable. Using a combination of travel speed and heat input through pulsing the arc is very good advice.

I think that your comments are very valid and further demonstrate the complexity of this type of pipe welding.

Tony Anderson
Technical Training Manager
ESAB North America

GTAW Using AC Current Goes Up for Discussion

The communication here relates to the same Aluminum Q&A section. Tony Anderson's response is given as well.

I am writing to you because it seems to me that a misprint has crept into the April 2009 issue of the *Welding Journal*.

On page 20 in the Aluminum Q&A section, the figure is explained as showing an aluminum AC gas tungsten arc welding (GTAW) process clearly shows a tipped tungsten, which is impossible in AC-GTAW. The tungsten electrode in AC-GTAW will always show a spherical calotte tip.

Christoph Matz
Linde AG, Linde Gas Division
Unterschleissheim, Germany

The picture is not a misprint. I also have to disagree with your remark that it is impossible to use tipped (pointed) tungsten with AC-GTAW. Your comment relating to electrodes used for AC-GTAW always having a spherical tip (balled tip) was once true. Still today, when using conventional GTAW equipment, it is very common to use the balled tip electrode.

It is possible to use a pointed electrode for AC welding if the welding machine has an adjustable electrode preheating function — Figs. 1, 2. This type of equipment is made and provided with instructions on how to set the equipment in order to use a pointed electrode — Fig. 3.

The preheating is an adjustable duration of the reverse polarity, during start. It will establish the arc as fast as possible and since the start is optimized, the electrode gets longer life. The correctly set preheating value will give the desired electrode tip shape.

When using modern inverter technology, AC-GTAW equipment with an electrode preheating feature and taking advantage of the ability to vary the AC frequency (using the high end of the frequency 100–150 Hz) and balance control (adjusting the balance control to 10–20% electrode positive), you can typically use a smaller electrode and grind it to a point. If your welding amperage is low, the point on the electrode will last for a long time, and if the current is higher, the point will deteriorate more quickly.

Fig. 1 — The red ring shows the electrode preheat function on the ESAB CaddyTig.

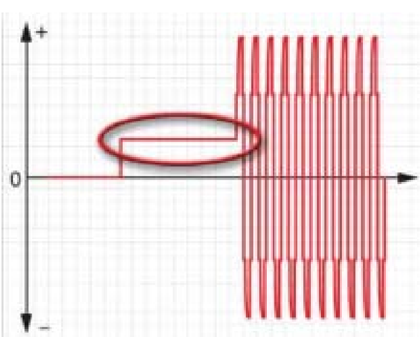

Fig. 2 — Electrode preheating is an adjustable duration of reverse polarity.

Electrode preheating

Tungsten electrode				Setting value Shielding gas	
Ø	Colour	Type		Ar	Ar + 30%He
1.6	Green	WP	V	–	–
1.6	Green	WP	U	[illegible]	[illegible]
1.6	Black	WL10	V	20	20
1.6	Black	WL10	U	[illegible]	[illegible]
2.4	Green	WP	V	45	–
2.4	Green	WP	U	[illegible]	[illegible]
2.4	Black	WL10	V	40	40
2.4	Black	WL10	U	[illegible]	[illegible]
3.2	Green	WP	V	[illegible]	–
3.2	Green	WP	U	[illegible]	[illegible]
3.2	Black	WL10	V	[illegible]	[illegible]
3.2	Black	WL10	U	70	70
4.0	Green	WP	V	[illegible]	[illegible]
4.0	Green	WP	U	[illegible]	[illegible]
4.0	Black	WL10	V	65	65
4.0	Black	WL10	U	[illegible]	[illegible]

WP = Pure tungsten electrode
WL10 = Tungsten electrode alloyed with lanthan

Fig. 3 — The electrode preheating settings required to maintain pointed tungsten electrodes when using AC-GTAW.

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Thermal Arc
www.thermalarc95s.com
(800) 426-1888

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The Lincoln Electric Co.
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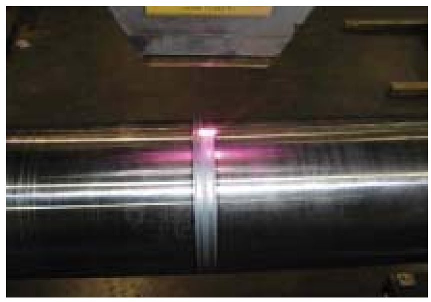

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The fifth generation of Caddy™ machines have an advanced inverter technology along with a compact design of impact-resistant polymer and aluminum casing. The Caddy™ Arc 151i and 201i single-phase DC/CC power supplies, designed primarily for SMAW, feature an adjustable arc force that sets the intensity of the arc. Additional highlights include an adjustable hot start making it easy to strike the electrode and avoid starting problems, and ESAB's ArcPlus II. The Caddy™ Tig 1500i and 2200i single-phase DC/CC machines offer control panels presenting all welding parameters in an easily understood layout. The company's two-program function allows preprogramming and program changes during welding. It offers a pulsed GTA feature for greater control of heat input and the weld pool, and micro pulse minimizes the heat-affected area. Extra details include a hot start and arc force settings. The Caddy™ Tig 2200i AC/DC adds AC welding capability with good arc stability and provides SMA and GTA performance. Its QWave™ provides low noise, and the AC frequency and balance control optimizes the weld pool. Other features include electrode preheating to facilitate good starts and extend electrode life, as well as the company's two-program function, hot start, arc force, and DC pulsed and micro pulse functions.

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(800) 372-2123

Durable Coatings Tolerate High Temperatures

When coated onto thin stainless steel sheets via the company's patented MicroDyn® sputtering technology, High Temperature Spectral Metal can withstand high temperature ranges up to 400°C. The new sheets can be cut and formed to specific sizes and various shapes. The mounting features such as slots, screw holes, and tabs can be formed into the mirror after the coating is applied. The sized mirrors can be formed into curves and cylinders with radii as small as 25 mm. These characteristics reduce the complexity of assembly into the finished product. Plus, with the ability to fabricate after coating, long trough reflectors for inline exposure systems can be created using multiple lengths. These long sheets are placed into a frame to hold their shape, permitting the fabrication of reflectors several meters in length.

Deposition Sciences, Inc.
www.depsci.com
(707) 573-6785

Comfortable Earplugs Come in Bright Colors

A line of disposable and reusable earplugs is available with optional breakaway cords. Disposable Earplugz™ provide high noise reduction ratings (NRR) of 29 and 31 NRR. GloPlugz® feature a 31 NRR, a smooth, tapered design, vibrant blue color, and soft nonallergenic polyurethane formula. SoftPlugz™ are designed with a standard barrel shape in a slightly longer design for a deeper, more secure fit. Made of nonallergenic and moisture-resistant bright orange polyurethane, they provide a 29 NRR. Washable, reusable Twisters™ have a 25 NRR, making them a choice for midrange hearing protection applications. The triple-flange design forms a triple seal in any size ear and allows wearers to hold the plug post and easily insert them without having to roll or touch the plug. An air bubble tip helps make them soft, yet durable enough for long-term use. These are made of high-visibility purple silicone.

Gateway Safety, Inc.
www.GatewaySafety.com
(800) 822-5347

Beveler Utilizes 2-hp Motor

The Model 5000 Bevel-Mill is designed for plate edge beveling for weld preparation and finish chamfering. It uses indexable carbide inserts in a mill cutting device to produce clean and accurate bevels. Additionally, the product uses a 2-hp

motor for beveling up to 8 ft/min on aluminum to stainless steel and weighs 18 lb. Other features include variable angle 15–45 deg, adjustable depth of cut, handy trigger operation, and available variable-speed controller. Corner rounding or radiuses can also be performed with interchangeable inserts used for cleaning welds off box corners or rounding edges prior to painting.

Heck Industries
www.heckind.net
(810) 632-5400

Vertical Press Brakes Include Wide Guide Ways

The BP series of vertical press brakes has been added to the company's line of metal working machinery. Each one in-

cludes features designed for years of productivity. Wide guide ways and encoder positioning of the vertical movement enable accuracy to 0.0001 in. Two-speed movement reduces cycle times. Standard items include digital readouts, photo-electric safety curtains, and electric back gauges with manual micrometer adjustment. Models range from 33 to 123 t and come in NC and Delem CNC control.

Baileigh Industrial Inc.
www.bii1.com
(920) 684-4990

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Sticky Tape Ideal for Pipe Wrapping

The Thermeez 397PS is a thermally insulating, ceramic sticky tape. It is backed with high-temperature, pressure-sensitive adhesive that is easy to align and simple to apply. This simplifies tape placement and ensures a neat and uniform installation for any thermal and electrical insulation application. Also, it is useful for any industrial, maintenance, research, and production application including pipe wrapping, insulating wires, handling molten metals, flange gaskets, expansion joints, welding arc, and molten metal splash protection. The product is woven from durable, flexible, industrial-grade ceramic fibers that have good chemical stability and resistance to thermal shock, corrosive attack, mechanical vibration, and stress. Packaging is in job-sized rolls 1, 2, or 3 in. wide and 25 ft long.

Cotronics Corp.
www.cotronics.com
(718) 788-5533

CALL FOR PAPERS

LÖT 2010
9th Int'l Conf. on Brazing, High-Temperature Brazing, and Diffusion Bonding

June 15–17, 2010
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Deadline for submission of papers: August 20, 2009.

Topics of interest include, but are not limited to, industrial applications; fundamentals; micro- and nanotechnologies; joining of glass, ceramics, and lightweight metals; modeling and simulation; quality assurance; inspection; and corrosion issues.

Sponsored by DVS and cosponsored by American Welding Society, ASM Int'l, Int'l Institute of Welding, and other societies.

For complete information and online registration, visit *www.dvs-ev.de/loet2010.*

AMERICAN WELDING SOCIETY AND AWS FOUNDATION FINANCIAL REPORT

Fiscal 2008 year in review — Deputy Executive Director and CFO Frank Tarafa

AWS continues to perform very well financially as our Treasurer Earl C. Lipphardt states in his editorial on page 8, and we are pleased to report that in 2008 the organization achieved several financial milestones as noted below and in our audited financial statements. For the third consecutive year it was a year of outstanding financial performance and growth. AWS continues to be fiscally sound as a result of an overall increase in its revenues during fiscal 2008. The Society's operating revenues were $25.5 million, representing a 12.5% increase over 2007. The surplus of revenues over expenditures in the operating funds reached a milestone as the highest surplus ever attained.

While the stock market conditions in 2008 were very dismal as the Dow Jones Industrial declined by 34% and the NASDAQ by 40%, the AWS Reserve fund investments had an unrealized loss on investments of 26.6% and the AWS Foundation's loss was 20%.

Due to the operating funds exceptional financial performance in 2008, it was able to transfer $5 million to the Reserve Fund. Although AWS is not pleased with the loss, it was minimized due to our conservative investment approach.

As a result, Total Net Assets climbed more than $1.1 million to an all-time high of $28.1 million, an increase of 4.3% over 2007.

The Society's Statement of Financial position is the healthiest in the history of the Society. Total assets at the end of 2008 exceeded $31.5 million, an increase of 4.2% over 2007.

Highlights for 2008

The AWS Board of Directors approved the transfer from the Society of $1.1 million to the multimillion-dollar portfolio of scholarship endowments of the AWS Foundation. Funding from the American Welding Society's cash reserves will enable the AWS Foundation to increase its scholarship awards to future welding professionals.

With the first acquisition in AWS history, the AWS/WELDMEX show was held January 29-31, 2008, and was extremely successful and had record exhibitors and attendees. The details of the acquisition can be found on page 44. Note 10 of the audited financial statements.

The American Welding Society joined the National Association of Manufacturers (NAM), which is led by former Governor and current President of NAM John Engler. NAM became an industry partner with the FABTECH International and AWS Welding Show in 2008. In January 2009, NAM and the Manufacturing Institute launched a new Manufacturing Skills Certification System that assists the welding industry with the workforce development challenge in helping to alleviate the shortage of welders. AWS is pleased to be at the forefront as a partner with NAM in this important certification effort.

The AWS Board approved the funding of the Iron Man comic book in combination with Marvel Comics and distributed 50,000 copies in conjunction with the premiere of the Iron Man movie.

The Welding for the Strength of America Capital Campaign inaugurated in 2006 has resulted in contributions through 2008 of $3.3 million plus the $1.1 million transfer for scholarships. The effort has dual goals to support additional scholarships for students for both entry-level welders, as well as additional training for those already in the welding profession. Our scholarship programs began in 1991 when $20,000 was awarded to grow to awards to more than 300 students in 2008 for more than $360,000. Since 1991, total awards to 2,641 students have been made for more than $3.8 million. The increase in demand for scholarship assistance continues so additional funds are needed.

Additionally, our capital campaign has, as its other focus, the American Welding Society Workforce Development Program. The focus of these efforts is welder "Recruitment to Retirement." We have implemented many programs and efforts to support this major objective. The most important undertaking has been the establishment of our SOS team — Solutions Opportunity Squad. In the United States, many of the efforts being discussed as a part of our recovery plan will require welding professionals. We must continue to recruit, train, and enlarge our welding workforce. We need your partnership to be successful. For more information, please contact Sam Gentry at sgentry@aws.org

Looking ahead, our strong Statement of Financial Position, coupled with the projected increase in revenues for 2009, continues to gives us the ability to provide and fund future programs and opportunities for our members, volunteers, and the welding industry.

We continue to be prudent in our expenditures, and we realize that there is a global economic recession that the world is currently facing. We continue to monitor our key financial indicators on a regular basis to make any adjustments needed in order to continue to provide the highest customer service for our members.

— *Continued on page 35*

AMERICAN WELDING SOCIETY AND AWS FOUNDATION FINANCIAL REPORT

— *Continued from page 34*

In conclusion, the AWS Board of Directors and AWS Foundation Trustees would like to express their appreciation to all of our members, volunteers, industry leaders, and the cooperation of organizations with which we share common goals in helping us make this a successful year during this current global economic recession.

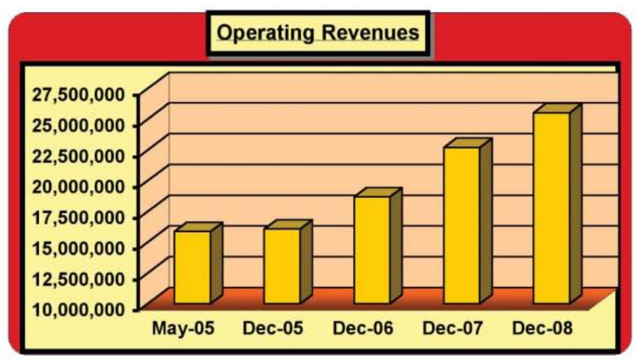
Financial highlights for 2008

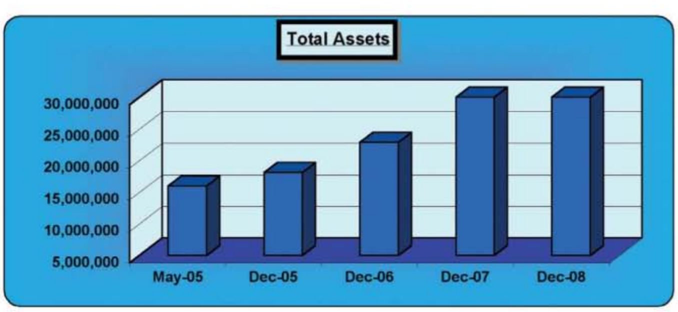
•The AWS and FABTECH alliance continues to be very successful, and the fourth FABTECH International and AWS Welding show was held in October 2008 in Las Vegas. The convention revenue square footage for AWS was 178,700 net square feet (NSF), an increase of 15,700 NSF, or 10% more than Chicago in November 2007. This is the second highest square footage in the history of AWS since Detroit in 1998 (180,200 NSF).
•Educational CWI Seminars saw continued growth during 2008 and reached record levels for both attendees and revenues.
•Membership attained a record high of 55,072, an increase of 4.6% over a one-year period.
•The Certified Welding Inspector program continues to show healthy growth with the total number of Certified Welding Inspectors reaching a record high of 25,932, an increase of 8.4% over 2007. This program is also growing globally with an increase from our 22 international agents of 102%.
•Technical – The change AWS made in order fulfillment partners to WEX (World Engineering Exchange) has continued to be very beneficial in having a dedicated focus on AWS publications that has resulted in improved customer service. The favorable trend continued in FY 2008 as total sales achieved historical highs for hard copy and electronic book revenues.
•*Welding Journal* advertising despite the economic downturn in 2008 was able to have an increase in revenue of 6% over 2007 and recorded the highest revenues for advertising since FY 2001, and it launched the *Welding Journal en Español* in coordination with the January AWS WELDMEX show.

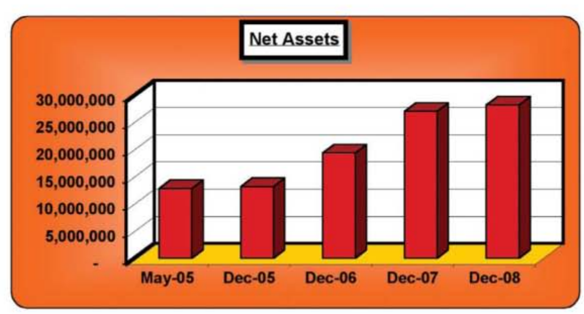
Growth at a Glance

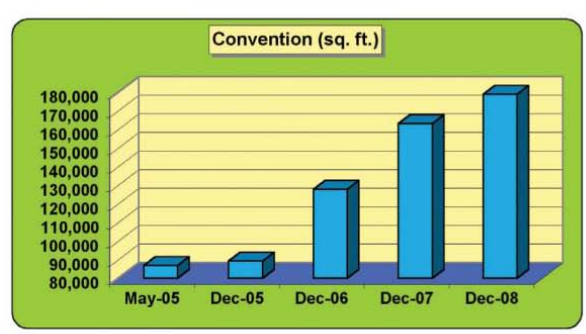
Five year comparisons

	May-05	Dec-05	Dec-06	Dec-07	Dec-08
Operating Revenue	15,870,374	16,082,208	18,689,442	22,705,914	25,541,336
Total Assets	15,955,292	18,078,856	22,862,536	30,238,890	31,506,599
Net Assets	12,812,957	13,189,728	19,339,264	27,003,910	28,164,569
Membership	47,946	48,798	50,337	52,654	55,072
Convention (sq. ft.)	86,700	89,100	127,700	163,000	178,700









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REPORT OF INDEPENDENT CERTIFIED PUBLIC ACCOUNTANTS

To the Board of Directors
American Welding Society, Inc. and AWS Foundation

We have audited the accompanying combining statement of financial position of American Welding Society, Inc. and AWS Foundation (the "Organizations") as of December 31, 2008, and the related combining statements of activities and cash flows for the year ended December 31, 2008. These combining financial statements are the responsibility of the Organizations' management. Our responsibility is to express an opinion on these combining financial statements based on our audit. Information for year ended December 31, 2007 is presented for comparative purposes only and was extracted from the audited combining financial statements presented for that year.

We conducted our audit in accordance with auditing standards generally accepted in the United States of America. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the combining financial statements are free of material misstatement. An audit includes consideration of internal control over financial reporting as a basis for designing audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion in the effectiveness of the Organization's internal control over financial reporting. An audit also includes examining, on test basis, evidence supporting the amounts and disclosures in the combining financial statements, assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

In our opinion, the combining financial statements referred to above present fairly, in all material respects, the financial position of American Welding Society, Inc. and AWS Foundation as of December 31, 2008, and the changes in their net assets and their cash flows for year then ended in conformity with accounting principles generally accepted in the United States of America.

Morrison, Brown, Argiz & Farra, LLP
Certified Public Accountants
Miami, Florida
April 1, 2009

American Welding Society

550 N.W. LeJeune Road
Miami, Florida 33126

800-443-9353
305-443-9353
305-443-7559 Fax
e-mail: info@aws.org
www.aws.org

Foundation, Inc.
Building Welding's Future through Education

550 N.W. LeJeune Road
Miami, Florida 33126

800-443-9353, ext. 293
305-445-6628
305-443-7559 Fax
e-mail: found@aws.org
www.aws.org/foundation/index.html

AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
COMBINING STATEMENT OF FINANCIAL POSITION

DECEMBER 31, 2008 (WITH COMPARATIVE TOTALS FOR DECEMBER 31, 2007)

	Operating Fund	Reserve Fund	AWS Foundation	Total 2008	Total 2007
ASSETS:					
Cash and cash equivalents	$ 1,294,571	$ 100	$ 159,098	$ 1,453,769	$ 1,521,159
Certificates of deposit	2,203,436	49,008	-	2,252,444	2,145,356
Accounts and other receivables, net of allowance for doubtful accounts of approximately $189,000 and $154,000 at December 31, 2008 and 2007, respectively	2,006,433	-	-	2,006,433	1,424,231
Pledges receivable	-	-	714,120	714,120	951,840
Inventory	235,908	-	-	235,908	183,226
Prepaid and other assets	855,593	-	80,928	936,521	447,727
Deposits and other receivables	16,733	-	6,528	23,261	36,387
Investments	-	15,181,964	6,137,367	21,319,331	20,967,749
Property and equipment, less accumulated depreciation	2,564,812	-	-	2,564,812	2,561,215
TOTAL ASSETS	$ 9,177,486	$ 15,231,072	$ 7,098,041	$ 31,506,599	$ 30,238,890
LIABILITIES:					
Accounts payable and accrued expenses	$ 867,278	$ -	$ -	$ 867,278	$ 1,039,994
Deferred membership, subscription and seminar income	2,474,752	-	-	2,474,752	2,194,986
TOTAL LIABILITIES	3,342,030	-	-	3,342,030	3,234,980
COMMITMENTS AND CONTINGENCIES (NOTE 9)					
NET ASSETS (DEFICIT):					
Unrestricted	5,835,456	15,231,072	(745,860)	20,320,668	20,134,748
Temporarily restricted	-	-	3,278,062	3,278,062	3,477,567
Permanently restricted	-	-	4,565,839	4,565,839	3,391,595
TOTAL NET ASSETS	5,835,456	15,231,072	7,098,041	28,164,569	27,003,910
TOTAL LIABILITIES AND NET ASSETS	$ 9,177,486	$ 15,231,072	$ 7,098,041	$ 31,506,599	$ 30,238,890

The accompanying notes are an integral part of these financial statements.

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AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
COMBINING STATEMENT OF ACTIVITIES

FOR THE YEAR ENDED DECEMBER 31, 2008 (WITH COMPARATIVE TOTALS FOR THE YEAR ENDED DECEMBER 31, 2007)

	Unrestricted Net Assets			Temporarily Restricted	Permanently Restricted	Total	Total
	Revenues	Expenses	Net	Net Assets	Net Assets	2008	2007
OPERATING ACTIVITIES:							
Convention	$ 2,069,440	$ 454,574	$ 1,614,866	$ -	$ -	$ 1,614,866	$ 1,347,323
Educational Services	3,991,941	3,346,711	645,230	-	-	645,230	873,523
Marketing and corporate communications	-	629,167	(629,167)	-	-	(629,167)	(540,868)
International activities and governmental affairs	6,600	230,780	(224,180)	-	-	(224,180)	(185,369)
AWS Foundation	-	498,295	(498,295)	-	-	(498,295)	(302,303)
WEMCO	95,094	214,274	(119,180)	-	-	(119,180)	(126,076)
RWMA	94,603	190,855	(96,252)	-	-	(96,252)	(102,054)
Membership	2,704,533	1,485,187	1,219,346	-	-	1,219,346	1,174,489
Certification	8,543,872	2,436,066	6,107,806	-	-	6,107,806	5,253,723
Technical	4,244,974	1,781,357	2,463,617	-	-	2,463,617	1,873,357
Publications	3,610,373	2,829,692	780,681	-	-	780,681	747,073
Administration	121,240	4,100,322	(3,979,082)	-	-	(3,979,082)	(3,756,240)
Building operations	58,666	58,666	-	-	-	-	-
Board approved programs	-	75,557	(75,557)	-	-	(75,557)	(89,700)
Safety and Health	-	-	-	-	-	-	73
TOTAL OPERATING FUND BEFORE TRANSFER	25,541,336	18,331,503	7,209,833	-	-	7,209,833	6,166,951
INTERFUND TRANSFER	-	6,100,000	(6,100,000)	(221)	-	(6,100,221)	-
TOTAL OPERATING FUND AFTER TRANSFER	25,541,336	24,431,503	1,109,833	(221)	-	1,109,612	6,166,951
RESERVE:							
Gain (loss) on investments	-	5,327,247	(5,327,247)	-	-	(5,327,247)	220,571
TFPS, Inc.	2,142	-	2,142	-	-	2,142	2,199
Interest and dividends	551,610	-	551,610	-	-	551,610	454,145
TOTAL RESERVE FUND BEFORE TRANSFER	553,752	5,327,247	(4,773,495)	-	-	(4,773,495)	676,915
INTERFUND TRANSFER	5,000,000	-	5,000,000	-	-	5,000,000	-
TOTAL RESERVE FUND AFTER TRANSFER	5,553,752	5,237,247	226,505	-	-	226,505	676,915
AWS FOUNDATION:							
Donations	185,555	-	185,555	552,679	86,159	824,393	897,985
Interest	106,099	-	106,099	99,139	-	205,238	289,186
Gain (loss) on investments	-	1,115,328	(1,115,328)	(735,568)	-	(1,850,896)	43,010
Net assets released from restrictions by satisfaction of purpose restrictions	127,670	-	127,670	(127,670)	-	-	-
Operating expenses	-	128,866	(128,866)	-	-	(128,866)	(113,321)
Scholarships	-	189,338	(189,338)	-	-	(189,338)	(192,195)
Fellowships	-	91,666	(91,666)	-	-	(91,666)	(80,556)
Fundraising and other	-	44,544	(44,544)	-	-	(44,544)	(23,329)
TOTAL AWS FOUNDATION FUND BEFORE TRANSFER	419,324	1,569,742	(1,150,418)	(211,420)	86,159	(1,275,679)	820,780
INTERFUND TRANSFER	-	-	-	12,136	1,088,085	1,100,221	-
TOTAL AWS FOUNDATION FUND AFTER TRANSFER	419,324	1,569,742	(1,150,418)	(199,284)	1,174,244	(175,458)	820,780
Change in Net Assets	-	-	185,920	(199,505)	1,174,244	1,160,659	7,664,646
Net Assets, Beginning	-	-	20,134,748	3,477,567	3,391,595	27,003,910	19,339,264
Net Assets, Ending	$ -	$ -	$ 20,320,668	$ 3,278,062	$ 4,565,839	$ 28,164,569	$ 27,003,910

The accompanying notes are an integral part of these financial statements.

AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
COMBINING STATEMENT OF CASH FLOWS

FOR THE YEAR ENDED DECEMBER 31, 2008 (WITH COMPARATIVE TOTALS FOR THE YEAR ENDED DECEMBER 31, 2007)

	Operating Fund	Reserve Fund	AWS Foundation	Total 2008	Total December 31, 2007
CASH FLOWS FROM OPERATING ACTIVITIES:					
Change in net assets before interfund transfer	$ 7,209,833	$ (4,773,495)	$ (1,275,679)	$ 1,160,659	$ 7,664,646
Adjustments to reconcile change in net assets to net cash provided by operating activities:					
(Gain) loss on investments	-	5,327,247	1,850,896	7,178,143	(263,581)
Depreciation	227,425	-	-	227,425	245,465
Provision for losses on accounts receivable	45,000	-	-	45,000	45,000
Changes in operating assets and liabilities:					
Increase in accounts and other receivables	(627,202)	-	-	(627,202)	(338,715)
Decrease in pledges receivable	-	-	237,720	237,720	64,258
Increase in inventory	(52,682)	-	-	(52,682)	(31,810)
(Increase) decrease in prepaids and other assets	(495,008)	-	6,214	(488,794)	(134,922)
(Increase) decrease in deposits and other receivables	6,570	-	6,555	13,125	(11,933)
Decrease in accounts payable and accrued expenses	(164,088)	-	(8,627)	(172,715)	(517,189)
Increase in deferred membership, subscription and seminar income	279,766	-	-	279,766	228,898
NET CASH PROVIDED BY OPERATING ACTIVITIES	6,429,614	553,752	817,079	7,800,445	6,950,117
CASH FLOWS FROM INVESTING ACTIVITIES:					
Increase in certificate of deposits	(104,946)	(2,142)	-	(107,088)	(2,100,689)
Purchases of property and equipment	(231,022)	-	-	(231,022)	(258,338)
Purchases of investment securities	-	(5,551,610)	(1,978,115)	(7,529,725)	(6,271,733)
NET CASH USED IN INVESTING ACTIVITIES	(335,968)	(5,553,752)	(1,978,115)	(7,867,835)	(8,630,760)
CASH FLOWS FROM FINANCING ACTIVITIES:					
Interfund transfers	(6,100,221)	5,000,000	1,100,221	-	-
NET CASH (USED IN) PROVIDED BY FINANCING ACTIVITIES	(6,100,221)	5,000,000	1,100,221	-	-
NET DECREASE IN CASH AND CASH EQUIVALENTS	(6,575)	-	(60,815)	(67,390)	(1,680,643)
CASH AND CASH EQUIVALENTS, BEGINNING	1,301,146	100	219,913	1,521,159	3,201,802
CASH AND CASH EQUIVALENTS, ENDING	$ 1,294,571	$ 100	$ 159,098	$ 1,453,769	$ 1,521,159

The accompanying notes are an integral part of these financial statements.

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AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
NOTES TO COMBINING FINANCIAL STATEMENTS DECEMBER 31, 2008

NOTE 1. NATURE OF ORGANIZATION AND SIGNIFICANT ACCOUNTING POLICIES

Organization and Purpose

The accompanying combining financial statements include the accounts of American Welding Society, Inc., its wholly-owned subsidiary TFPS, Inc. and its affiliate, AWS Foundation (collectively, the "Organizations").

All material inter-organization accounts and transactions have been eliminated in the combination. American Welding Society, Inc. and AWS Foundation are not-for-profit entities, exempt from income tax under Section 501 (c)(3) of the Internal Revenue Code and are primarily engaged in welding technology, education and research activities. For income tax purposes, publication advertising revenue and rental income are "considered unrelated business income" and subject to income tax. TFPS, Inc., a taxable organization, engages in profit-oriented activities.

Basis of Accounting

The financial statements of the Organizations are prepared on the accrual basis of accounting. The accounts of the Organizations are maintained for internal reporting purposes in accordance with the principles of fund accounting.

Basis of Presentation

Financial statement presentation follows the recommendations of the Financial Accounting Standards Board ("FASB") and the provisions of the Statements of Financial Accounting Standards ("SFAS") No. 117, *Financial Statements of Not-For-Profit Organizations*. Under SFAS No. 117, the Organization is required to report information regarding its financial position and activities according to three classes of net assets: unrestricted net assets, temporarily restricted net assets, and permanently restricted net assets based on the existence or absence of donor-impose restrictions. The three classes of net asset categories are as follows:

Unrestricted — Net assets which are free of donor-imposed restrictions; all revenues, gains, and losses that are not changes in permanently or temporarily restricted net assets.

Temporarily Restricted — Net assets where the use by the Organization is limited by donor-imposed stipulations that either expire by passage of time or that can be fulfilled or removed by actions of the Organization pursuant to those stipulations.

Permanently Restricted — Net assets where the use by the Organization is limited by donor-imposed stipulations that neither expire with the passage of time nor can be fulfilled or otherwise removed by actions of the Organization.
The transactions of the Organization are categorized into separate funds. The purpose and net asset classification are as follows:

Operating — This fund is used to account for all unrestricted net assets of American Welding Society, Inc., except for those accounted for in the reserve fund. The operating fund also provides administrative support to the AWS Foundation.

Reserve — This fund is used to account for Board designated reserve funds which are to be used to supplement the cash needs of the operating fund and to account for the activities of TFPS, Inc.

AWS Foundation — AWS Foundation's temporarily restricted net assets consists of donor-restricted contributions to be used for awards and scholarships. Permanently restricted net assets consist solely of an endowment fund.

Membership Fees and Services

Membership and subscription revenues are deferred when received and recognized as revenue over life of the membership and subscription.

Contributions

In accordance with SFAS No. 116, *Accounting for Contributions Received and Contributions Made*, contributions received are recorded as unrestricted, temporarily restricted or permanently restricted support depending on the existence and/or nature of any donor restrictions.

Support that is restricted by the donor is reported as an increase in unrestricted net assets if the restriction expires in the reporting period in which the support is recognized. All other donor-restricted support is reported as an increase in temporarily or permanently restricted net assets, depending on the nature of the restriction. When a restriction expires (that is, when a stipulated time restriction ends or purpose restriction is accomplished), temporarily restricted net assets are reclassified to unrestricted net assets and reported in the combining statement of activities as net assets released from restrictions.

Promise to Give

Contributions are recognized when the donor makes a promise to give to the Organizations, that is, in substance, unconditional. All other donor-restricted contributions are reported as increase in temporarily or permanently restricted net assets depending on the nature of the restrictions.

When a restriction expires, temporarily restricted net assets are transferred to unrestricted net assets. The Organizations had unconditional promises to give of $714,120 as of December 31, 2008 (NOTE 2).

The Organizations use the allowance method to determine the estimated unconditional promise to give that are doubtful of collection. The allowance is based on prior years' experience and management's analysis of specific promises made.

Cash Equivalents

The Organizations consider all highly liquid investments with an initial maturity of three months or less to be cash equivalents.

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AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
NOTES TO COMBINING FINANCIAL STATEMENTS DECEMBER 31, 2008

NOTE 1. NATURE OF ORGANIZATION AND SIGNIFICANT ACCOUNTING POLICIES (CONTINUED)

Certificates of Deposit

At December 31, 2008, the Organization had various Certificates of Deposit amounting to $2,252,444. The Certificates of Deposit bear interest between 4.40% and 4.76% and mature at various dates through September 23, 2009.

Investments

The Organizations report their investments under SFAS No. 124, *Accounting for Certain Investments Held by Not-For-Profit Organizations*. Under SFAS No. 124, a not-for-profit organization is required to report investments in equity securities with readily determinable fair values and all investments in debt securities at fair value. The fair value of marketable securities is determined by quoted market prices. Investment income, including realized and unrealized gains and losses are reported as either unrestricted, temporarily restricted or permanently restricted, depending on the existences of donor imposed restrictions on the income from the investments in the statement of activities and changes in net assets.

Risk and Uncertainties

The Organizations have investments in mutual funds that are exposed to various risk, such as interest rate, market and credit risk. Due to the level of risk associated with certain investment securities and the level of uncertainty related to changes in the value of investments securities, it is at least reasonably possible that changes in risks in the near term would materially affect combining statement of activities. The Organizations, through their investment advisor, monitors the Organizations' investments and the risk associated on a regular basis, which the Organizations believe minimizes these risks.

Property and Equipment

Property and equipment are defined by the Organizations as assets with an initial, individual cost of more than $1,000 and an estimated useful life in excess of one year. Property and equipment is stated at cost and is depreciated using the straight-line method over the following estimated useful lives of the respective assets:

	Estimated Useful Lives (Years)
Building and improvements	14-29
Furniture and equipment	5-7

Inventory

Inventory consists primarily of work-in-process relating to various publications and is valued at cost. Cost is determined by the actual expenditures incurred in the production process.

Concentration of Credit Risk

Financial instruments that potentially subject the Organizations to a concentration of credit risk is cash and certificates of deposit. The Organizations maintain their cash and certificates of deposit with a commercial bank. Accounts at the bank are insured by the Federal Deposit Insurance Corporation up to $250,000 per bank. At December 31, 2008, the Organizations maintained cash balances totaling approximately $1,454,000 at an institution in excess of this federally insured limit; of this amount, approximately $878,000 was invested in overnight repurchase agreements to obtain optimum investment income.

The Organizations' investments are subject to the normal "market risks" of these types of investments, which are traded on equity markets.

Volunteer Services

A large number of people have contributed significant amounts of time to the activities of the Organizations. The combined financial statements do not reflect the value of these contributed services because they do not meet the recognition criteria of SFAS No. 116, *Accounting for Contributions Received and Contributions Made*.

Allocation Expenses

The cost of performing the Organizations' various activities have been summarized on a functional basis in the accompanying combining statement of activities. Certain occupancy costs have been allocated among the activities benefited.

Prepaids and Other Assets

Prepaids and other assets consist primarily of work-in-process costs relating to various publications that have not yet been released for distribution. Once the publication is complete and ready for its intended use, the costs are amortized over the life of the publications, usually between two to three years. Additionally, expenditures which relate to programs for the next fiscal year are reported as a prepaid asset and are expensed during the next year as the related program function takes place.

Impairment of Long-Lived Assets

The carrying value of long-lived assets is reviewed if the facts and circumstances, such as significant declines in revenues, earnings or cash flows, or material adverse changes in the business climate indicate that they may be impaired. The Organizations perform their review by comparing the carrying amounts of long-lived assets to the estimated undiscounted cash flows relating to such assets. If any impairment in the value of the long-lived assets is indicated, the carrying value of the long-lived assets is adjusted to reflect such impairment based on the fair value of the impaired assets or an estimate of fair value based on discounted cash flows.

AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
NOTES TO COMBINING FINANCIAL STATEMENTS DECEMBER 31, 2008

NOTE 1. NATURE OF ORGANIZATION AND SIGNIFICANT ACCOUNTING POLICIES (CONTINUED)

Use of Estimates

The preparation of financial statements in conformity with accounting principles generally accepted in the United States of America requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues and expenses during the reporting period. Actual results could differ from those estimates.

Income Taxes

American Welding Society, Inc. and AWS Foundation are not-for-profit corporations and are exempt from federal income taxes under Section 501(c)(3) of the Internal Revenue Code. Accordingly, no provision for federal or state income tax is required for revenues derived from its tax-exempt function. The Organizations are taxed on unrelated business income less the related expenses. During the year ended December 31, 2008, there was no net income generated from unrelated business activities.

Recently Issued Accounting Standards

Fair Value Measurements

In September 2006, the FASB issued SFAS No. 157, "Fair Value Measurements," which defines fair value, establishes a framework for measuring fair value, and expands disclosures about fair-value measurements required under other accounting pronouncements. SFAS No. 157 does not change existing guidance as to whether or not an instrument is carried at fair value and is effective for financial statements issued for fiscal years beginning after November 15, 2007, and interim periods within those fiscal years. In February 2008, the FASB issued FASB Staff Position ("FSP") No. FAS 157-1 (FSP FAS 157-1), which excludes SFAS No. 13, "Accounting for Leases" and certain other accounting pronouncements that address fair value measurements under SFAS No. 13, from the scope of SFAS No. 157. In February 2008, the FASB issued FASB Staff Position No. 157-2 (FSP 157-2), which provides a one-year delayed application of SFAS No. 157 for nonfinancial assets and liabilities, except for items that are recognized or disclosed at fair value in the financial statements on a recurring basis (at least annually). The adoption is not expected to have a material impact on the combining financial statements.

In October 2008, the FASB issued FASB Staff Position No. FAS 157-3, "Determining the Fair Value of a Financial Asset in a Market That Is Not Active" (FSP 157-3), which clarifies the application of SFAS No. 157 when the market for a financial asset is inactive. Specifically, FSP 157-3 clarifies how (1) management's internal assumptions should be considered in measuring fair value when observable data are not present, (2) observable market information from an inactive market should be taken into account, and (3) the use of broker quotes or pricing services should be considered in assessing the relevance of observable and unobservable data to measure fair value. The guidance in FSP 157-3 is effective immediately and will apply to the Organizations upon adoption of SFAS No. 157.

The Fair Value Option for Financial Assets and Financial Liabilities

In February 2007, the FASB issued SFAS No. 159, *"The Fair Value Option for Financial Assets and Financial Liabilities."* SFAS No. 159 permits entities to choose to measure many financial instruments and certain other items at fair value that are not currently required to be measured at fair value. The objective is to improve financial reporting by providing entities with the opportunity to mitigate volatility in reported earnings caused by measuring related assets and liabilities differently without having to apply complex hedge accounting provisions. SFAS No. 159 also establishes presentation and disclosure requirements designed to facilitate comparisons between entities that choose different measurement attributes for similar types of assets and liabilities. SFAS No. 159 is effective for fiscal years beginning after November 15, 2007. The adoption of SFAS No. 159 did not have a material impact to the Organizations' combining financial statements.

The Hierarchy of Generally Accepted Accounting Principles

In May 2008, the FASB issued SFAS No. 162, "The Hierarchy of Generally Accepted Accounting Principles." The new standard is intended to improve financial reporting by identifying a consistent framework, or hierarchy, for selecting accounting principles to be used in preparing financial statements that are presented in conformity with accounting principles generally accepted in the United States of America (GAAP) for nongovernmental entities. Prior to the issuance of SFAS No. 162, GAAP hierarchy was defined in the American Institute of Certified Public Accountants (AICPA) Statement on Auditing Standards (SAS) No. 69, "The Meaning of Present Fairly in Conformity With Generally Accepted Accounting Principles." SFAS No. 162 is effective for fiscal years beginning after November 15, 2008. Management does not expect that the adoption of SFAS No. 162 will have a material effect on the Organizations' combining financial statements.

Net Asset Classification of Funds

In February 2008, the FASB issued FSP No. FAS 117-1, "Endowments of Not-for-Profit Organizations: Net Asset Classification of Funds Subject to an Enacted Version of the Uniform Prudent Management of Institutional Funds Act ("UPMIFA"), and Enhanced Disclosures for all Endowment Funds."

This FSP provides guidance on the net classification of donor-restricted endowment funds for a not-for-profit that is subject to an enacted version of the UPMIFA of 2006. This FSP improves disclosures about an organization's endowment funds (both donor-restricted and board designated) whether or not the organization is subject to UPMIFA.

AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
NOTES TO COMBINING FINANCIAL STATEMENTS DECEMBER 31, 2008

NOTE 1. NATURE OF ORGANIZATION AND SIGNIFICANT ACCOUNTING POLICIES (CONTINUED)

In initially applying the guidance, an organization shall report any resulting net asset reclassifications in a separate line item within the organization's statement of activities for that period. If the organization applies the provisions of this FSP subsequent to the period in which UPMIFA is first effective, the reclassification shall be reported in those financial statements in the earliest comparative period presented for which UPMIFA was effective. If the period in which UPMIFA first became effective is not presented, the effects of the reclassification shall be reported retrospectively in the earliest period presented.

The provisions of this FSP shall be effective for fiscal years ending after December 15, 2008. Earlier application is permitted provided that annual financial statements for that fiscal year have not been previously issued. The Organizations are currently evaluating the effect FSP No. FAS 117-1 will have on its combining financial statements.

NOTE 2. PLEDGES RECEIVABLE

Unconditional promises to give that are expected to be collected within one year are recorded at net realizable value. Unconditional promises to give that are expected to be collected in future years are recorded at the present value of the estimated future cash flows. Amortization of the discounts is included in donations in the combining statement of activities.

Pledges receivable include the following unconditional promises as of December 31, 2008:

Amounts due in:		
Less than one year	$	443,440
One to five years		311,950
More than five years		2,500
Total		757,890
Less: Unamortized discount		43,770
Net unconditional pledges	$	714,120

Pledges receivable in the amount of $713,220 as of December 31, 2008, are restricted for awards and scholarships. Management believes that all pledges are fully collectible. Therefore management has not recorded an allowance for collection losses.

NOTE 3. INVESTMENTS

Investments, which are comprised entirely of mutual funds, are presented in the combining financial statements at their fair market values and consist of the following at December 31, 2008:

Vanguard Investments – Reserve Fund

High-Yield Corporate Fund	$	836,868
Intermediate - Term Corporate Fund		1,012,647
Intermediate - Term Bond Index Fund		1,437,318
Long - Term Bond Index Fund		1,213,964
Short - Term Bond Index Fund		1,222,499
Short - Term Investment Grade Fund		1,211,222
Explorer Fund		422,128
Total Stock Market Index Fund		1,556,975
Strategic Equity Fund		415,956
Morgan Growth Fund		682,965
Total International Stock Index Fund		3,113,075
U.S. Growth Fund		685,902
Windsor II Fund		1,370,445
Reserve Fund Investments		15,181,964

Vanguard Investments - AWS Foundation

Prime Money Market Fund	$	14,418
High-Yield Corporate Fund		384,658
Intermediate - Term Bond Index Fund		627,629
Long- Term Bond Index Fund		707,339
Short-Term Bond Index Fund		684,570
Intermediate-Term Investment Grade Fund		679,107
Short-Term Investment Grade Fund		841,038
Explorer Fund		290,045
Total Stock Market Index Fund		692,870
Strategic Equity Fund		142,614
Morgan Growth Fund		248,270
Total International Stock Index Fund		1,500,130
U.S. Growth Fund		249,152
Windsor II Fund		497,935
Less: Section Fund Investments		(1,422,408)
AWS Foundation Investments		6,137,367
Total Investments	$	21,319,331

AWS Foundation administers investments on behalf of certain affiliated sections. The investments aggregated $1,422,408 at December 31, 2008 and are not included in the combining financial statements.

Investment income (losses) consisted of the following for the year ended December 31, 2008:

		Reserve Fund		AWS Foundation
Interest and dividends	$	553,752	$	205,238
Net realized and unrealized losses on investments		(5,237,247)		(1,850,896)
	$	(4,773,495)	$	(1,645,658)

Interest and dividends under the Reserve Fund include the activities of TFPS, Inc.

During the period January 1, 2009 through April 1, 2009, the market values in the global financial markets incurred significant losses. As of March 31, 2009, the Organizations' investments have declined approximately $1,100,000 or 5% in value from December 31, 2008, the date of the Statement of Financial Position.

AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
NOTES TO COMBINING FINANCIAL STATEMENTS DECEMBER 31, 2008

NOTE 4. PROPERTY AND EQUIPMENT, NET

Property and equipment consist of the following as of December 31, 2008:

Land	$ 816,726
Construction in-progress	81,220
Building and improvements	4,828,272
Furniture and equipment	4,472,685
	10,198,903
Less: accumulated depreciation	7,634,091
	$ 2,564,812

Depreciation expense was $227,425 for the year ended December 31, 2008.

NOTE 5. TEMPORARILY RESTRICTED NET ASSETS

Net assets of the AWS Foundation in the amount of $3,278,062 as of December 31, 2008, are restricted for awards and scholarships. Net assets of $127,670 were released from donor restrictions by granting awards and scholarships for the year ended December 31, 2008.

NOTE 6. PERMANENTLY RESTRICTED NET ASSETS

Net assets in the amount of $4,565,839 as of December 31, 2008, are permanently restricted endowments which are to provide a source of funds predominantly for educational, research and other charitable purposes.

NOTE 7. INTERFUND TRANSFER

Funds are periodically transferred from the Operating Fund to the Reserve Fund and the AWS Foundation Fund. For the year ended December 31, 2008, the Operating Fund transferred $5,000,000 to the Reserve Fund, due to positive financial results and cash flows. In addition, for the year ended December 31, 2008 the Operating Fund transferred $1,100,221 to the AWS Foundation Fund to increase scholarship awards.

NOTE 8. BOARD APPROVED PROGRAMS

American Welding Society, Inc.'s Board of Directors periodically approves expenditures for special programs designed, among other things to further the development and public awareness of welding technology, education and standards. Expenses incurred for special board approved programs during the year ended December 31, 2008 amounted to $75,557.

NOTE 9. COMMITMENTS AND CONTINGENCIES

Operating Leases

During 2008, the Organizations entered into various operating lease agreements involving equipment. Minimum monthly payments are approximately $17,000. Minimum annual payments on the non-cancellable portion of the leases are as follows:

2009	$ 203,000
2010	203,000
2011	203,000
2012	59,000
2013	25,000
Total	$ 693,000

Royalty Agreement

On October 26, 2005, the American Welding Society, Inc. (the "Organization") entered into a Publication Sales Agreement with World Engineering Exchange ("WEX"), whereby WEX has been given non-exclusive worldwide rights to duplicate, package, facsimile transmit, price, promote, distribute, sell and or lease the Organization's documents and technical publications through paper and electronic media formats and compilations. On May 8, 2007, the term of the agreement was amended to extend the initial period to sixty (60) months commencing on January 1, 2006. The agreement can be renewed for two (5) year periods with the same terms and conditions except for the pricing which shall be negotiated by the parties in good faith.

WEX will pay the Organization royalties based on the percentages indicated per the agreement. The agreement is contingent upon the Organization's continued performance, which includes the production and release of new and revised publications periodically. In addition, the list price shall be no less than the prices as indicated in the Organization's catalog. Under the terms of this agreement, the Organization earned approximately $4,343,000 during the year ended December 31, 2008. Such amount has been included in revenues in various departments in the combining statement of activities.

On April 2, 2007 the Organization entered into an agreement with The American Society of Mechanical Engineers ("ASME"), whereby ASME has the nonexclusive right to reproduce the Organization's Standards. ASME will pay the Organization royalties equal to 20% of the net sales per quarter. Under the terms of this agreement, the Organization earned approximately $303,000 during the year ended December 31, 2008.

NOTE 10. WELDMEX LLC

On December 5, 2007, the Organization entered into an agreement with Trade Show Consulting, LLC ("TSC") to create a limited liability company known as Weldmex LLC

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AMERICAN WELDING SOCIETY, INC. AND AWS FOUNDATION
NOTES TO COMBINING FINANCIAL STATEMENTS DECEMBER 31, 2008

NOTE 10. WELDMEX LLC (CONTINUED)

(the "LLC") to acquire and operate the Weldmex Trade Show, a show solely owned by TSC.

In consideration for the sale, transfer and assignment of the Weldmex Trade Show to the LLC, TSC was paid an initial sum in the amount of $400,000 on January 2, 2008. At the end of the 2008 Weldmex show, the Organization is to pay TSC $122,000 no later than sixty days from the completion of the show. The Organization is to also pay TSC $122,000 at the end of the 2009 Weldmex show. The existence of the LLC shall continue through January 30, 2013 at which point the LLC is to purchase the entire percentage interest of TSC for an amount equal to 45% of the earnings before interest, taxes, depreciation and amortization calculated for the 2012 Weldmex show multiplied by a factor of 6.5. Funds for the purchase of the Weldmex Trade Show shall come from the LLC, or, if the LLC does not have sufficient funds, the Organization shall make the payment.

The percentage interest of the Organization in the LLC is 55% and the percentage of TSC in the LLC is 45%. Each Member is entitled to vote its percentage interest with respect to any action required or permitted to be taken by the Members under the Operating Agreement entered into or the Florida Limited Liability Act. The business and affairs of the LLC, including strategic direction and budget approval is to be overseen under the direction and control of the Executive Director at the Organization and the President of TSC. Allocations of profit or loss will be allocated to the Members in accordance with the percentage interest of each member. The Organization will be responsible for the management and administration of the finances of the LLC.

The initial payment in the amount of $400,000 was made by the Organization on January 2, 2008. The second payment of $122,000 was made on April 30, 2008. Such amounts have been included in the caption prepaids and other assets in the statement of position of the accompanying combining financial statements.

NOTE 11. EMPLOYEE BENEFIT PLAN

The Organizations have a simplified employee pension plan for all full-time employees. Full-time employees are eligible for participation in the plan the first day of the month after they are employed. Effective June 1, 2007, the Organizations will contribute a maximum of 6% of the employees' base salary, composed of a 4% initial contribution and a match of 50% of the first 4% of an employee's voluntary contribution. The Organizations made contributions totaling approximately $312,700 during the year ended December 31, 2008.

NOTE 12. EMPLOYMENT AGREEMENT

The Organizations entered into an employment agreement with its Executive Director on January 1, 2007 for a term of three years; the first year commencing January 1, 2007. The Organizations will provide certain benefits for the period set forth in the agreement.

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SMAW BEST PRACTICES

Shielded metal arc welding (SMAW) uses an arc between a covered electrode and a weld pool to accomplish the weld. As the welder steadily feeds the covered electrode into the weld pool, the decomposition of the covering evolves into gases that shield the pool. The process is used without the application of pressure, and with filler metal from the covered electrode. The sound weld metal the process deposits is used not only for joining but also for applying a functional surface to metal products.

Because of the many possible variations in the composition of the electrode

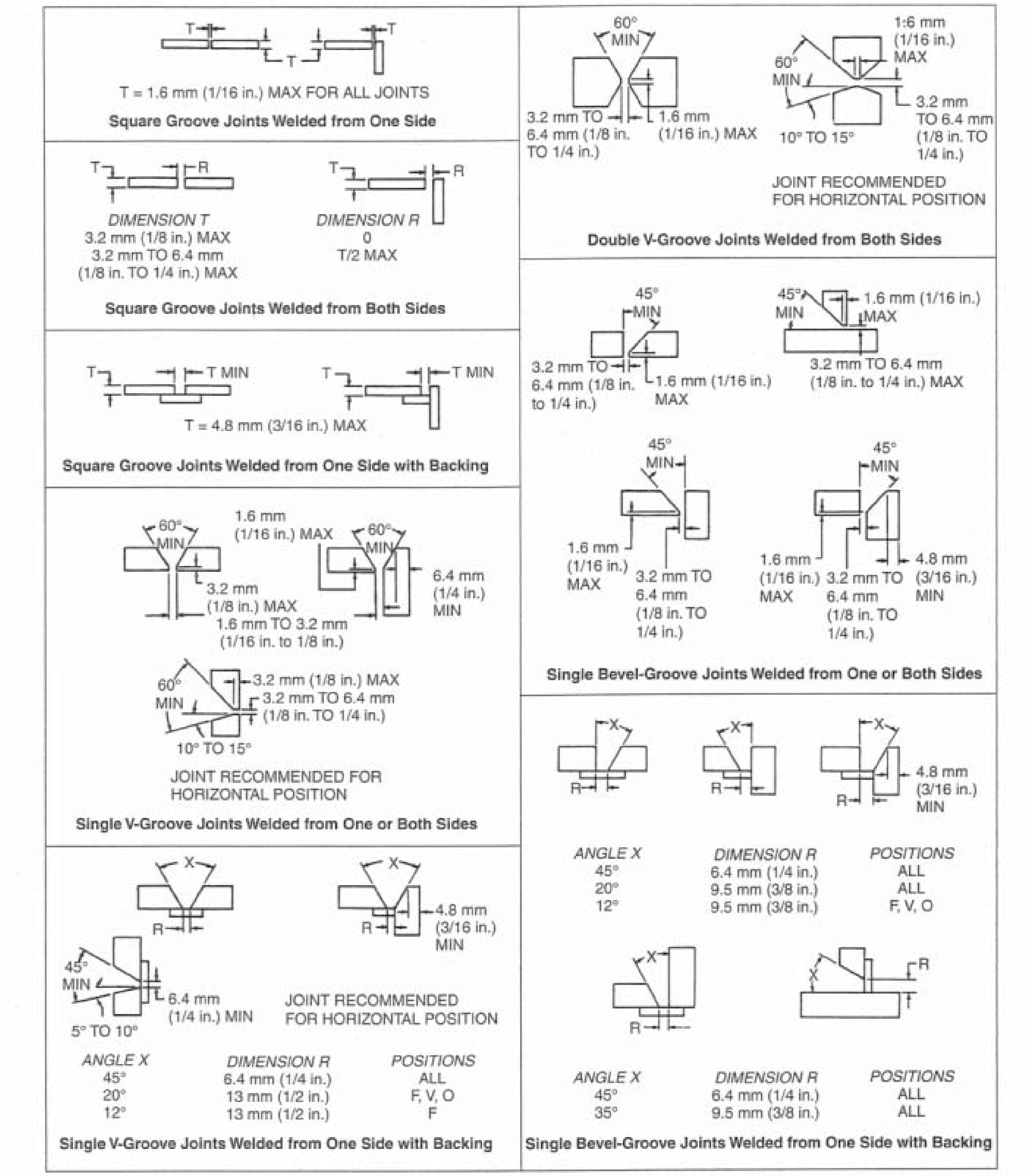

Fig. 1 — Typical joint geometries for the shielded metal arc welding of steel.

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covering and the large selection of core wire chemistry, SMAW can produce an extensive range of weld metal deposits with desirable mechanical and physical properties, while providing for a smooth arc, uniform metal transfer characteristics, and ease of operation. These features combine to make SMAW the favorite process of many welders and fabricators.

One of the oldest and simplest processes, SMAW continues to be widely used. The simplicity of the process extends to the number and nature of the circuit components required — a power source of adequate current rating and

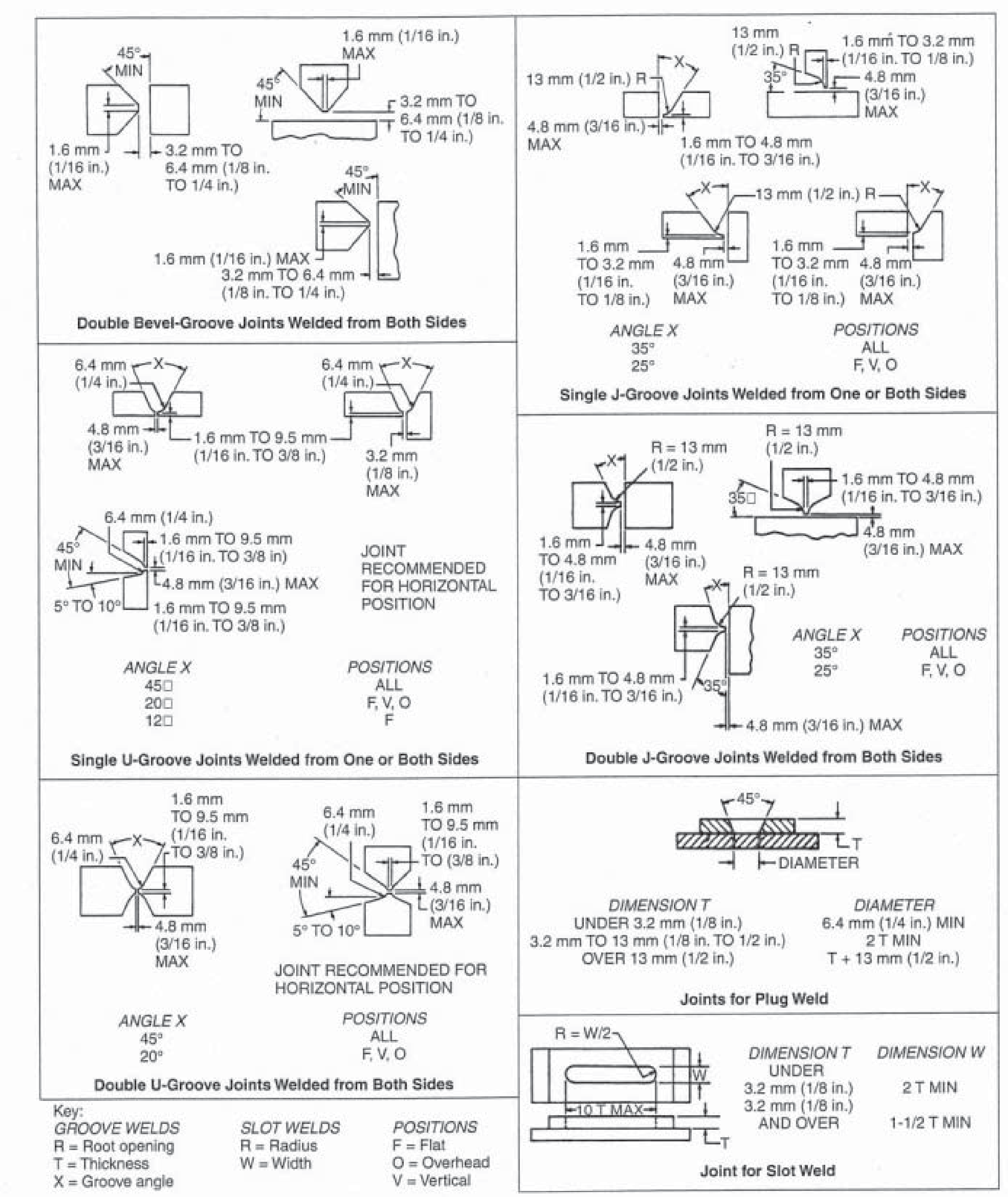


Fig. 1 — continued.

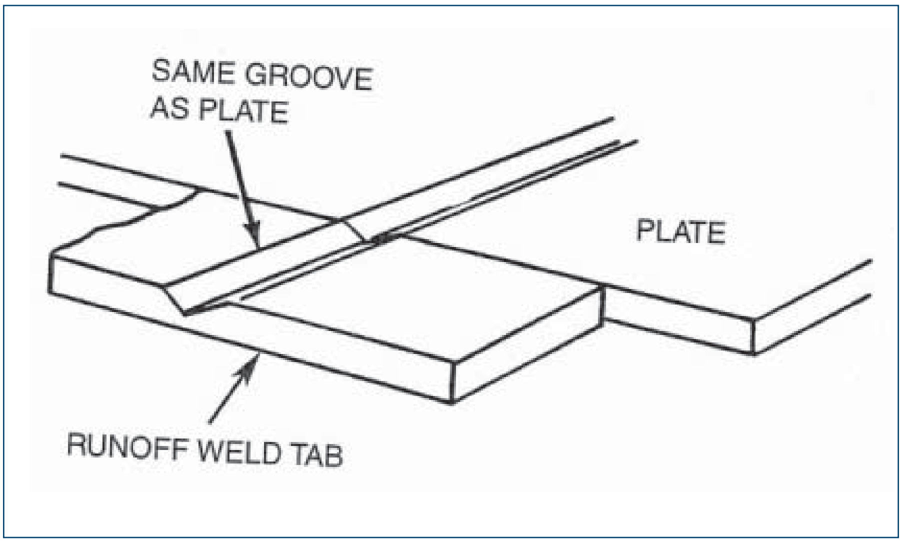


Fig. 2 — Runoff weld tab at the end of a joint.

duty cycle, a SMAW electrode compatible with the output of the power source, suitably sized welding cable, an electrode holder, and a workpiece lead.

Each word in the phrase shielded metal arc welding conveys an attribute of the process: **shielded** refers to its ability to displace the air surrounding the weld to avoid the harmful effects of the gases in air; **metal** denotes the core of the electrode, which is a conducting rod that contributes a substantial portion of liquid metal to the weld pool; **arc** refers to the plasma discharge that converts the electrical energy into heat. The term **welding**, in this case, denotes that the metals are joined by fusion. While all these attributes distinguish SMAW from other welding processes, the distinctive feature of the process is the physical presence of the covering (coating) that surrounds the core wire of the consumable electrode. The covered rod is called an electrode because it functions as the terminal from which the electric flow changes from the conducting solid to the conducting plasma of the welding arc.

Electrode Storage and Conditioning

Shielded metal arc welding electrode coverings interact with the atmosphere. The coverings absorb moisture and carbon dioxide, but the amounts vary depending on the type of covering and its composition.

Control of moisture pickup in the covering is extremely important for low-hydrogen electrodes used to join high-strength steels with SMAW. The moisture these electrodes acquire on exposure to a humid atmosphere dissociates to form hydrogen and oxygen during welding. The hydrogen atoms dissolve into the weld and diffuse into the heat-affected zone and may cause cold cracking.

To minimize moisture problems, the electrodes must be properly packaged, stored, and handled. Electrodes shipped and stored in hermetically sealed steel containers offer the most resistance to moisture pickup. After being removed from the container, a heated holding oven provides the best storage conditions. Once issued for use, the electrodes should be kept in a rod warmer and the time interval in which they are exposed to the atmosphere should be minimized. Low-hydrogen SMAW electrodes that have been exposed too long require baking at a substantially higher temperature to remove the absorbed moisture. Follow the specific recommendations of the manufacturer. The time and temperature limitations can vary from one manufacturer to another, even for electrodes in the same classification. Note that excessive heating can damage the electrode covering.

Typical Joint Geometries

Figure 1 shows typical designs and dimensions of joints for shielded metal arc welding of steel. These joints are generally suitable for economically achieving sound welds.

Runoff Weld Tabs. Some applications require the groove to be completely filled to the very ends of the joint, but with SMAW, weld starts tend to be overfilled and weld craters underfilled. These features create an unfavorable shape at the start and at the end of multipass groove and fillet welds. Therefore, runoff tabs are used to completely fill out the groove and achieve a uniform weld. The runoff tabs extend the groove beyond the ends of the workpieces. The welding begins on a runoff tab and is carried over onto the finishing runoff tab. This technique ensures that the entire length of the joint is uniformly filled with sound weld metal to the necessary depth. Runoff tabs provide an excellent method for starting and stopping all welding because all defects normally associated with starts and stops are located in areas that later will be discarded. A typical runoff tab is shown in Fig. 2.

Selection of material for runoff tabs is important. The composition of the tabs should not adversely affect the properties of the weld metal.

Joint Fitup. The points of concern with regard to joint fitup are the size of the root opening and the misalignment of the members along the root of the weld. Both the root opening and the joint alignment have an important influence on weld quality and the economics of the process. Once the joint has been properly aligned throughout its length, maintain fitup with clamps or tack welds. Finger bars or U-shaped bridges (strongbacks) can be placed across the joint and tack welded to each member of the weldment.

If the root opening is not uniform, the amount of weld metal will vary from location to location along the joint, and shrinkage and resulting distortion will not be uniform. This can cause problems when the finished dimensions have been predicated on the basis of uniform, controlled shrinkage.

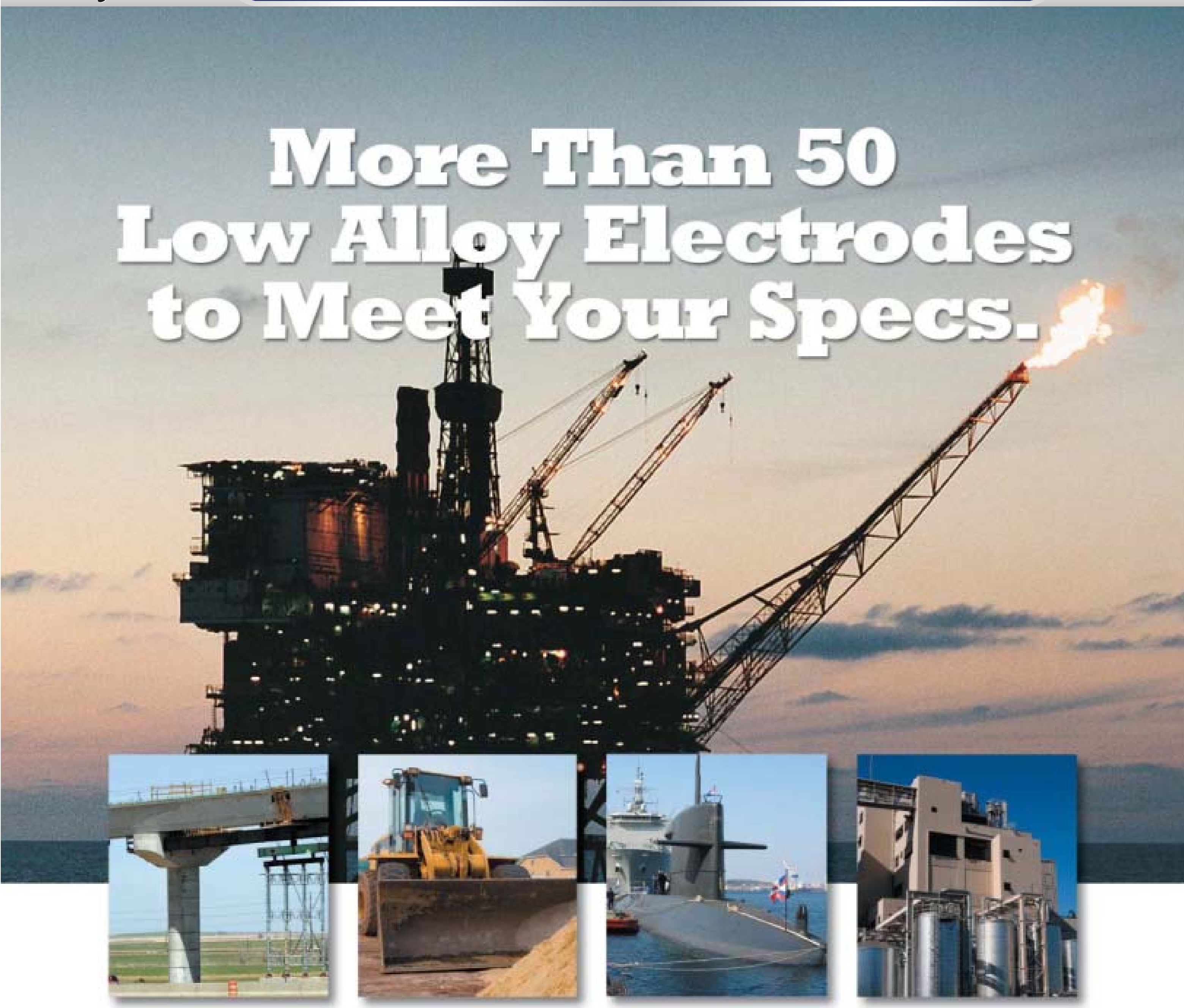
Misalignment along the root of the weld may result in incomplete penetration in some areas or poor root surface contour, or both. An inadequate root opening can cause incomplete joint penetration. Too wide a root opening makes welding difficult and requires more weld metal to fill the joint. More weld metal means more welding time and more cost. In thin members, an excessive root opening may cause excessive melt-through on the back side.♦

Do You Have Some News to Tell Us?

If you have a news item that might interest the readers of the *Welding Journal*, send it to the following address:

Welding Journal Dept.
Attn: Mary Ruth Johnsen
550 NW LeJeune Rd.
Miami, FL 33126.

Items can also be sent via FAX to (305) 443-7404 or by e-mail to *mjohnsen@aws.org*.


More Than 50
Low Alloy Electrodes
to Meet Your Specs.

'Those Were the Days'

A trio of experts take a look at what happened in the world of welding in the ***1940s, 1960s, and 1980s***

BY OMER W. BLODGETT, AUGUST F. MANZ, AND GERALD D. UTTRACHI

To help provide perspective on what happened in welding over the years, the Welding Journal *asked three prominent members of the industry to describe what occurred in welding and their roles in the industry during three seminal periods of its development: the 1940s, 1960s, and 1980s.*

The 1940s: When Welding Came to Prominence

BY OMER W. BLODGETT

"Welding Has Great Future" was the headline of an article I wrote in February 1945 for *Around the Globe*, the monthly newsletter of Globe Shipbuilding Co., Superior, Wis. The company began operations shortly before the bombing of Pearl Harbor on December 7, 1941. I was hired to be the welding superintendent there after graduating from the University of Minnesota. It was an exciting and challenging time of my life — Fig. 1.

"In 1931, (the United States) produced almost 16 million pounds of welding electrode; last year (1944), we produced over a billion pounds," I am again quoting from the newsletter article. "We expect a further increase for 1945; this will represent an increase of about 100 times over the amount produced in 1931. Here is an industry that has expanded a hundred-fold within 13 years.

"This tremendous increase has largely been brought about by a more extensive use of welding. Not only more products are being fabricated by welding but a larger ratio or percentage; for example, in 1932 there were 4.8 lb of welding electrode made for every ton of steel produced in plate and shapes, by 1943 this figure had increased to 46.7 lb of electrode per ton of finished steel, an increase of almost ten times."

One of the reasons for the increase: In World War I, ships were riveted. In World War II, all ships were welded. Many new shipyards were set up to meet the demand. The head of the Great Lakes — Duluth, Minn., and Superior, Wis. — had six yards, including Globe. In normal times, the area had perhaps a dozen or two welders. During the war, the number swelled to more than 2000. Almost all were trained at National Defense Training Schools in Duluth and Superior, although some yards started their own schools. There was a tremendous turnover in welders. On average, we had them from six months to a year, then they usually volunteered or were drafted for the Armed Services.

The decision to weld the ships during World War II was based upon the following four facts:

- A welded ship saved about 20% of its weight in steel.
- It took less time to train a good welder than it did a good riveter.
- It took less new equipment to weld a ship than to rivet it.
- A welded joint did not need to be caulked to make it tight.

Globe's first contract from the Maritime Commission was for ten oceangoing tugs for the U.S. Navy. They sailed with the fleet into battle. These ships were about 200 ft long with five diesel engines. Before the war, this type of ship was designed for riveted joints on the longitudinal seam of the shell, and the plates were lapped. We simply welded the hull with a continuous fillet weld on the outside and intermittent fillet welds on the inside.

The shipyard included five "ways" and we worked on five hulls at the same time. World War II brought out mass production techniques for ship construction and the use of prefabricated units, allowing more people to work by spreading out the work. This allowed more welds to be positioned for flat welding at greater welding speeds.

Our first ships were side launched without engines. Because the yard was expanding and more were working there, each ship would have more steel on it before launching. This included more deck houses and superstructure. Our seventh ship to be launched was a little top heavy and it almost rolled over, going over a little past 45 deg — Fig. 2. After that we launched with engines installed. That also shortened the time to delivery after launch. We also installed bow and stern sections as subassemblies — Fig. 3. They were fabricated on flat areas called tables, then hoisted into position with only an erection butt joint to be welded. Whole deck houses were built this way with most of the work, including piping, completed before erection onto the ship.

Building ships during wartime was very different than in peace. Following are just some of the challenges shipyards faced:

- A constant turnover of welders and other workers. The average was 82% and one yard had 212% turnover in a year.
- Material was difficult to obtain. Electrodes were on about a six-month delivery; we had to lend and borrow between shipyards to keep going.
- Much of the steel was not up to standard, but we had to make use of what we were given.
- Equipment was difficult to obtain. We waited some time to get a set of rolls.
- Because of the shortage of gases oxygen and acetylene — we did very little preheating.

We were constantly improvising, making use of what was available. Many things we learned by trial and error. For instance, one day at Globe we ran short of E6012 electrode, but were able to get some E6020 from another yard. We used this on the night shift to weld the masthead of one of the ships. This was the top of a large mast to which the cables of three booms were fastened. It was a large, box-shaped weldment. The next morning, we found

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Fig. 1 — Omer Blodgett (left) with coworkers at the Globe Shipbuilding Co. shipyard in 1945.

Fig. 3 — This upended bow section of a destroyer escort was completed on the ground before erection.

Fig. 2 — As more ships were launched in the Globe yard, more of the superstructure of each ship was added before launching, making the vessels increasingly top heavy. This one almost rolled over during launching. From then on, the engines were installed before launching to lower the center of gravity.

that most of these welds had cracked. These were single-pass fillet welds, and when made with the E6020, they were concave. This was the cause of the shrinkage cracks. We had to chip out all of the cracked fillet welds and reweld them with E6012 electrodes, which produced a convex fillet weld that seldom cracked. We never again used E6020 electrodes for fillet welds. Today, of course, the advantage of convex fillet welds over concave fillet welds is well known, but we had to learn it by trial and error.

An example of the state of our design knowledge at the time was that we soon realized that along with all the advantages of a welded ship, there's a possible disadvantage. If a plate in a riveted ship cracks, the crack can't jump across to another plate. This fact provides a natural crack arrestor. If a crack appears in a welded configuration, there is nothing to stop it. Riveted ships had square and rectangular hatch openings, so we found that one of the first things we had to do was go back and retrofit all of our square corner openings and make them round to decrease the stress risers. We wanted to eliminate any 90-deg corners that might start a crack.

Over the years, much has been made about fractures in merchant vessels built during the war years. The Secretary of the Navy convened an investigation following the war "to inquire into the Design and Methods of Construction of Welded Steel Merchant Vessels." The Navy Board of Investigation considered 4694 welded steel merchant vessels built by the Maritime Commission in the United States and concluded the following in its final report:

"The results of the investigation have vindicated the all-welded ship. The statistics show that the percentage of vessels sustaining serious fractures is small. With proper detailed design, high-quality workmanship, and a steel which has low notch sensitivity at operating temperatures, a satisfactory all-welded ship structure may be obtained; and

"The Board considers it imperative to reaffirm the statement that, if welded construction in the building of both merchant and naval vessels had not been adopted at the outset of the program, the extraordinary results in speed and volume of construction would have been an impossible accomplishment."

The 1960s: New Processes Help Welding Expand

BY AUGUST F. MANZ

After World War II, many GIs took advantage of the GI Bill and went to college and trade schools. They began their welding careers in the early 1950s. By the time the 1960s rolled around, many had established careers in the welding and cutting industries.

The 1960s was a period of expansion and invention. Not just in the United States, but all around the world. Gas metal arc welding (GMAW) became a dominant factor in steel fabrication. Until this time, most of the steel welding had been done with shielded metal arc welding (SMAW) and submerged arc welding (SAW).

In the United States, industrial gas producers (like Linde, a division of Union Carbide Corp., Air Reduction Corp., and others) investigated the effects of shielding gases and their mixtures on GMAW metal transfer. Most of the shielding gas mixtures that were found to be useful were based on combinations of argon, oxygen, and carbon dioxide.

Fig. 4 — Typical installation of silicon rectifier arc welding units, which became popular during the 1960s. (From "Silicon — The Key to a Reliable Welding Power Source" by Lewis F. Petit, which appeared in the the November 1961 Welding Journal*.)*

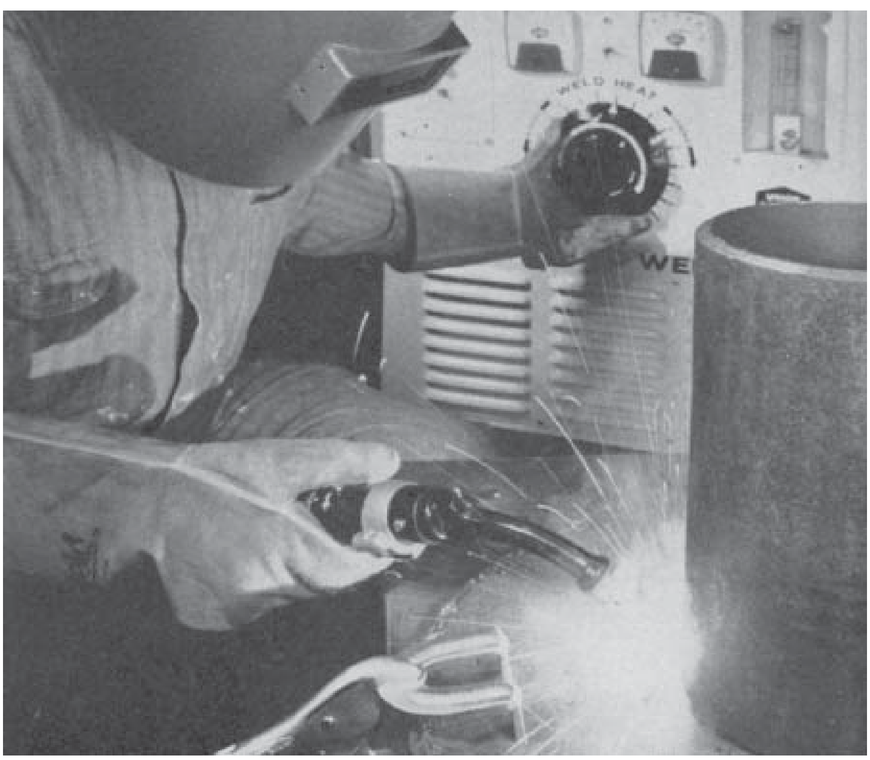

Fig. 5 — An operator is shown adjusting the welding conditions by use of one-knob control. This welding machine for short-circuiting arc welding was characterized by preset inductance and slope as well as automatic correlation of open circuit voltage and electrode feed rate through adjustment of a single control knob. (From "The 'One Knob Welder'" by A. F. Manz, which appeared in the September 1968 Welding Journal*.)*

In Europe, carbon dioxide was the focus of attention. After WWII, carbon dioxide was the main gas used for shielding the arc. Argon, helium, etc., were in short supply. As a consequence, in the United States, short circuit metal transfer versions of GMAW using argon-based mixtures were developed, while in Europe, carbon dioxide was the predominant shielding gas used, because argon and the other rare atmospheric gases were not readily available.

In the United States, a number of GMAW processes with trade names such as short arc, dip transfer, microwire, pinch arc, etc., appeared. These all described commercial versions of short circuit metal transfer GMAW processes. Not only gases were investigated, but electric power supplies were a source of intense investigation. Electromagnetic pinch forces and fuse action, which depend on current, are important factors in metal transfer. Control of the power supply characteristics gave control over the metal transfer. This resulted in a number of inventions. For example, GMAW power supplies with adjustable volt-ampere slope, voltage, and inductance were introduced (Ref. 1). For the first time an operator could separately adjust the static and dynamic characteristics of a welding power supply.

GMAW with pulsed power became popular in the 1960s (Ref. 2). Pulse arc power supplies that provided current with 60 and 120 pulses per second became available. These

*Fig. 6 — AWS moved into the United Engineering Center in New York, N.Y., in 1961. The view from the then-*Welding Journal *office shows United Nations Park and the East River.*

units extended the spray metal transfer welding range of GMAW (especially with aluminum). It was during the 1960s that silicon rectifiers and silicon-controlled rectifiers (SCRs) became popular — Fig. 4. Up to this time, selenium rectifiers were used to create direct current power supplies. The new rectifiers created a revolution in power supply design. Efficiencies increased, while size and weight decreased. The printed circuit era was just beginning. Development of new chemistry fluxes, wire electrode alloys, shielding gas mixtures, and power supplies helped expand the use of GMA welding, here in the United States and around the world. Similar development work was being done in Europe and Asia. The American Welding Society served as a forum for discussions of the new technologies that were emerging. Its *Welding Journal* published many excellent articles on metal transfer physics. A significant number of papers were presented by Russians and Japanese. The 1960s was a period of great activity.

At the time I was working as a development engineer for the Linde Division of Union Carbide Corp. laboratory, located in Newark, N.J. Nearby, in Murray Hill, N.J., the Air Reduction Co. laboratories were in full swing. Members of both these companies were also members of the AWS New Jersey Section. We all got to follow the published works of each other and participated in AWS activities. I had a great time working with oscilloscopes, high-speed filming, all kinds of arc processes, etc. I was lucky enough to invent what is known as the Hot Wire Welding processes (Ref. 3) and the "One Knob" GMAW process (Ref. 4) that has evolved into what is now known as synergic welding — Fig. 5.

During this time, the so-called "Cold War" with the Soviet Union (USSR) was underway. The United States was developing rocket engines, boosters, etc. A great deal of investigation was done on how to weld heavy aluminum structures (some of the equipment that was developed became known as "missile makers"). This was truly a period full of inventiveness and development. What follows is a short listing of some of the things that happened in the 1960s (Ref. 5).

1960 The first laser beam produced, using a ruby crystal.

1960 The Federal Hazardous Substances Labeling Act was approved. Product liability was beginning to become an issue for the welding industry.

1960s Pulsed gas metal arc welding was introduced by Airco.

1960 Argon and carbon dioxide mixtures introduced for GMAW of steel.

1961 In the fall, the AWS relocated from 33 W. 39th St., New York, N.Y., to the United Engineering Center on East 47th St., New York, N.Y., near the United Nations — Fig. 6.

1961 Yuri Gagarin, a Russian cosmonaut, became the first man in space.

1961 Friction welding demonstrated for the first time in the United Kingdom.

1961 The first public disclosure of electron beam welding by the French Atomic Energy Commission.

1962 Electrogas welding patent issued (Belgium).

1962 The National Fire Protection Association published Standard 51B, *For Prevention of Fire in Welding and Cutting*. It was no longer a "tentative" standard.

1964 "Hot Wire" welding processes and "One Knob" (synergic control) gas metal arc welding were patented by August Manz.

1965 The St. Louis Arch was built.

1965 Apollo 10 was launched to the moon.

1965 Oil and gas discovered beneath the North Sea.

1967 The first precautionary label for welding was introduced in the United States Standard Z49.1, *Safety in Welding and Cutting.*

1967 The world's first undersea pipeline was "hot tapped" by Frank Pilia of the Linde Div. of Union Carbide Corp.

1968 HY-180 steel was developed by U.S. Steel for the Navy.

1968 The 1968 Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) were adopted by OSHA as the basis for nearly all of its permissible exposure limits (PELs) for use in the regulations to follow.

1969 Plasma arc hotwire cladding introduced by Linde.

1969 Neil Armstrong, an American, was the first man to set foot on the moon.

1969 AWS membership topped 20,000 for the first time. There were 130 Sections, a staff of 42, and a budget of more than $1 million.

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The 1980s: A Decade of Change

BY GERALD D. UTTRACHI

The 1980s brought significant change to the welding industry. A major reason was the reduction in heavy steel construction. This is best quantified by the more than 25% reduction in steel production in the 1980s compared to the 1970s. The rapid reduction in fabricated steel consumed was even more dramatic from the late 1970s to the early 1980s. The drastic reduction in heavy fabrication heralded major changes in the fabricating and welding industry. Steel companies that owned construction companies, shipyards, and railcar fabrication facilities divested or closed them. Large vessel fabricators were sold or consolidated.

The decade prior had seen the production of numerous very heavy wall nuclear pressure vessels, fossil fuel and nuclear power plant construction, and many steel bridges. The petrochemical and chemical industries had expanded with new plants and products. Large-diameter gas and oil transmission pipelines were constructed to deliver products from the Gulf Coast to the population centers in the East and Midwest. The United States launched a submarine on about a monthly basis in the late 1970s. Aircraft carriers and other Navy and commercial ship construction consumed many welding products. Many large steel buildings were fabricated in that decade, like the Bank of America Center in Los Angeles, Transamerica Pyramid in San Francisco, the John Hancock Building and Sears Tower in Chicago, the U.S. Steel Building in Pittsburgh, and the World Trade Center Towers in New York City.

In the 1970s, railroad cars of various types were being manufactured in numerous plants throughout the country. Many offshore drill rigs were produced requiring a tremendous amount of welding. Many of these production facilities were significantly downsized or closed in the 1980s as demand dropped.

Welding technology was also in transition with most of the major welding processes developed as we entered the 1980s. The decades preceding had seen the development of many of the more advanced welding processes we take for granted today, namely gas tungsten arc welding, gas metal arc welding, and flux cored electrode GMAW. Both self-shielded and gas shielded flux cored electrodes were in common use. Submerged arc welding — first developed in the 1930s — had expanded with two- and three-electrode high-speed systems in common use. A major new process that expanded rapidly in the decade was plasma cutting. This process had been mostly restricted for use on automatic cutting machines. In the 1980s, the process was introduced with low-cost compressed air as the plasma gas. This greatly reduced the cost and complexity of operation. Manual plasma cutting became a viable tool for the average fabrication shop.

Fig. 7 — An advertisement from the March 1988 Welding Journal *showing the Digipulse 450 pulsed-GMAW system from L-TEC, Inc. The switch to inverter-based power supplies was one of the most significant developments of the 1980s.*

One of the significant welding developments in the 1980s was the use of power transistors allowing the replacement of large transformers in welding power supplies. These inverter systems converted AC to DC power then chopped the DC power creating high-frequency AC. This allowed small, efficient transformers to replace large transformers operating at 60 cycles. With high-frequency switching, power supply dynamic performance characteristics that previously required large, heavy inductors could now be created with electronic circuits. This improved starting and arc performance. The use of microprocessors also allowed wire feeders to have digital accuracy at maintaining preset voltage within tenths of a volt and wire feed speeds to close tolerances. Combining inverter power with microprocessor wire feeders allowed the creation of simple-to-use pulsed GMAW. Previous systems had been too complex for the average welder to set and use. Now the complexity could be handled by the microprocessor allowing simple inputs. As a comparison, a conventional 450-A DC power source manufactured by the company I worked for at the time, L-TEC, weighed 210 kg (465 lb); the MOSFET inverter 450-A GMAW power source with pulse power capability and excellent arc characteristics weighed 52 kg (115 lb) — Fig. 7. The inverter also had half the footprint.

To give further perspective on the weight savings provided by inverter power supplies: A conventional 30-A manual plasma power supply weighed 68 kg (150 lb). In the mid 1980s, L-TEC introduced one of the first inverter plasma cutting systems. It also had 30-A capacity and used the same torch with the same performance as its 68 kg (150 lb) counterpart. It weighed 18 kg (39 lb). This made it portable and significantly expanded the places it was used. The 30-A inverter system was truly portable at a volume of about one cubic foot. It was easily lifted and moved from job to job. The volume reduction was as dramatic as the weight savings. The conventional power supply had a volume of three cubic feet and required wheels to be moved on the shop floor. I recall one order for 35 systems that went to Las Vegas. I called the distributor to find out where they were being used. He said behind the walls in all the casinos were the kitchens that feed the patrons. Designers change the layout in the casino frequently to alter traffic patterns for increased gambling revenue having no regard for the kitchens. The light, portable plasma was ideal for making the required alterations of the stainless countertops.

Also in the 1980s, welding filler metals continued to evolve to meet the demands of higher-strength and higher-toughness steels. Significant advances occurred particularly in flux cored electrodes — Fig. 8. Formulations and production methods were developed that produced low-hydrogen weld deposits avoiding delayed hydro-

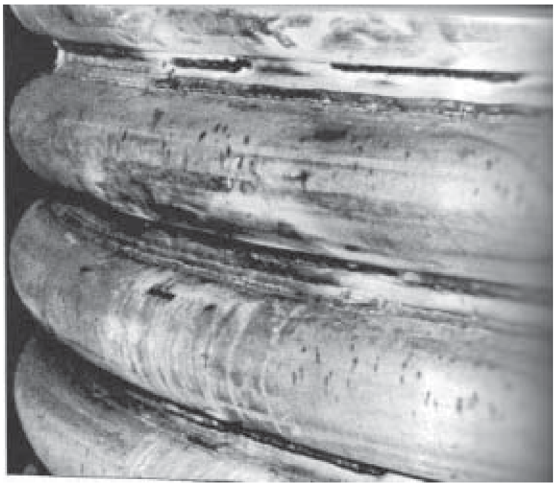

Fig. 8 — An all-position, stainless steel, flux cored welding wire was used to repair the welds that attach half-pipes to the exterior of an aspirin batch tank. (From the article "Aspirin-Makers' Headache Gets Fast Relief from Stainless Steel Flux Cored Electrode" in the June 1988 Welding Journal*.)*

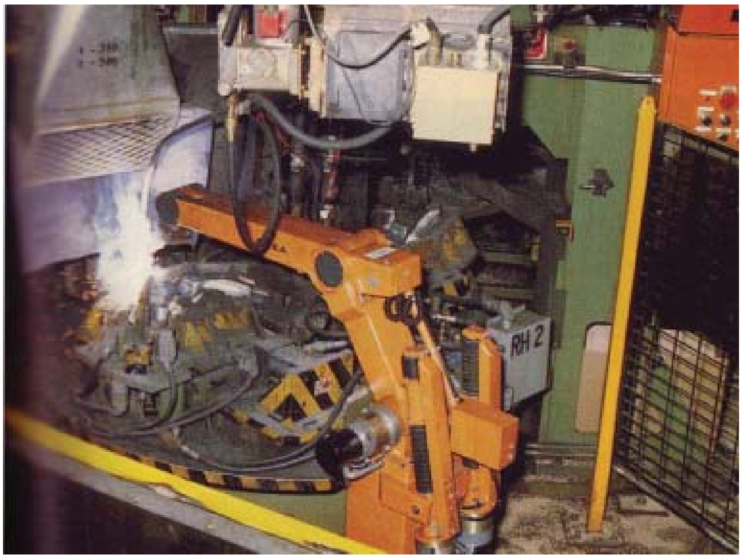

Fig. 9 — A robotic arc welding station custom designed to produce an automotive front crossmember assembly. The 1980s saw much greater use of arc welding robots in the United States. (Photo from the article titled "Speed Doubled on Robotic Arc Welding of Complicated Automotive Assembly" in the November 1986 Welding Journal*.)*

gen cracking. The use of small additions of titanium and boron allowed flux cored electrodes to be used in critical applications requiring stringent impact toughness properties and low diffusible hydrogen levels. Another major development was the introduction of flux cored electrodes that reduced welding fumes. Reducing the carbon content and matching core ingredients with the proper shielding gas reduced fume generation by more than 50%. A whole range of flux cored electrodes called the Ultra Series utilized this technology and gained wide welder acceptance. GMAW using flux cored electrodes with improved arc characteristics moved to smaller 0.9 mm (0.035 in.) diameter and were extensively used for all-position welding, pipe welding, and on thinner-gauge sheet metal. Manufacturing methods and formulations for making very small diameter [0.8 mm (0.030 in.)] self-shielding flux cored electrodes were introduced for welding thin sheet metal. The first all-position stainless flux cored electrodes were also introduced in the 1980s.

Arc welding robots were starting to make their presence felt in the United States during the decade — Fig. 9. Unimation had been a leading supplier of large hydraulic resistance welding robots that were used extensively in automotive assembly. For arc welding they were integrating Kawasaki electric motor-driven smaller robots into their product line. Other Japanese robotic companies were also introducing more accurate electric-driven robots for arc welding. Unfortunately, U.S. fabrications were often expecting these robots to replace a manual welder's intelligence in handling gaps and misaligned joints. With the joint tracking capability available at the time they often could not handle these inconsistencies in fitup.

The reduced demand for welding products during the decade helped lead the industry to consolidation. One of the major companies with leading welding R&D, Airco, was purchased by a European company. Many European industrial gas companies had already divested the hardgoods portion of their welding business from their industrial gas business. This eliminated product inventory, obsolescence, scrap, shrinkage, frequency of delivery, and other distribution costs of the less profitable segment of the business. Airco and the other leading industrial gas company with extensive welding R&D, the Linde Division of Union Carbide, sold their welding hardgoods businesses. My own career took a turn at that time. I went from managing a welding R&D operation in the 1970s to marketing roles in the 1980s. Expanding the use of existing processes and products became the priority of the day.

Thermadyne consolidated ownership of some of the leading welding products segment producers: Tweco, Victor, Arc Air, Stoody, and Thermal Dynamics.

In addition, major changes in welding distribution were occurring. Welding distributors had brought new welding technology to fabricators as these processes were developed. Many had started and/or grew significantly after World War II. Many of these companies were being passed on to the second-generation owners in the 1980s. They were forward integrating into the profitable cylinder rental business, owning and filling their own cylinders and no longer renting filled cylinders from the large industrial gas companies. They had significant capital invested in these gases-related assets. A combination of the downturn in the economy and the second-generation ownership caused some to decide to sell their businesses. In 1982, Peter McCausland formed Airgas and started acquiring welding distributors who desired to sell. This put a different complexion on the welding distribution business. (Of note: Airgas, with more than 1000 retail stores, gas filling stations, and warehouse locations, has acquired more than 350 companies. It now has the largest welding distribution network in North America with sales of about $4 billion.)

The face of the industry had changed dramatically as we entered the decade of the 1990s.♦

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2. U.S. Patent 3,071,680, January 1, 1963, Anderson et al., assigned to Air Reduction Corp.

3. U.S. Patent 3,122,629, February 25, 1964, Manz, assigned to Union Carbide Corp.

4. U.S. Patent 3,125,671, March 17, 1964, Manz, assigned to Union Carbide Corp.

5. See Jefferson's *Welding Encyclopedia*, 18th edition, Appendix I, American Welding Society, 1997, for some additional things that happened between 1836 and 1993.

Evaluating SMAW Electrodes for Coke Drum Construction

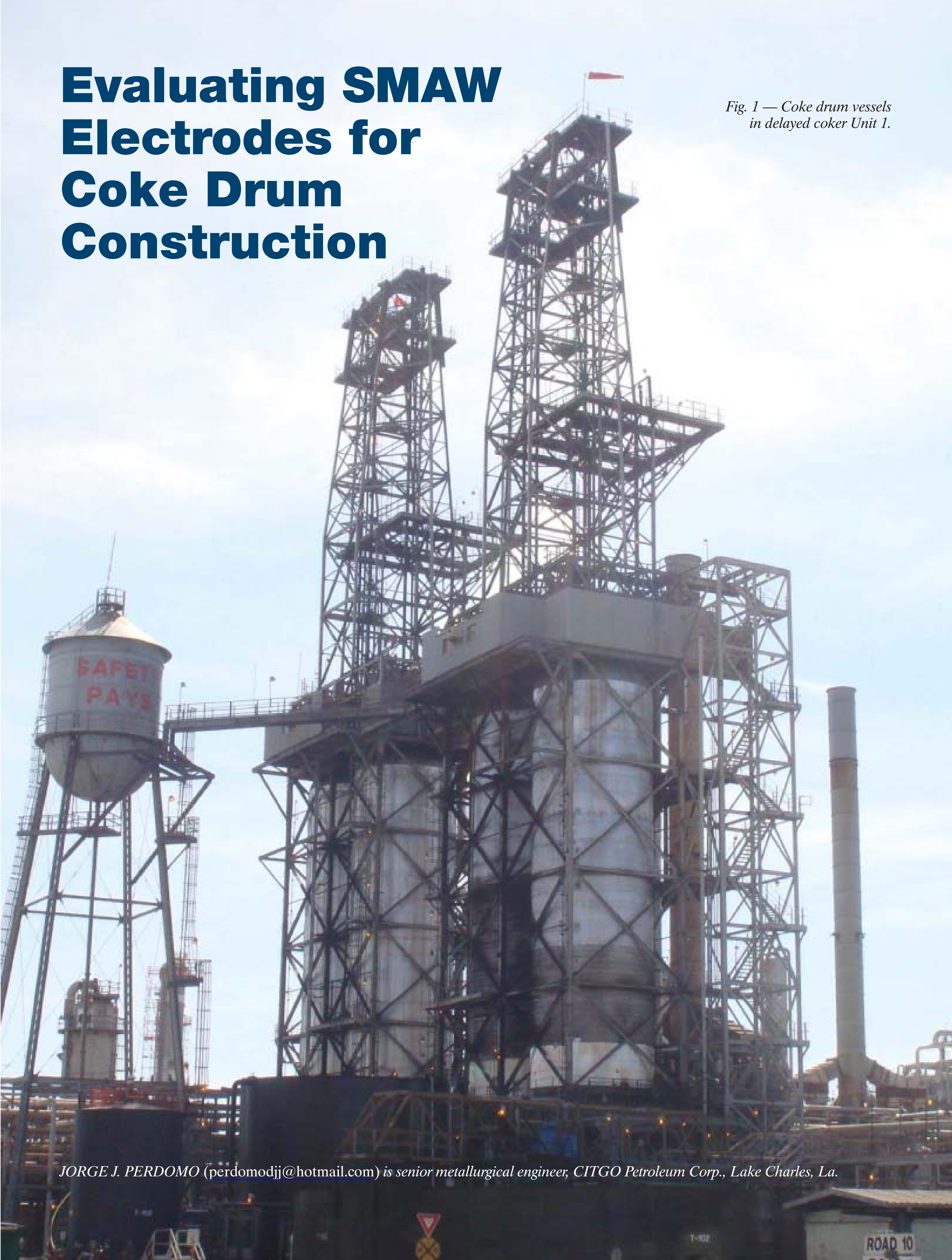

Fig. 1 — Coke drum vessels in delayed coker Unit 1.

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The end user should be aware of performance limitations and availability issues that may be faced with 2.25Cr-1Mo filler metals

BY JORGE J. PERDOMO

Among Cr-Mo steels, 2.25Cr-1Mo low-alloy steel is widely used in the petroleum industry in the construction of power boilers, pressure vessels, and process pipelines. In particular, heavy-wall reactor pressure vessels have been constructed from this type of Cr-Mo steel because of its excellent high-temperature strength, corrosion resistance, and resistance to high-temperature hydrogen attack. In the last two decades, some manufacturers have introduced 2.25Cr-1Mo steels in the construction of coke drums. Coke drum vessel plate metallurgy includes common materials such as carbon-half molybdenum (SA-204 Grade C), 1Cr-0.5Mo (SA-387 Grade 12), and 1.25Cr-0.5Mo (SA-387 Grade 11).

The CITGO facility in Lake Charles, La., includes six 2.25Cr-1Mo coke drum vessels. The conical head sections of two of these vessels were redesigned to install state-of-the-art unheading devices — Fig. 1. This new design required the removal of the original conical head sections and the installation of new ones. The new conical sections were manufactured of explosion-clad, low-alloy steel of ASME-approved material SA-263 (1.375-in.-thick SA-387, Grade 22, Class 2 base plate and 0.125-in.-thick SA-240 Type 410 stainless steel clad) to match the existing metallurgy of the vessel. During welding procedure qualification, we evaluated three commercially available matching covered electrodes E90XX-B3.

Toughness Requirements and Brittlement Concerns

We imposed a Charpy V-notch toughness requirement of 45/35 ft-lb (average/minimum) at 20°F for the 2.25Cr-1Mo plate, forgings, and weld material. Even though toughness requirements during procedure qualification are established by the construction code for low-temperature in-service applications, Cr-Mo low-alloy steels are typically toughness tested due to their use in relatively cold climates and concerns with temper embrittlement.

Temper embrittlement (TE) is the loss of ductility after heating susceptible steels to prolonged exposure in the temperature range of 700°–1000°F. Susceptibility is exhibited by specific Cr-Mo steels containing high levels of residual elements (Ref. 1). Temper embrittlement particularly affects 2¼Cr–1Mo and 3Cr-1Mo steels. More highly alloyed (e.g., 5Cr-0.5Mo and 9Cr-1Mo) and less highly alloyed (e.g., 1Cr-0.5Mo and 1.25Cr-0.5Mo) steels are less susceptible to TE. The loss in ductility due to TE is apparent only at temperatures below approximately 300°F (Ref. 1). In the case of 2.25Cr-1Mo shielded metal arc welds, the Bruscato factor, a.k.a. X-bar factor, provides a measure of the susceptibility of welds to TE (Ref. 2). The currently maximum accepted limit for the X-bar factor (Ref. 3) above which a 2.25Cr-1Mo weld is susceptible to this phenomenon is 15 according to Bruscato's equation, which follows:

X-bar = (10P + 5Sb + 4Sn + As)/ 100 (elements in ppm)

For pressure vessel construction, we have adopted the X-bar factor limit of 15 on 2.25Cr-1Mo welds.

Welding Procedure

We conducted welding procedure qualification in accordance with the requirements of ASME *Boiler and Pressure Vessel Code* Section IX and the additional toughness and chemical requirements stated previously. We welded 1.5-in.-thick coupons using a single-V groove of ASME-approved material SA-387, Grade 22, Class 2 with the shielded metal arc welding (SMAW) process using three commercially available matching filler metal brands (from three different manufacturers), classification E90XX-B3 per ASME filler specification SFA 5.5 (AWS A5.5). Table 1 presents the welding parameters used during welding procedure qualification (WPQ).

We welded using a 400°F preheat and a 650°F maximum interpass temperature, with a maximum heat input of 63 kJ/in. Coupons were welded in the vertical position with upward progression. Preheat was maintained until a 6-hour postweld heat treatment (PWHT) cycle with a soak temperature of 1275°F was completed.

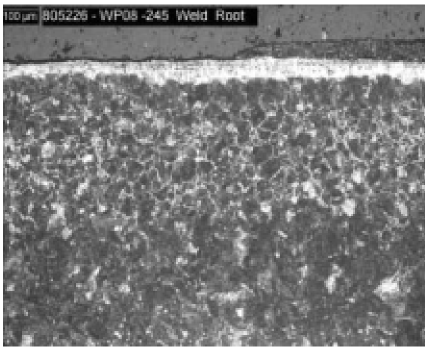

Fig. 2 — McQuaid-Ehn etch of weld metal Brand B to establish prior austenite grain size.

After welding and PWHT, the coupons were sectioned for testing.

Details of the Results

For the sake of this discussion, we have omitted Section IX mechanical test results, and focused on Charpy V-notch impact test, hardness measurements, and weld chemical analysis results. However, side bends and tensile tests of coupons with each filler metals were acceptable per code requirements.

We found that the filler metal Brand A exhibited the lowest toughness of all three filler metals tested (Table 2) and did not meet our minimum toughness requirements stated herein. The largest weld hardness measured also corresponded to Brand A (Table 2). We also had deposited weld metals chemically analyzed by means of optical emission spectroscopy (Table 3) from which we calculated the X-bar factor for each filler metal (Table 3). Only Brand C met the X-bar <15 requirement. We contacted the manufacturer of Brand A filler metal and discussed the relatively low weld toughness and X-bar factor value of 17.1. The company indicated that it had no test data for weld toughness available and manufacturing of filler metals with X-bar <15 had

Table 1 — Welding Parameters Used in WPQ

Electrode Classification	Size (in.)	Voltage (V)	Current (A)	Polarity
E9018-B3 (Brand A)	1/8	23–26	130–135	DCEP
E9015-B3 (Brand B)	1/8	20–23	104–115	DCEP
E9016-B3 (Brand C)	5/32	20–26	120–170	AC

Table 2 — Charpy V-notch Impact Test Results at ½T Locations at 20°F and Microhardness Measurements of Deposited Welds (HV-10)

Electrode Classification	Impact Energy (ft-lb)	Average Vickers Hardness (HVN)
E9018-B3 (Brand A)	35, 39, 39, Average 38	242
E9015-B3 (Brand B)	124, 116, 113, Average 118	204
E9016-B3 (Brand C)	63, 92, 83, Average 79	215

been discontinued due to a lack of demand. We unsuccessfully tried to contact Brand B filler metal manufacturer to see if it offers lower X-bar number filler metals other than the 16.6 obtained in our tests. Brand B did exhibit the best weld metal toughness tested. Brand C met both our toughness requirements and the residual element limitations of the X-bar. However, Brand C is only available by special order.

There are a number of factors that may affect weld metal toughness in low-alloy steels.

Temper Embrittlement. We did not test after a simulated step cooling procedure as the one described in API 934A (Ref. 3). Again, heavy-wall reactor equipment is usually more problematic than in our 2.25Cr-1Mo coke drum case since the thicker reactor vessel wall increases susceptibility to brittle fracture. Temper embrittlement occurs after heating susceptible steels in the 700°–1000°F temperature range for prolonged periods of time. The total accumulated time in this temperature range is important, including during fabrication (welding thermal cycles, postweld heat treatments, repairs), normal service conditions, as well as temperature excursions. We believe that the TE effect caused during our weld tests was minimal.

Copper and Nickel Content. The presence of copper and nickel content in these welds is expected to improve the weld toughness at the expense of increasing the susceptibility of temper embrittlement. The API 934-A document limits copper and nickel contents to 0.20 and 0.30 wt-% maximum to prevent this deleterious effect. Brand A filler metal had the largest amounts of nickel and copper of all three filler metals (Table 3). Because of the lack of step cooling in our tests, i.e., an anticipated low level of TE, and the higher copper and nickel content present, we expected the toughness to be higher than that measured.

Grain Size. Prior austenite grain boundary refinement has an effect on weld metal toughness. Grain refinement, i.e., the larger the amount and smaller size of austenite per unit area, is essential to achieve improved toughness. Aluminum as an alloying element can control austenite grain growth in steels and is subsequently added for this purpose (Ref. 4). We did not test for aluminum in the weld metal. However, under this premise we metallographically examined cross sections of all three weld metals (Fig. 2) by etching the prior austenite grain boundaries using a modified McQuaid-Ehn method as described in ASTM E 112. All three weld metals had a prior austenite ASTM grain size No. 8.

Current Polarity. One of the filler metal manufacturers indicated that the polarity of welding current (DCEP vs. AC) affects the chemical composition of the weld and subsequently the mechanical properties. Its study showed that polarity affected the tensile strength of the weld metal. However, there were little to no effects of polarity on V-notch toughness of both postweld heat treated, and postweld heat treated and step-cooled material.

Carbon Content. The carbon content has a significant effect on hardenability and toughness of low-alloy weld metals (Ref. 5). While increasing amounts of carbon increases strength, it also decreases ductility and toughness. Relatively small increasing amounts of carbon content will increase the toughness transition temperature. Most low-alloy weld metals have deposited carbon content in the range of 0.03 to 0.10% to mitigate notch-toughness reduction. From Table 3, we see that all three filler metals met the chemical requirements of their filler metal classification. However, the carbon content present in filler metal Brand A was the largest measured in all three filler metals and may have offset the anticipated beneficial effects on toughness of other alloying elements such as copper and nickel and caused the relatively low toughness measured.

Table 3 — Deposited Weld Chemical Analysis by Optical Emission Spectroscopy

Wt-%	E9018-B3 (Brand A)	E9015-B3 (Brand B)	E9016-B3 (Brand C)	SFA 5.5 E90XX-B3(a)
C	0.12	0.075	0.09	0.05–0.12
Mn	0.53	0.74	0.59	0.90
P	0.013	0.01	0.004	0.03
S	0.006	0.008	0.006	0.03
Si	0.22	0.26	0.22	1.00 for E9015-B3 0.60 for E9016-B3 0.80 for E9018-B3
Ni	0.33	0.05	0.19	—
Mo	0.93	1.03	1.05	0.90–1.20
Cr	2.28	2.30	2.36	2.00–2.50
Cu	0.2	0.03	0.023	—
V	0.003	0.006	0.02	—
Ti	0.002	0.008	0.001	—
Nb	0.002	0.004	0.001	—
Co	0.007	0.010	0.001	—
B	0.0005	0.001	0.0005	—
W	0.01	0.01	0.01	—
Sn	0.008	0.004	0.001	—
As	0.002	0.01	0.002	—
Sb	0.002	0.008	0.001	—
Fe	95.3	95.4	95.4	—
X-Bar	17.4	16.6	5.1	N/A

(a) Single values indicate maximum.

Summary

The results of this study show the importance of chemistry control on weld metal properties. There are a number of other factors related to tight chemical controls that influence toughness, temper embrittlement, and strength in Cr-Mo weld metals including carbide and inclusion-type formation and morphology. These are beyond the scope of our study and are likely proprietary information already known to some Cr-Mo filler metal manufacturers. However, the point of this article is to show that in order to meet more stringent requirements spelled out in technical documents such as those published by the American Petroleum Institute API 934-A document, the owner/user, engineering firm, shop, and contractor must be aware of the performance limitations and availability issues of 2.25Cr-1Mo filler metals to be faced during new construction and repair of Cr-Mo pressure vessel equipment. Therefore, there is a need to plan and test accordingly.♦

Acknowledgment

The author wants to express immense gratitude to Buck Tingle at Atlairstrickland, La Porte, Tex., for having provided welded coupons for this analysis.

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Anniversary Highlights

BY ANDREW CULLISON

The Welding Committee of the Emergency Fleet Corp., a temporary body that grew out of the U.S. involvement in WWI, established a permanent organization known as the American Welding Society. The first meeting of the directors of the AWS, headed by Comfort A. Adams, was held on March 28, 1919. The purpose of the Society was to spread knowledge of the emerging technology of welding and assist in putting it to practical use. One of the means of spreading information was through the publication of a journal. Below is a look back into the pages of the Welding Journal*, highlighting March, the Society's anniversary month.*

70 years ago

March 1939 — The all-welded, steel framed, 12-room residence of John Wilson of the Wilson Manufacturing Co., Wichita Falls, Tex., was prominently displayed on the cover of this issue. The structure was supported by 96,000 lb of steel framework. It had been shop fabricated in sections with the shielded metal arc process. A field crane erected the sections, some of which were three stories high.

The automatic shielded carbon arc welding process was touted as an accepted method of fabricating automotive parts. This was made possible by the development of the electronic tornado system of controlling the arc. The arc stream was intensely focused on a localized spot by means of superimposing a strong magnetic field on the arc. The magnetic field made the electrons rapidly gyrate, which controlled arc wander and agitated or "refined" the molten weld pool. It was this swirling action of the electrons that gave "electronic tornado" its name. A shielding gas was produced by introducing either a "brushed on" or fibrous flux. The flux elements, when contacted by the arc, released gases that protected the weld pool from oxygen and nitrogen contamination, while producing a slag cover. The system (Fig. 1) automatically struck the arc, and maintained a constant arc length. The electrode was also automatically rotated to keep it symmetrically pointed.

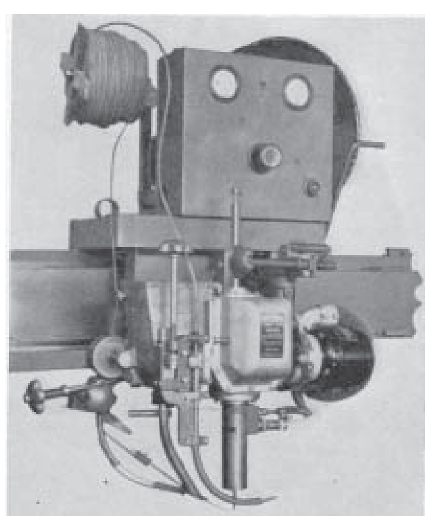

Fig. 1 — Electronic tornado automatic carbon arc welding machine.

50 years ago

March 1959 — An air-arc cutting and gouging torch came to the rescue of salvaging 4000-lb iron castings. Unless a 4-in.-thick, 3-in.-wide, and 30-in.-long section could be cut from the casting, 20 of them would have to be scrapped at a total loss of $6000. A plan to drill a series of holes side-by-side and then another series at a 90-deg angle failed because the drill bits were constantly breaking. Then oxyfuel cutting was tried, but the large quantity of oxygen and acetylene used and time expended didn't make it feasible. Finally, at the point where the project was almost abandoned, air-arc (air carbon arc) cutting was suggested. After 100 lb of carbon electrodes (Fig. 2) and six hours per casting, the job was successfully finished.

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Fig. 2 — As a last resort, air carbon arc cutting was used to salvage this iron casting.

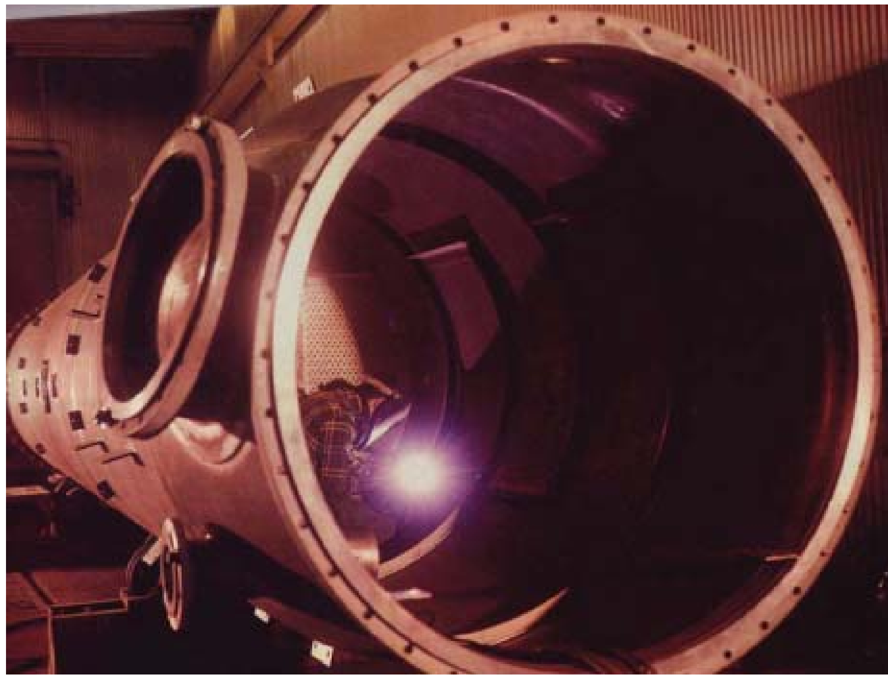

Fig. 3 — Welding on a pressure vessel at Nooter Fabricators in St. Louis.

The U.S. Army Ordnance Michigan Missile plant, operated by the Missile Division of Chrysler Corp., was fabricating the Jupiter and Redstone missiles with thin-walled aluminum.

The atomic power station at Shippingport, Pa., was in the midst of erecting 97-ft-long and 50-ft-diameter boiler containers. The 1$\frac{1}{4}$-in.-thick steel containers transferred heat from the nuclear reactor to the turbines. They were welded throughout with $\frac{3}{16}$-in. E6010 electrodes. Once erected, the containers were encased in concrete.

30 years ago

March 1979 — This issue previewed the upcoming AWS annual meeting and welding show noting "Michigan's great city of Detroit — automotive capital of the world…" was ready to receive more than 250 exhibitors to Cobo Hall. One of the exhibitors was displaying a 1936 Ford with an all stainless steel body. It was one of six Fords with such bodies manufactured at the behest of the Allegheny Ludlam Corp. to display the versatility of stainless steel.

The AISI reported that domestic steel shipments reached 97,935,000 tons in 1978, the third highest in history. The increase was attributed to strong demand in machinery, oil, transportation, and construction industries. There was a cautionary note about the growing tonnage of imported steel, which in 1978 was 21,135,000 tons.

This issue also reported on the success of attracting new AWS members. Since April of 1978, there had been a 32% increase in new members, associate members, and sustaining members. The great success was attributed to the EMGAM incentive program where members were awarded prizes for getting new members. For signing up 20 members, a lucky Pittsburgh Section member got a "Pierre Cardin ladies' French purse and key case of luxurious peau de sole cowhide, a Sharp 8-digit total memory calculator, and a set of 'Granny and Me' dolls."

10 years ago

March 1999 — With the AWS Welding Show planned to open in St. Louis, Mo., an overview article of industry around that city noted Nooter Fabricators, a subsidiary of Nooter Corp., was employing 450 welders in the fabrication of pressure vessels (Fig. 3) and heat exchangers. In addition to joining pressure vessels with walls from 2 to 6 in. thick, the company was also cladding the vessels with corrosion-resistant metals with the hot-wire plasma arc process using two wires.

Tower Automation was being kept busy fabricating engine cradles for the Ford Taurus. The company had heavily invested in automation, using 152 welding and material handling robots in production.

Alabama Shipyard, Mobile, Ala., was hard at work fabricating a tug-barge. The unit was designed with a special coupling mechanism that connected the tug and the barge. This design allowed the 124-ft tug to push the 460-ft barge, which gained a speed advantage over towed barges.♦

1919 A Year of Innovation and Change

BY HOWARD M. WOODWARD

Auto sales doubled, workers fought for their rights, the atom was split for the first time, and the American Welding Society was founded

What Was It Like to Live in 1919?

1919 was a fitting springboard year to launch the country into the Roaring 20s. The entire world was breathing easier. World War I, known as "the war to end all wars," had ended just four months before, and the **Treaty of Versailles** documented its conclusion. Officiating for the United States was President **Woodrow Wilson.**

The U.S. population was 105,063,000 (currently about 304 million), a total of 203,523 miles of paved highways existed (vs. 5.7 million miles today). The busiest spot in the country with the most auto traffic was Columbus Circle in New York City. The Dow rang in at 107, the median price of a new home was $5626, new births rose to 2,929,000, milk was 12¢/qt, gas cost 25¢/gal, a loaf of bread was 9¢, eggs cost 38¢/doz, beefsteak was 34¢/lb, postcards cost 1¢, and letters needed a 3¢ stamp.

On the down side, the average family's annual income was $1125.

How the American Welding Society Was Formed

The war's demand for building ships faster and better highlighted the need for developing electric welding processes. In response to this need, in 1918, a welding committee was formed at Emergency Fleet Corp., chaired by **Comfort Avery Adams,** president of the American Institute of Electrical Engineers, and dean of the Harvard University School of Engineering. Also in 1918, the National Welding Council was formed to pursue developments in gas welding. A merger of the two committees was explored at a meeting held January 3, 1919, at the Engineers Societies Bldg., 33 W. 39th St. in New York City. Dr. Adams chaired the meeting that involved 88 representatives from a cross section of American industry. It resulted in the preparation of a constitution, bylaws, and an organization chart for a new entity. The followup meeting was held at the same venue March 28, when the **American Welding Society** was officially formed, with Dr. Adams appointed its first president for a one-year term. The initial pronouncement read, *"It is the purpose of the Society to become a disinterested and dependable source of information on welding, not only for the benefit of manufacturers of welding apparatus and supplies, but also to aid those who use welding in their production and those who purchase welded goods. The Society will give greater stability to welding by standardizing welding processes and thus make its economies available in a wider field of industry."*

The *AWS Journal,* Vol. 1, No. 1, appeared October 1919, but cost restraints delayed publication of the next issue until January 1922, when regular issues began again starting with Vol. 1, No. 1.

Einstein's Right! Gravity Bends Light

After the sky went black at noon on May 29, a 40-year-old **Albert Einstein** learned that the general theory of relativity he proposed in 1915 had replaced Newton's theory of gravity during what is arguably the most important total solar eclipse in history. Einstein predicted that starlight bends when passing near strong gravitational bodies like our sun. The 1919 eclipse offered **Arthur Eddington** and other scientists their first opportunity to view stars near the sun in the daytime to verify starlight does bend. The vindication of his revolutionary theory made Einstein a household name for "genius." Meanwhile, at Cambridge University, Sir **Ernest Rutherford** was the first to split the atom. He changed nitrogen into oxygen, paving the way to further atomic research.

Auto Production Doubles in 1919

A total of 1,651,625 passenger cars were produced this year, nearly double the 1918 figure, plus 224,731 trucks.

HOWARD M. WOODWARD (woodward@aws.org) *is associate editor of the* Welding Journal.

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A 1919 Buick coupe touring car.

Ford produced 820,445 cars, Chevrolet: 129,118, Buick: 119,310, Dodge: 106,000, Willys-Overland: 80,853, Oakland: 52,124, Maxwell: 50,000, and Oldsmobile: 39,042. The most popular model was the Buick H-45 touring car (44,589 built), and the most luxurious was the $1110 Chevrolet FB touring car, with a 110-in. chassis and flowing 'reverse-curve' front fenders.

New automaker brands that appeared in the 1919 showrooms included Argonne Four, Bentley (UK), Briggs & Stratton, Champion, Citröen (France), Cleveland, Climber, DuPont, Essex, Hilander, Lone Star, Meteor, Noma, Pan, Porter, Rock Falls, and Spacke.

During the year, Ford produced its three-millionth Model-T, and **Studebaker** stopped production of carriages to focus solely on building motor vehicles.

Ninety percent of American cars built were open (touring) models that averaged 20 miles/gal, with a top speed of 40 mph.

The median price of a U.S. car was $826. The cheapest GM car was the Chevrolet 490 roadster at $715. By contrast, in year 2006, 7,667,066 cars were sold in the United States, and the average vehicle sticker price was $29,746. The all-time record year was 1985 when more than 11-million vehicles were sold.

1919 Firsts and Breakthroughs

René Thomas became the first driver to exceed 100 mph at the **Indianapolis 500,** and a **Duesenberg** racing car with two straight-8 engines set a land speed record of 158 mph at Daytona Beach, Fla.

Detroit installed the first three-color traffic light. **The University of California, Los Angeles,** opened. **Clarence Avery** introduced continuous process plate glass at Ford making cheap closed-cars possible, an electric starter became available on the **Ford Model-T;** and Ford started testing ergonomics using a human dummy.

Previously, buyers had to pay cash for cars, but in 1919, **GM** became a financing pioneer with the establishment of **General Motors Acceptance Corp.** (GMAC), which put more people in new cars by offering credit and easy-payment plans.

Oregon imposed the first state gasoline tax (1¢/gal). **American Express** issued its first Traveler's Checks. The pogo stick was invented**. Eureka** starting shipping 2000 **vacuum cleaners** daily, and the first **dial telephone** appeared. **Charles Strite** invented the first **pop-up toaster,** and **President Wilson** won the **Nobel Peace Prize.**

The dial telephone was a technical breakthrough.

Established in 1919 were **The League of Nations, Grand Canyon, Zion,** and **Acadia National Parks,** the **American Legion,** plus **greyhound racing** with mechanical rabbits, **pulp magazines** like *True Story,* and commercial airline service began on **Deutsche Luftreederie**.

The **18th Amendment** to the Constitution, prohibiting the manufacture and sale of alcohol, came into force, and Congress approved the **19th Amendment** giving women the right to vote. **Benito Mussolini** founded the Fascist Party in Italy.

1919 Mayhems and Disasters

But, all was not well in 1919. There were serious strikes by railroad employees, longshoremen, and coal workers, and **The Great Steel Strike** resulted in a nationwide uprising against the **United States Steel Corp.** by 350,000 recently organized steel workers that was marked by violence. There was a general strike in Seattle, Wash., and riots in Cleveland, Ohio, and Omaha, Neb.

The **'Great Boston Molasses Tragedy of 1919'** occurred Jan. 15, when a huge tank exploded releasing 2.3-million gallons of molasses in a 40-ft flood that killed 21 people, injured 150, buckled the elevated railroad tracks, crushed buildings, and inundated the neighborhood.

A powerful **hurricane,** Sept. 2–16, passed south of Key West, crossed the Gulf of Mexico shipping lanes and made landfall just south of Corpus Christi, Tex. The death toll in Texas was 286, but the overall death toll was more than 600 from ships lost at sea.

An "iron horse" circa 1919.

Volcano Kelut erupted in Java killing 16,000.

The **Black Sox Scandal** occurred wherein the **Cincinnati Reds** "won" the **World Series.**

1919 Celebs Who Came and Went

Notable too, are the celebrities who were born and died this year. Births include **Andy Rooney, J. D. Salinger, Ernie Kovacs, Jackie Robinson, Red Buttons, Eva Gabor, Tennessee Ernie Ford, Jack Palance, Jennifer Jones, Nat King Cole, Eva Perón, Lex Barker, Liberace, Margot Fonteyn, George Gobel, Robert Merrill,** and Sir **Edmund Hillary.**

Deaths in 1919 included **William Crookes, Emiliano Zapata, L. Frank Baum, Ruggero Leoncavallo, Andrew Carnegie, Alfred Werner, Theodore Roosevelt,** and **Pierre-Auguste Renoir.**

Portrait of a Watershed Year

In retrospect, 1919, the first year after the war, offered the country the opportunity to seek higher goals in manufacturing and scientific achievements, and concern for preserving the nation's natural resources. The formation of the American Welding Society at this critical time ensured industries would have the peer-reviewed construction standards essential to build confidently for the future.♦

Preventing Shock during SMAW

Tips are offered to help you keep safe during shielded metal arc welding

Welders performing shielded metal arc welding (SMAW) can experience shocks because of improper personal protection and awareness of proper procedures. A shock — no matter how small — should never be assumed to be an acceptable practice; that assumption can prove fatal.

SMAW Basics

In shielded metal arc welding (SMAW), the intense heat from an electric arc is used to melt and fuse metals to form a weld. It is one of the oldest and most widely used welding processes. Although used chiefly for joining iron and mild steel, SMAW is well suited for maintenance tasks because the equipment is relatively inexpensive, simple to operate, and can be used to weld many different kinds of metals.

The typical SMAW package consists of an electric welding machine, two welding cables, a ground clamp, an electrode holder, and a flux-covered metal electrode. Electric current from the welding machine is used to form an electric arc between the tip of the electrode and the work.

Welding is started by touching the end of the electrode to the base metal, then lifting the electrode about ¼ in. This forms the arc, which produces temperatures up to 5550°F. The intense heat at the arc area instantly melts the base metal and begins to burn the flux off the electrode and to melt the rod. The melted rod becomes the filler metal for the weld, and the decomposition of the flux forms a protective gaseous atmosphere around the arc area. The gas forms a shield against contamination from oxygen and nitrogen in the surrounding air. Additionally, shielding is provided by the electrode flux, which forms a deposit called slag.

Either direct current (DC) or alternating current (AC) is used. The arc voltage or working voltage is the voltage present in the welding current while an arc is struck and welding is being done. The arc voltage typically ranges from 15 to 40 V, depending on the arc length.

The open circuit voltage (OCV) is the voltage generated by the welding machine when no welding is being done. Open circuit voltages are normally set between 50 and 100 V (most are at 80 V), but drops to the arc voltage level when an arc is struck and welding begins.

As the name implies, with OCV no current is flowing because the circuit is open. The voltage is impressed upon the circuit, however, so that when the circuit is completed, the current will flow immediately. For example, a welding machine that is turned on but not being used for welding at the moment will have an open-circuit voltage applied to the cables attached

Based on information provided by NLC-Lenco Inc., Jackson, Mo.

Table 1 — Possible Effects of Electric Shock

DC Current (mA)	Effects
15–20	Makes hands "clamp on"
30–40	Paralysis of diaphragm
50+	Ventricular fibrillation
1000	Death

to the output terminals of the welding machine.

Preventing OCV Shock

Remember that in hot conditions, the risk of electrocution is increased because clothing and equipment may be soaked in perspiration. In addition, the risk is worse in closed environments, such as tanks or vessels. Therefore, extra care should be taken. Table 1 shows the effects of electrical shock.

Some suggestions to avoid OCV electrical shock follow:
- Use dry, hole-free welding gloves on both hands, particularly when changing electrodes.
- Remove stub ends immediately after welding; do not leave an electrode stub in the holder.
- Turn off the power at the end of each shift or when taking a break.
- Do not drag live leads to the work.
- Follow recommendations provided by the equipment manufacturer.
- Check equipment periodically to make sure there are no cracks or worn spots on the electrode holder or cable insulation.
- Do not weld while standing on a wet surface.

Equipment is available to create a safer working environment by protecting the welder from the open circuit voltage that is inherent in SMAW. For example, the ISOLATOR electrode holder from Lenco has a latching mechanism built into the body. When used as recommended, the welder pulls the cable while holding the electrode holder and the mechanism latches, disrupting the current path between the welding machine and the jaws of the electrode holder. This action allows the welder to touch and maneuver the electrode without fear of an electrical shock or arcing against the workpiece. When the welder is ready to weld, he or she releases the latching mechanism by pressing the release button in the electrode holder handle to reestablish welding current to the electrode.♦

American Welding Society

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, 2009. The committee looks forward to receiving these nominations for 2010 consideration.

Sincerely,

Alfred F. Fleury
Chair, Counselor Selection Committee

(please type or print in black ink)

CLASS OF 2010

COUNSELOR NOMINATION FORM

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 COUNSELOR ACCOMPANY THE NOMINATION PACKET. IF NOMINEE IS SELECTED, THIS STATEMENT MAY BE INCORPORATED WITHIN THE CITATION CERTIFICATE.

****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.

SUBMITTED BY:
PROPOSER____
AWS Member No.________________

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.

NOMINATING MEMBER:______________________________Print Name______________________________
AWS Member No.____________
NOMINATING MEMBER:______________________________Print Name______________________________
AWS Member No.____________
NOMINATING MEMBER:______________________________Print Name______________________________
AWS Member No.____________
NOMINATING MEMBER:______________________________Print Name______________________________
AWS Member No.____________

SUBMISSION DEADLINE JULY 1, 2009

American Welding Society

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 partici pation 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

Maximum of 10 Counselors selected each year.

Return completed Counselor 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: 800-443-9353, extension 293

SUBMISSION DEADLINE: July 1, 2009

WELDING WORKBOOK

Datasheet 306

Welding Current and SMAW

Shielded metal arc welding (SMAW) can be accomplished with either alternating or direct electrical current, provided that the appropriate electrode has been selected. The magnitude of the welding current, the polarity, and the constituents in the electrode covering influence the melting rate of all covered electrodes. For any given electrode, the melting rate is directly related to the electrical energy supplied to the arc, but only a fraction of that energy is used to melt the electrode. The rest melts and heats the base metal or is lost to the environment.

Direct current always provides a steadier arc and smoother metal transfer than alternating current because the amperage and direction of current flow is not constantly changing as it is with AC. Most covered electrodes operate better on direct current electrode positive (DCEP), although some electrodes are designed for use with direct current electrode negative (DCEN). DCEP produces deeper penetration, while DCEN produces a higher electrode melting rate. The DC arc produces good wetting action and uniform weld bead size, even at low amperage, making it particularly suited to welding thin sections. Direct current is preferred for the vertical and overhead welding positions and for welding with a short arc. The DC arc is less likely to short out and to eject the globules of molten metal as they transfer across the arc and into the weld pool. Arc blow may be a problem when magnetic metals are welded with DC. The magnetic field the current induces may deflect the arc and eject molten droplets from the arc area. One way to overcome this is to change to AC.

Alternating current offers two advantages over DC for SMAW. One is the absence of arc blow and the other is the cost of the power source. Without arc blow, larger electrodes and higher welding currents can be used. Certain electrodes (specifically those with iron powder in the covering) are designed for use at higher amperages with AC. The highest welding speed for the SMAW process is possible using these electrodes on AC with the drag technique. The absence of arc blow with AC also minimizes any impact of a welding fixture, the fixture design, and the location of the workpiece connection. An AC transformer costs less than an equivalent DC power source; however, cost should not be the sole criterion in the selection of the power source.

Amperage. Covered electrodes of a specific size and classification will operate satisfactorily at various amperages within a given range. The range will vary somewhat with the formulation and thickness of the covering. Deposition rates increase as the amperage increases. For a given size of electrode, the amperage ranges and the resulting deposition rates will vary from one electrode classification to another. The relationship between deposition rates and amperage for several classifications of carbon steel electrodes of one size is shown in Fig. 1.

With a specific type and size of electrode, the optimum amperage depends on factors such as the position of welding and type of joint. The amperage must be sufficient to obtain good fusion and penetration, yet permit proper control of the weld pool. For welding in the vertical and overhead positions, the optimum amperages will likely fall on the low end of the allowable range. Amperage beyond the recommended maximum should not be used. This can overheat the electrode and cause excessive spatter, arc blow, undercut, and weld metal cracking.

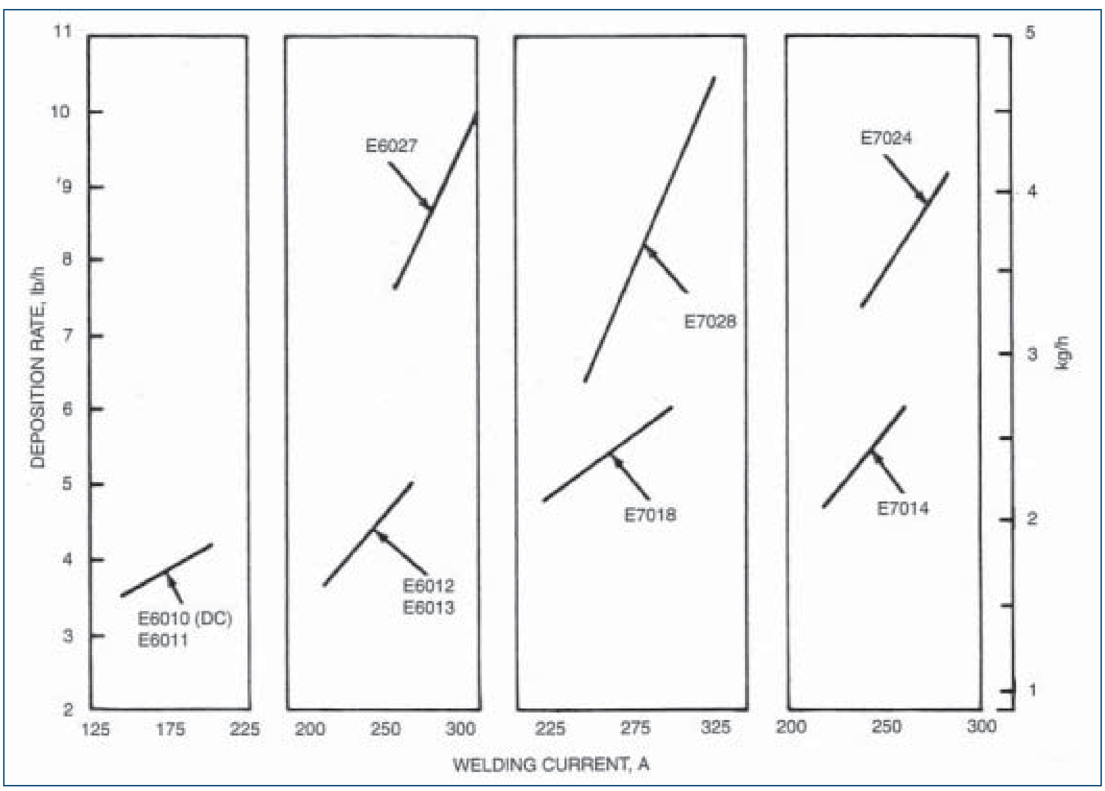

Fig. 1 — The relationship between deposition rates and welding current for various types of 4.8-mm-diameter carbon steel electrodes.

Excerpted from the *Welding Handbook,* Vol. 2, ninth edition.


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COMING EVENTS

NOTE: A DIAMOND (♦) DENOTES AN AWS-SPONSORED EVENT.

♦AWS Weldmex. June 2–4, Cintermex Exhibition Center, Monterrey, Mexico. Colocated with Metalform Mexico, FABTECH Mexico, and COATech. Contact American Welding Society, (800/305) 443-9353, ext. 229; or visit *www.aws.org.*

Beijing-Essen Welding & Cutting Fair. June 2–5, Shanghai, China. Visit *www.beijing-essen-welding.de.*

Emerging Technologies for High-Productivity Heavy Fabrication, EWI Workshop. June 3, 4, EWI, Columbus, Ohio. Visit *www.ewi.org/events.*

AeroMat® 2009 Conf. and Expo. June 7–11, Dayton Convention Center, Dayton, Ohio. Call ASM (800) 336-5152, ext. 0; visit *http://asmcommunity.asminternational.org/content/Events/aeromat09/* or e-mail *customerservice@asminternational.org.*

SME Annual Conf. June 7–9, Hyatt Regency Philadelphia, Philadelphia, Pa. Contact Society of Manufacturing Engineers, (313) 425-3069; *www.sme.org.*

♦Weld Cracking VII 'The Heat-Affected Zone' Conf. June 9, 10, Columbus, Ohio. Contact American Welding Society, (800/305) 443-9353, ext. 229; or visit *www.aws.org.*

First Int'l Conf. on Welding Technologies. June 11–13, Gazi University, Ankara, Turkey. Visit *www.icwet09.org.*

First Annual White Mountain Railfest. June 12–14, North Woodstock, N.H. Presented by The Flying Yankee Restoration Group, Inc. For information, visit *www.flyingyankee.com,* or call (603) 968-3003.

♦6th Annual Charting the Course in Welding: U.S. Shipyards Conf. June 16, 17, Sheraton Metairie Hotel, New Orleans, La. Contact American Welding Society, (800/305) 443-9353, ext. 229; or visit *www.aws.org.*

Western Manufacturing Technology Show. June 16–18. Northlands Park-AgriCom, Edmonton, Alb., Canada. Contact Society of Manufacturing Engineers, (800) 733-4763; or visit *www.sme.org.*

7th Int'l Expo on Electric Power Equipment and Technology and **6th Int'l Expo on Electrical Engineering, Electrical Equipment, and Contractors' Supplies.** July 8–10. Shanghai Int'l Expo Center, Shanghai, PR, China. Visit *www.2456.com/ep.*

Int'l Metallographic Society Annual Convention. July 26–30, Richmond, Va. Sponsored by ASM Int'l. Held during Microscopy and Microanalysis. Visit *http://mm2009.microscopy.*

Titanium 2009 Conf. Sept. 13–16, Hilton Waikoloa Village, Waikoloa, Hawaii. Sponsored by the International Titanium Assn. Visit *www.titanium.org.*

Essen Welding Fair (Schweissen & Schneiden). Sept. 14–19, Essen, Germany. Visit *www.messe-essen.de.*

25th ASM Heat Treating Society Conf. and Expo. Sept. 14–17, Indiana Convention Center and RCA Dome, Indianapolis, Ind. Visit *www.asminternational.org.*

Asiamold — Int'l Trade Fair for Moldmaking and Tooling, Design, and Application Development. Sept. 16–18, Poly World Trade Centre Expo, Guangzhou, China. Visit *www.asiamold-china.com.cn.*

♦**GAWDA Annual Meeting.** Sept. 20–23, Grand Hyatt Hotel, San Antonio, Tex. Sponsored by Gases and Welding Distributors Assn. Visit *www.gawda.org.*

Numerical Analysis of Weldability, 9th Int'l Seminar. Sept. 28–30, Graz-Seggau, Austria. Sponsored by Graz University of Technology, Austria Institute for Materials Science and Welding, and IIW Commission IX working group Mathematical Modeling of Weld Phenomena. Visit *http://iws.tugraz.at.*

SOUTH-TEC. Oct. 6–8, Charlotte Convention Center, Charlotte, N.C. Contact Society of Mfg. Engineers, (800) 733-4763; or visit *www.sme.org/southtec.*

♦**Welding of Corrosion-Resistant Alloys Conf.** Oct. 6, 7, New Orleans, La. Contact American Welding Society, (800/305) 443-9353, ext. 229; or visit *www.aws.org.*

Power-Gen Asia and Renewable Energy World Asia Conf. and Expo. Oct. 7–9, IMPACT Exhibition & Convention Centre, Bangkok, Thailand. Visit *www.powergenasia.com.*

SNAME 2009 Annual Meeting and Expo. Oct. 21–23, Providence, R.I. Contact Society of Naval Architects & Marine Engineers. Visit *www.snameexpo.com.*

96th ASM Annual Meeting at MS 2009. Oct. 25–29, Pittsburgh, Pa. Coorganized by ASM Int'l, ACerS, and AIST. Visit *www.matscitech.org.*

The Aluminum Assn. Annual Meeting. Oct. 25–27, Charleston Place, Charleston, S.C. Visit *www.aluminum.org.*

National Robot Safety Conf. XXI. Oct. 26–29, Hyatt Regency, Dearborn, Mich. Contact Robotic Industries Assn. at *ria@informz.net* or *ria@robotics.org.*

ICALEO®, 28th Int'l Congress on Applications of Lasers & Electro-Optics. Nov. 2–5, Hilton in the Walt Disney World Resort®, Orlando, Fla. This conference is where researchers and end-users will meet to review state-of-the-art laser materials processing and project what lies in the future. Laser Institute of America's goal for ICALEO® is to bring both academic and industrial people together who may benefit from laser technology. E-mail Laser Institute of America at *conferences@laserinstitute.org;* or visit *www.icaleo.org.*

♦ **FABTECH International & AWS Welding Show** now including **METALFORM.** Nov. 15–18, McCormick Place, Chicago, Ill. This show is the largest event in North America dedicated to showcasing the full spectrum of metal forming, fabricating, tube and pipe, welding equipment, and technology. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit *www.aws.org.*

35th Int'l Symposium for Testing Failure Analysis (ISTFA). Nov. 15–19, San Jose, Calif. Visit *www.asminternational.org.*

♦ **Thermal Spray and Coatings Conf.** Nov. 16, Chicago, Ill. Held in conjunction with the FABTECH International & AWS Welding Show. Sponsored by the International Thermal Spray Assoc. and the American Welding Society. Visit *www.thermalspray.org.*

♦ **Weld Cracking VII.** Nov. 16, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit *www.aws.org.*

♦ **Int'l Electron Beam Conf.** Nov. 16, 17, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit *www.aws.org.*

♦ **Welding Chrome-Moly Steels Conf.** Nov. 17, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit *www.aws.org.*

♦ **Welding Corrosion-Resistant Alloys Conf.** Nov. 18, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit *www.aws.org.*

9th Int'l Welding Conf. and Expo. Dec. 1–3, World Trade Center, Yekaterinburg, Russian Federation. Visit *www.uv2000.ru.*

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)

Location	Seminar Dates	Exam Date
Spokane, WA	Jun. 7-12	Jun. 13
Oklahoma City, OK	Jun. 7-12	Jun. 13
Birmingham, AL	Jun. 7-12	Jun. 13
Hartford, CT	Jun. 14-19	Jun. 20
Pittsburgh, PA	Jun. 14-19	Jun. 20
Beaumont, TX	Jun. 14-19	Jun. 20
Corpus Christi, TX	EXAM ONLY	Jun. 20
Kansas City, MO	Jun. 21-26	Jun. 27
Knoxville, TN	EXAM ONLY	Jun. 27
Miami, FL	EXAM ONLY	Jul. 16
Fargo, ND	Jul. 12-17	Jul. 18
New Orleans,LA	Jul. 12-17	Jul. 18
Sacramento,CA	Jul. 12-17	Jul. 18
Phoenix, AZ	Jul. 19-24	Jul. 25
Orlando, FL	Jul. 19-24	Jul. 25
Milwaukee, WI	Jul. 19-24	Jul. 25
Cleveland,OH	Jul. 26-31	Aug. 1
Los Angeles, CA	Jul. 26-31	Aug. 1
Louisville, KY	Jul. 26-31	Aug. 1
Denver, CO	Aug. 2-7	Aug. 8
Philadelphia, PA	Aug. 2-7	Aug. 8
San Diego, CA	Aug. 9-14	Aug. 15
Miami, FL	Aug. 9-14	Aug. 15
Charlotte, NC	Aug. 16-21	Aug. 22
San Antonio, TX	Aug. 16-21	Aug. 22
Bakersfield,CA	Aug. 16-21	Aug. 22
Rochester, NY	EXAM ONLY	Aug. 22
Portland, ME	Aug. 23-28	Aug. 29
Salt Lake City, UT	Aug. 23-28	Aug. 29
Seattle, WA	Aug. 23-28	Aug. 29
Corpus Christi, TX	EXAM ONLY	Aug. 29
Pittsburgh, PA	Aug. 30-Sept. 4	Sept. 5
Houston,TX	Aug. 30-Sept. 4	Sept. 5
Minneapolis, MN	Aug. 30-Sept. 4	Sept. 5
St. Louis, MO	Sept. 20-25	Sept. 26
Miami, FL	Sept. 20-25	Sept. 26
New Orleans, LA	Sept. 20-25	Sept. 26
Anchorage, AK	EXAM ONLY	Sept. 26
Tulsa,OK	Oct. 4-9	Oct. 10
Long Beach, CA	Oct. 4-9	Oct. 10
Newark, NJ	Oct. 4-9	Oct. 10
Miami, FL	EXAM ONLY	Oct. 15
Portland ,OR	Oct. 18-23	Oct. 24
Roanoke, VA	Oct. 18-23	Oct. 24
Cleveland,OH	Oct. 18-23	Oct. 24
Atlanta,GA	Nov. 1-6	Nov. 7
Dallas, TX	Nov. 1-6	Nov. 7
Sacramento, CA	Nov. 1-6	Nov. 7
Spokane, WA	Nov. 1-6	Nov. 7
Corpus Christi, TX	EXAM ONLY	Nov. 21
St. Louis, MO	EXAM ONLY	Dec. 5
Syracuse, NY	Dec. 6-11	Dec. 12
Reno, NV	Dec. 6-11	Dec. 12
Miami, FL	Dec. 6-11	Dec. 12

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.

9-Year Recertification Seminar for CWI/SCWI

Location	Seminar Dates	Exam Date
Pittsburgh, PA	Jun. 1-6	NO EXAM
San Diego, CA	Jul. 13-18	NO EXAM
Orlando, FL	Aug. 24-29	NO EXAM
Dallas, TX	Oct. 5-10	NO EXAM
Miami, FL	Nov. 30-Dec. 5	NO EXAM

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 Welding Supervisor (CWS)

Location	Seminar Dates	Exam Date
Columbus, OH	Jun. 1-5	Jun. 6
Minneapolis, MN	Jul. 20-24	Jul. 25
Philadelphia, PA	Aug. 31- Sep. 4	Sep. 5
Tulsa, OK	Oct. 5-9	Oct. 10
Long Beach, CA	Nov. 30-Dec. 4	Dec. 5

CWS exams are also given at all CWI exam sites.

Certified Radiographic Interpreter (CRI)

Location	Seminar Dates	Exam Date
Miami, FL	Jun. 22-26	Jun. 27
Houston, TX	Jul. 27-31	Aug. 1
Miami, FL	Oct. 19-23	Oct. 24

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

Certified Welding Sales Representative (CWSR)

Location	Seminar Dates	Exam Date
Miami, FL	Oct. 21-23	Oct. 23
Chicago, IL	Nov. 16-18	Nov. 18

CWSR exams will also be given at certain CWI exam sites. Call for details.

Certified Welding Educator (CWE)

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

Senior Certified Welding Inspector (SCWI)

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

Code Clinics & Individual Prep Courses

The following workshops are offered at all sites where the CWI seminar is offered (code books not included with individual prep courses): Welding Inspection Technology (general knowledge and prep course for CWI Exam-Part A); Visual Inspection Workshop (prep course for CWI Exam-Part B); and D1.1 and API-1104 Code Clinics (prep courses for CWI Exam-Part C).

On-site Training and Examination

On-site training is available for larger groups or for programs customized to meet specific needs of a company. Call ext. 455 for more information.

International CWI Courses and Exams

AWS training and certification for CWI and other programs are offered in many countries. For international certification program schedules and contact information, please visit *http://www.aws.org/certification/inter_contact.html*

American Welding Society®

SOCIETY NEWS

BY HOWARD M. WOODWARD

District 12 Winter Meeting Becomes an Anticipated Event

District 12 members prepare to tour the John Deere facilities during their annual winter meeting, hosted by the Madison-Beloit Section.

Four years ago, District 12 Section officers founded the idea of an annual winter meeting, hosted by a different Section each year, designed to bring the Sections together. The model for the meeting would be a tour of a local manufacturing facility followed by speakers, an awards-presentation meeting, and dinner. This year, the Madison-Beloit Section hosted the fourth annual District 12 winter meeting February 13 at Rock River Hills Golf Club. The event included tours of the John Deere Horicon Works, in Horicon, Wis.

One-hundred sixteen AWS members, including keynote speaker AWS President **Victor Matthews,** participated. The attendees split into six groups to tour the John Deere plants to study the welding, painting, and assembly techniques in several facilities that manufacture riding lawn equipment, utility vehicles, and various other products. They also had the opportunity to see several large stamping presses, where the majority of the company's steel components are made.

Awardees at the District 12 winter meeting are (front, from left) Josh Steinbrecher and Neil Marshall; (standing, from left) Tony Stute, Dan Jones, District 12 Director Sean Moran, Ken Karwowski, Dave Ramseur, Ben Newcomb, and Scott Tenent.

After the tours, they reassembled at the Rock River Hills Golf Club, where they enjoyed a presentation detailing the 3-D virtual tour planning tools John Deere engineers used to design the X300 and X500 lawn tractor assembly line, given by **Jeff Hollett,** John Deere's manager, manufacturing engineering.

President **Victor Mathews's** talk discussed the various careers available in the welding field. He also spoke of the critical issues facing American industry due to shortages of skilled labor and explained how the Society is working to address them. Matthews also enumerated the benefits of the various professional certifications that AWS offers.

Sean Moran, District 12 director, presided over the presentation of the District recognitions. **Dan Jones** received the District Educator and District Meritorious Awards; **Scott Tenent** received the District Educator award; **Ken Karwowski** received the District CWI of the Year Award; **Ed Bohnart** received the District Private Industry Instructor Award; and Madison-Beloit Section Chair **Ben Newcomb, Antone (Tony) Stute,** and **Dave Ramseur** received District 12 Director Awards. Also celebrated were the winners in the Wisconsin SkillsUSA welding contests, **Josh Steinbrecher** and **Neil Marshall,** who received certificates of recognition from the AWS board of directors.

This fast-paced annual meeting, well-received by the more than 100 attendees each year, is a much-anticipated event that greatly enhances the camaraderie among the District's Section members.

Tech Topics

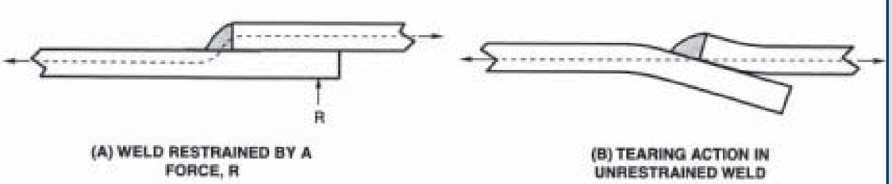
ERRATA

AWS D1.1/D1.1M:2008
Structural Welding Code — Steel

The following errata have been identified and incorporated into the current reprint of this document.

Page 8, Clause 2.3.5.4 — Heading "Depth of Filing" should read "Depth of Filling".

Page 439, Figure C-2.7, Single Fillet Welded Lap Joints. Incorrect illustration. Revert to figure as shown in the D1.1:2006 code (shown below):



ERRATA

D1.5M/D1.5:2008, *Bridge Welding Code*

The following errata have been identified and incorporated into the current reprint of this document.

Page 319, Figure C-3.5 — Illustration of Camber Tolerances for Steel Beams.

For sketches (A) and (B), the lines depicting the "Detailed Camber Shape" were corrected and made bolder than the lines depicting "Actual Camber of the Steel" for improved clarity. See corrected figure below.

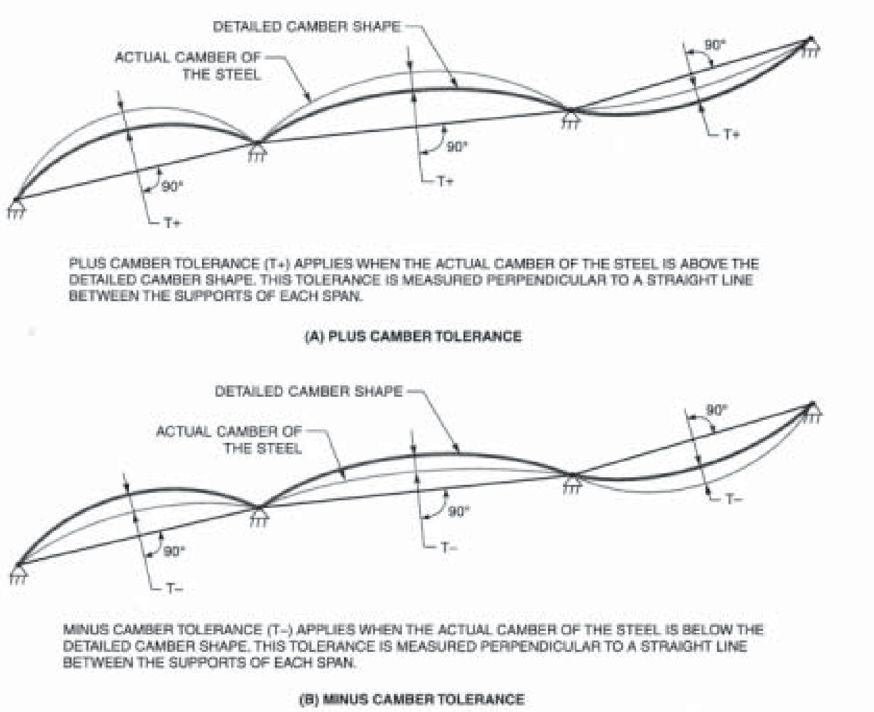


Figure C-3.5—Illustration of Camber Tolerances for Steel Beams

OFFICIAL INTERPRETATION

D1.5, *Bridge Welding Code*

Subject: AWS Standard Welding Procedure Specification and Welder Qualification
Code Edition: D1.5M/D1.5:2008
Code Provision: Clause 5.21
AWS Log: D1.5-08-I02

Inquiry: Does Clause 5.21 allow you to use an AWS Standard Welding Procedure Specification for welder performance qualification?

Response: Yes, providing the particular Standard Welding Procedure Specification is applicable to D1.5 welder qualification requirements.

Revised Standards Approved by ANSI

A5.12M/A5.12:2009 (ISO 6848:2004 MOD), *Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting.* Approved 4/17/2009.

D18.1/D18.1M:2009, *Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications.* Approved 4/17/2009.

Standards for ANSI Public Review

A5.8M/A5.8:200X, *Specification for Filler Metals for Brazing and Braze Welding.* Revised — $36. 6/1/2009.

D18.2:200X, *Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube.* Revised — $25. 5/25/2009.

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 standards are open for review until the dates shown. Draft copies may be obtained from R. O'Neill, ext. 451, *roneill@aws.org*.

ISO Standard for Public Review

ISO/DIS 14344.2, *Welding and allied processes — Procurement of welding consumables.*

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

A5 Filler Metals Committees Meet in Orlando

Shown March 30 during the A5 Committee meetings are (front, from left) Vice Chair Henry Wehr, Ashoke Mukherjee, Gregg Clark, Tom Myers, Alice Lau, Joe DeVito, Dennis Crockett, Dan Arthur, Jon Lee, Johnnie DeLoach Jr., and Bob Decker; (back, from left) are Roger Swain, Lee Kvidahl, Joel Feldstein, Henry White, Rick Sutherlin, Gene Franke, Janet Morse, Damian Kotecki, Russel Fuchs, and Sam Kiser. AWS staff engineer Rakesh Gupta, committee secretary, took the photograph.

New Standards Projects

Development work has begun on the following new or revised standards. Affected individuals are invited to contribute to the development of these standards. If you want to participate, contact the staff engineer listed with the document. Participation on all AWS technical committees is open to all persons.

B5.15:200X, *Specification for the Qualification of Radiographic Interpreters.* This specification defines the requirements for the qualification of radiographic interpreters. The qualification of radiographic interpreters requires experience, knowledge, and skills unique to the interpretation of radiographic media and the determination of acceptance criteria for weldments and adjacent base metal. Training and work experience in radiographic theory, procedures, weld and adjacent base metal defect recognition, radiographic processing, handling, storage, and code requirements relating to radiographic acceptance criteria are essential to ensuring the competence of individuals engaged in radiographic interpretation. Stakeholders: Users of radiography for weld testing, radiographic testing educators and trainers, producers and suppliers of radiographic equipment and supplies. Any fabrication or construction industry that uses radiography to evaluate weld soundness. Revised standard. J. Gayler, ext. 472.

C2.16/C2.16M:200X, *Guide for Thermal Spray Operator Qualification.* This guide contains recommendations for thermal spray operator qualification based on knowledge and skill testing. Twelve individual thermal spray operator qualification tests (TSOQT) are included for engineering and corrosion control applications: one each for job knowledge, high-velocity oxyfuel (HVOF) spraying and flame spray-fusing, two for arc spraying, and three each for flame spraying and air-plasma spraying. Stakeholders: Anyone involved with thermal spray. Revised standard. Call R. Starks, ext. 304.

C2.20/C2.20M:200X, *Specification for Thermal Spraying Zinc Anodes on Steel Reinforced Concrete.* This AWS standard is a specification for thermal spraying zinc anodes on steel-reinforced concrete. This standard is formatted as an industrial process instruction. The scope includes job description, safety, pass/fail job reference standards, feedstock materials, equipment, a step-by-step process instruction for surface preparation, thermal spraying, and quality control. There are two annexes: job control record and portable adhesion testing. Stakeholders: Anyone involved with thermal spray. Revised standard. Call R. Starks, ext. 304.

C2.21M/C2.21:200X, *Specification for Thermal Spray Equipment Acceptance Inspection.* This document specifies the thermal spray equipment acceptance requirements for plasma, arc-wire, flame-powder, -wire, -rod, and -cord, and high-velocity oxyfuel (HVOF) equipment. Evidence of the equipment capabilities are to be provided by the equipment manufacturer. Inspection reports are provided in five mandatory annexes. Stakeholders: Anyone involved with thermal spray. Revised standard. Call R. Starks, ext. 304.

C2.23M/C2.23:200X, *Specification for the Application of Thermal Spay Coatings.* This specification presents an industrial process for the application of thermal spray coating on steel. It covers safety, job reference standards, equipment setup and preparation, surface preparation, aluminum and zinc application, and sealer and topcoat application. Stakeholders: Anyone involved with thermal spray. Revised standard. Call R. Starks, ext. 304.

C2.25/C2.25M:200X, *Specification for Thermal Spray Feedstock — Solid and Composite Wire and Ceramic Rods.* This specification provides the as-manufactured chemical composition classification requirements for solid and composite wires and ceramic rods for thermal spraying. Requirements for standard sizes, marking, manufacturing, and packaging are included. Stakeholders: Anyone involved with thermal spray. Revised standard. Call R. Starks, ext. 304.

Technical Committee Meetings

June 9, B2F Subcommittee on Plastic Welding Qualifications. Dallas, Tex. Contact S. P. Hedrick, ext. 305.

June 9, G1A Subcommittee on Hot Gas Welding and Extrusion Welding. Dallas, Tex. Contact S. P. Hedrick, ext. 305.

June 17, Safety and Health Committee. Columbus, Ohio. Contact S. P. Hedrick, ext. 305.

July 16, 17, Committee on Personnel and Facilities Qualification. Pittsburgh, Pa. Contact J. L. Gayler, ext. 472.

New AWS Supporters

New Sustaining Company

Sunil HiTech Engineers Ltd.
97 E. High Court Rd.
Ramdaspeth
Nagpur, MS 440010, India
Representative: **Sunil R. Gutte**
www.sunilhitech.com

Sunil HiTech Engineers Ltd. has more than 15 years of technical expertise in the fabrication, erection, testing, and commissioning of 30- to 360-MW-capacity thermal power projects, in addition to manufacturing of pressure parts, piping, structural tanks, and other products. The company is also involved in infrastructure projects for the steel, petrochemical, and sugar industries.

Affiliate Companies

AASIA Steel Factory Co. Ltd.
PO Box 10372, Jubail Industrial City
31961, Saudi Arabia

Ace Tube Bending
14 Journey
Aliso Viejo, CA 92656

Alloy Construction Service, Inc.
Box 197, 401 Balsam
Carrollton, MI 48724

City of Vancouver
Equipment Services Branch
250 W. 70th
Vancouver, BC V5X 21X, Canada

DCL Testing & Inspection Services
4400 N. Galvez St.
New Orleans, LA 70117

Granite Petroleum Inc.
PO Box 6167
Spokane, WA 99217

Hebei Century Great Wall
Welding Material Co., Ltd.
Canghan R., Hejian Hebei 062450
China

ICATS
1000 Glen Johnson Loop
Okemah, OK 74859

Maya Steel Fabrications Inc.
301 E. Compton Blvd.
Gardena, CA 90248

Mengucci Kelly
15923 Spenner Rd.
Stayton, OR 97383

Mixer Center
990 E. South Loop
Stephenville, TX 76401

M & M Fabricating Inc.
1606 Broadway
Darien Center, NY 14040

R. Tinsley Projects Inc.
7500 Thomas Rd.
Altoona, KS 66710

Viasystems
9580 Joe Rodriguez
El Paso, TX 79927

Supporting Company

Aurora Welding & Fabrication, Inc.
1500 Dearborn Ave., Bldg. 17A
Aurora, IL 60505

Educational Institutions

Bellingham Technical College
3028 Lindbergh Ave.
Bellingham, WA 98225

Cass Civilian Conservation Center
21424 N. Hwy. 23
Ozark, AR 72949

North Central Texas College
Lifelong Learning Division
1525 W. California
Gainesville, TX 76240

Northeast Community College
801 E. Benjamin Ave.
Norfolk, NE 68701

Suffolk County Community College
Sally Ann Slacke Center
Grant Campus
Crooked Hill Rd.
Brentwood, NY 11717

Welding Distributor

Stillwater Steel & Supply, LLC
5320 E. 6th St.
Stillwater, OK 74074

Membership Counts

Member Grades	As of 5/01/09
Sustaining	521
Supporting	311
Educational	496
Affiliate	477
Welding distributor	47
Total corporate members	**1,852**
Individual members	51,004
Student + transitional members	5,832
Total members	**56,836**

Candidates Sought for Prof. Masubuchi Award

November 2 is the deadline for submitting nominations for the 2010 Prof. Koichi Masubuchi Award, sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology. This award includes an honorarium of $5000. It 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 be prepared by someone familiar with the research background of the candidate. It should include the candidate's résumé listing background, experience, publications, honors, and awards, plus at least three letters of recommendation from fellow researchers.

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

Membership Committee Meets in Orlando

Shown at the Membership Committee meeting April 1 in Orlando, Fla., are (from left) Cassie Burrell, Chairman Lee Kvidahl, Dennis Eck, Rhenda Mayo, David Trees, Jim Appledorn, and Mark Davidson. Russ Norris, District 1 director, took the photograph.

The AWS Membership Committee members met in Orlando, Fla., April 1 for a business meeting. The participants included Chairman **Lee Kvidahl,** Northrop Grumman Ship Systems; Vice Chairman **David Trees,** Grandee Enterprises, Inc.; District 1 Director **Russ Norris,** Airgas; **Dennis Eck,** National Alloy and Equipment; **Jim Appledorn,** The Lincoln Electric Co.; **Mark Davidson,** Best Welders Supply, Inc.; and AWS headquarters staff members **Cassie Burrell,** deputy executive director; and **Rhenda Mayo,** director, member services.

Student Chapter High Achievers Tapped for Awards

The following AWS Student Members have been chosen by their Chapter advisors to receive the Student Chapter Member Award.

Dennis W. Wyatt, AWS Lawson State Community College Student Chapter, has been selected by **Roy Ledford Jr.,** Chapter advisor, to receive the AWS Student Chapter Member Award. Wyatt has maintained nearly a 4.0 GPA average, and has been recognized on both the Lawson State Dean's List and the President's List. Wyatt, who served as Chapter chairman, was the recipient of the school's 2009 Outstanding Student Award in Welding Technology, and was also invited to attend the 14th annual workshop, hosted by the AWS Baton Rouge Section.

Jake Windon, AWS Columbiana County Career and Technology Center Student Chapter, has been selected by **Huck Hughes,** Chapter advisor, to receive the award. Windon has served as the Chapter's chairman and publicity chair. Active in the community, he built soccer goals for local youth teams, and helped to build ramps needed at the new home of a former student who is paralyzed. Windon won the local SkillsUSA contest and serves as the representative for the regional contest.

William Tomich Jr., AWS Ohio State University Student Chapter, has been selected by Dr. **Chon Tsai,** Chapter advisor, to receive the award. Tomich, who has been recognized on the Dean's List four times, served as the Chapter's junior representative this year, and will serve as the 2009–2010 Chapter chairman. He is AWS qualified in SMAW and FCAW, has attended the Engineer's Leadership Institute, and has completed the Lincoln Electric Welding Boot Camp.

Daniel Whiting, AWS Ohio State University Student Chapter, has been selected by Dr. **Chon Tsai,** Chapter advisor, to receive the award. Whiting, who served as the 2008–2009 Chapter chairman, initiated the NASA Moonbuggy project, and served as Moonbuggy team leader. He received the 2008–2009 Jack R. Barckhoff Welding Management Scholarship, and is a Dean's List Award winner.

Tom Crush, Ben Dehoff, Anthony Fletcher, Doug Hill, Nate Price, Randy Shoemaker, Antonio Stone, Moraima Valentin-Jimenez, Tavon Vazquez, and **Rheanna Wolf-Franqui** have all been selected by **Brian Yarrison,** York County School of Technology Student Chapter advisor, to receive the award. They are cited for the time, effort, and dedication they put forth in the planning and organization of the Chapter's car show that made this fund-raiser an overwhelming success.

Dennis W. Wyatt, a member of the Lawson State Community College Student Chapter, displays the certificate he received at a Birmingham Section meeting in April.

Member-Get-A-Member Campaign

Listed below are the people participating in the 2008–2009 AWS Member-Get-A-Member Campaign. For campaign rules and a prize list, see page 85 in this *Welding Journal*, and for complete campaign rules visit www.aws.org/mgm. The standings are as of March 17, 2009. If you have any questions regarding your member proposer points, call the AWS Membership Dept. (800/305) 443-9353, ext. 480.

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[7]
E. Ezell, Mobile[6]
J. Merzthal, Peru[2]
G. Taylor, Pascagoula[2]
L. Taylor, Pascagoula[2]
B. Mikeska, Houston[1]
W. Shreve, Fox Valley[1]
M. Karagoulis, Detroit[1]
S. McGill, NE Tennessee[1]
T. Weaver, Johnstown/Altoona[1]
G. Woomer, Johnstown/Altoona[1]
R. Wray, Nebraska[1]
M. Haggard, Inland Empire[1]

President's Guild

Sponsored 20+ new members.

S. Esders, Detroit — 22

President's Roundtable

Sponsored 9–19 new members.

E. Ezell, Mobile — 18
P. Betts, Mobile — 12
R. Biggs, Nebraska — 9
S. Keskar, India — 9

President's Club

Sponsored 3–8 new members.

J. Compton, San Fernando Valley — 8
L. Contreras, South Florida — 8
R. Ellenbecker, Fox Valley — 8
P. Shahoveisi, International — 7
C. Daon, Israel — 6
D. Marquard, Cleveland — 6
R. Robles, Corpus Christi — 6
D. Wright, Kansas City — 6
W. Rice, Tri-State — 5
R. Shepherd, Fox Valley — 5
M. Hackl, Cuautitlan Izcalli — 4
D. Herr, York-Central Pa. — 4
G. Koza, Houston — 4
R. Newman, Maine — 4
B. Vernyi, Cleveland — 4
C. Becker, Northwest — 3
B. Franklin, Mobile — 3
R. Johnson, Detroit — 3
L. Moss, Sangamon Valley — 3
P. Newhouse, British Columbia — 3
M. Rahn, Iowa — 3
M. Wheat, Western Carolina — 3

President's Honor Roll

C. Alfaro, San Diego — 2
T. Baldwin, Arrowhead — 2
M. Boggs, Stark Central — 2
M. Boyer, Detroit — 2
R. Boyer, Nevada — 2
K. Bristow, East Texas — 2
K. Campbell, L.A./Inland Empire — 2
J. Contreras, International — 2
M. Cyphyert, Northwestern Pa. — 6
B. Donaldson, British Columbia — 2
E. Dupree, Tidewater — 2
T. Ferri, Boston — 2
N. Goel, New York — 2
F. Hendrix, New Jersey — 2
J. Hope, Puget Sound — 6
T. Johnson, Pittsburgh — 2
G. Lawrence, N. Central Florida — 2
E. Levert, North Texas — 2
J. Livesay, Nashville — 2
J. Padilla, Cuautitlan Izcalli — 2
S. Luke, Acadiana — 2
J. Nash, Atlanta — 2
R. Pitt, Tidewater — 2
J. Polson, L.A./Inland Empire — 2
D. Roland, Upper Peninsula — 2
J. Rule, Cleveland — 2
J. Sisson, Niagara Frontier — 2
K. Smith, North Texas — 2
R. Somers, Northern New York — 2
M. Spangler, J.A.K. — 2
A. Stute, Madison-Beloit — 2
J. Svatos, Siouxland — 2
D. Thomason, Chicago — 2
M. Torres, Pascagoula — 2
B. Whatley, Albuquerque — 2
R. Young, Iowa — 2
M. Yung, Portland — 2
D. Zabel, SE Nebraska — 2
P. Zammit, Spokane — 2

Student Member Sponsors

J. Leen, Chicago — 136
D. Berger, New Orleans — 110
J. Kacir, Detroit — 86
B. Benyon, Pittsburgh — 42
A. Baughman, Stark Central — 36
M. Boggs, Stark Central — 36
R. Jones, Puget Sound — 36
A. Rowe, Philadelphia — 36
A. Zinn, Eastern Iowa — 34
T. Moore, New Orleans — 32
R. Hutchinson, Long Bch./Or. Cty. — 30
J. Carney, Western Michigan — 27
J. Roberts, Sacramento — 27
J. Harris, Pascagoula — 26
E. Norman, Ozark — 26
S. Siviski, Maine — 26
T. Geisler, Pittsburgh — 24
H. Hughes, Mahoning Valley — 24
J. Kline, Northern New York — 24
D. Newman, Ozark — 24
R. Newman, Maine — 24
R. Cook, Utah — 23
E. Hinojosa, L.A./Inland Empire — 23
D. Howard, Johnstown-Altoona — 23
B. Suckow, Northern Plains — 23
R. Young, Iowa — 23
L. Clark, Milwaukee — 22
D. Schnalzer, Lehigh Valley — 22
D. Zabel, SE Nebraska — 22
J. Rule, Cleveland — 21
R. Munns, Utah — 21
A. Duron, New Orleans — 19
J. Fox, NW Ohio — 19
D. Zabel, SE Nebraska — 22
D. Ketler, Willamette Valley — 19
J. Ciaramitaro, N. Central Florida — 18
D. Pickering, Central Arkansas — 18
R. Schmidt, Philadelphia — 18
T. Strickland, Arizona — 18
J. Boyer, Lancaster — 17
R. Boyer, Nevada — 17
C. Donnell, NW Ohio — 16
B. Hallila, New Orleans — 16
D. Vranich, N. Florida — 16
M. Arand, Louisville — 14
G. Smith, Lehigh Valley — 14
W. Galvery Jr., Long Bch./Or. Cty. — 13
A. Mattox, Lexington — 13
R. Rummel, Central Texas — 13
D. Saunders, Lakeshore — 13
A. Stute, Madison-Beloit — 13
D. Taylor, Kern — 13
J. Daugherty, Louisville — 12
R. Ledford Jr., Birmingham — 12
J. Marshall, Siouxland — 12
R. Evans, Siouxland — 11
D. Kowalski, Pittsburgh — 11
J. Theberge, Boston — 11
A. Badeaux, Washington, D.C. — 10
C. Kipp, Lehigh Valley — 10
C. Abram, Columbus — 9
K. Caliva, New Orleans — 9
S. Colton, San Diego — 9
R. Norris, Maine — 9
V. Facchiano, Lehigh Valley — 9
D. Kearns, Northern Michigan — 8
M. Rabo, Sacramento — 8
G. Saari, Inland Empire — 8
N. Carlson, Idaho/Montana — 7
L. Caughron, Kansas City — 7
J. Geesey, Pittsburgh — 7
S. MacKenzie, Northern Michigan — 7
D. Roskiewich, Philadelphia — 7
J. Fitzpatrick, Arizona — 6
J. Reed, Ozark — 6
C. Schiner, Wyoming — 6
M. Hayes, Puget Sound — 5
C. Hobson, Olympic Section — 5
T. Hopper, Mobile — 5
J. Livesay, Nashville — 5
R. Olesky, Pittsburgh — 5
S. Robeson, Cumberland Valley — 5
R. Sand, Northern Plains — 5
T. Shirk, Tidewater — 5
T. Buckler Sr., Columbus — 4
H. Evans, Portland — 4
W. Geiger, N. Central Florida — 4
W. Kielhorn, East Texas — 4
G. Rolla, L.A./Inland Empire — 4
S. Tennant, Fox Valley — 4
F. Gorglione, Connecticut — 3
D. Hamilton, Chattanooga — 3
S. Hansen, SE Nebraska — 3
J. Hayes, Oklahoma City — 3
R. Huston, Olympic Section — 3
J. Russell, Fox Valley — 3
R. Richwine — 3
D. Saunders, Holston — 3
M. Shelton, Sabine — 3
B. Suarez, Houston — 3
B. Wenzel, Sacramento — 3

SECTION NEWS

Shown at the Boston Section executive committee meeting are (from left) Warren Ballard, Neil Mansfield, Rick Moody, Chair Jim Shore, Jack Paige, Bob Lavoie, Tom Ferri, Gary Hylan, and Dick Jones.

District 1

Russ Norris, director
(207) 604-9262
russ.norris@airgas.com

APRIL 6
Activity: The Section members toured Hollis Line Machine Co. in Hollis, N.H., a fabricator of pressure vessels and numerous precision products. **John Siergiewicz Jr.** led the tour for the 33 attendees and demonstrated the company's capability for robotic laser beam welding of ½-in. stainless steel parts.

APRIL 15
Activity: The Boston Section executive committee met to discuss the upcoming District 1 conference, and to finalize plans for the annual golf outing. **Jim Shore** was presented an appreciation plaque for his services as chairman. The meeting was hosted by **Rick Moody** at Artisan Industries in Waltham, Mass.

Shown at the Connecticut Section program are (seated, from left) District 1 Director Russ Norris and Al Moore Jr., and (standing, from left) Chair Gary Shubert, Nino Olivares, and Walter Chojnacki.

CONNECTICUT

MARCH 26
Activity: The Section's executive board met to discuss current issues and the upcoming District conference. Chair **Gary Shubert** and Treasurer **Walter Chojnacki** reported on the finances, **Al Moore Jr.,** certification chair, reported on the CWI seminar scheduled for June, and **Nino Olivares,** a past chair, presented ideas for the upcoming District 1 conference. The meeting was held at Jacoby's Restaurant in Meriden, Conn. **Russ Norris,** District 1 director, attended the meeting.

GREEN & WHITE MOUNTAINS

APRIL 18
Activity: Several Green & White Mountains Section members volunteered to serve as judges for the Vermont Skills-USA welding contests, held at Stafford Regional Vo-Tech in Rutland, Vt. The judges included **Jerry Ouellette, Geoff Putnam, Joe Tokarski, Phil Witteman, Jim Reid, Ernie Plumb, John Steel,** and **Gary Buckley.**

Tom Ferri (left), Boston Section program chair, presents a speaker-appreciation plaque to John Siergiewicz Jr.

Award winners at the New Jersey Section meeting are (from left) Gold Members Al Fleury and Gus Manz, and CWI Nagesh Goel, Educator David Griep, and Richard Liberti, Private Sector Educator recipient.

Judging the Vermont SkillsUSA welding contests were Green & White Mountains Section members (from left) Jerry Ouellette, Geoff Putnam, Joe Tokarski, Phil Witteman, Jim Reid, Ernie Plumb, John Steel, and Gary Buckley.

The Vermont SkillsUSA welding contenders are shown at the Green & White Mountains-sponsored event.

New Jersey Section Chair Seann Bradley (left) chats with speaker William Dotson.

District 2

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

NEW JERSEY

FEBRUARY 17
Speaker: **William Dotson,** district manager
Affiliation: The Lincoln Electric Co.
Topic: Advancements in submerged arc welding technology and Power Wave® 1000 technology
Activity: The Section held its annual awards presentation program hosted by Chairman **Seann Bradley**. Treasurer **Al Fleury** and **August F. Manz** received Gold Membership certificates for 50 years of service to the Society. Manz, who is the Section historian and safety and health representative, also earned the Speaker of the Year Award. **Nagesh Goel** received the Dalton E. Hamilton Memorial CWI of the Year Award. **David Griep** was presented the Educator of the Year Award, **Richard Liberti** was tapped for the Private Sector Educator of the Year Award, and **Steven DeFillipps Jr.** accepted his Past Chairman Award.

District 3

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

READING

MARCH 26
Activity: The Section members toured Reading Tube Plant #4, a division of Cambridge-Lee Industries, in Reading, Pa. The facility manufactures copper tubing for the plumbing industry. **Jared Ramsburg** conducted the program. Participating were **Sharon Bally** and her students from Lebanon County Career and Technology Center, and **Daniel Millan** and his students from Reading-Muhlenberg Career and Technology Center.

District 4

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

SOUTHWEST VIRGINIA

MARCH 26
Speaker: **Ben Grimmett,** principal engineer
Affiliation: Babcock and Wilcox
Topic: The good, bad, and ugly about welding codes
Activity: The meeting was held at Dynasty Int'l Super Buffet in Salem, Va.

District 5

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

**NEW PRIZES.
NEW CAMPAIGN.
START SPONSORING
MEMBERS TODAY!**

Win Great Prizes in the **2009-2010 AWS** Member-Get-A-Member Campaign*

ABOUT: AWS is looking for individuals to become part of an exclusive group of AWS Members who get involved and win. Give back to your profession, strengthen AWS and win great limited-edition prizes by participating in the 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.

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

PRIZE CATEGORIES

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

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.

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.

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

American Welding Society
Visit www.aws.org

SPECIAL OFFER FOR NEW AWS INDIVIDUAL MEMBERS – TWO YEARS FOR $135 (a $25 savings)

★ *PLUS... Get a popular welding publication for only $25 ($192 value)*

AWS MEMBERSHIP APPLICATION

4 Easy Ways to Join or Renew:

Mail this form, along with your payment, to AWS

Call the Membership Department at (800) 443-9353, ext. 480

Fax this completed form to (305) 443-5647

Join or renew on our website <www.aws.org/membership>

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

Last Name ____________________

First Name ____________________ M.I. ______

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," Member's name: ______ Member's # (if known): ______

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

ADDRESS

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

Company (if applicable) ______

Address ______

Address Con't. ______

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

PROFILE DATA

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

❶ Who pays your dues?: ❑ Company ❑ Self-paid ❷ Sex: ❑ Male ❑ Female

❸ Education level: ❑ High school diploma ❑ Associate's ❑ Bachelor's ❑ Master's ❑ Doctoral

PAYMENT INFORMATION (Required)

ONE-YEAR AWS INDIVIDUAL MEMBERSHIP $80

TWO-YEAR AWS INDIVIDUAL MEMBERSHIP† ....~~$160~~ $135

SAVE $25 (New Members Only)

New Member? ___Yes ___No

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

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

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

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

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

TOTAL PAYMENT ....$______

AWS STUDENT MEMBERSHIP†††

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

❑ International $50

TOTAL PAYMENT..................$______

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

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

❑ Check ❑ Money Order ❑ Bill Me

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

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

Signature of Applicant: ______ Application Date: ______

Office Use Only Check # ______ Account # ______

Source Code **WJ** Date ______ Amount ______

American Welding Society
P.O. Box 440367
Miami, FL 33144-0367
Telephone (800) 443-9353
FAX (305) 443-5647
Visit our website: www.aws.org

Member Services Revised 12/12/08

†**Two-year Individual Membership Special Offer:** applies only to new AWS Individual Members. ††**Discount Publication Offer:** applies only to new AWS Individual Members. Select one of the six listed publications for an additional $25; International Members add $75 ($25 for book selection and $50 for international shipping); **Multi-Year Discount:** First year is $80, each additional year is $75. No limit on years (not available to Student Members). †††**Student Member:** Any individual who attends a recognized college, university, technical, vocational school or high school is eligible. Domestic Members are those students residing in North America (incl. Canada & Mexico). This membership includes the *Welding Journal* magazine. Student Memberships do not include a discounted publication. ††††**International hard copy *Welding Journal* option:** applies only to International AWS Welder Members (excludes Canada and Mexico). Digitized delivery of WJ is standard

BOOK/CD-ROM SELECTION

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

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

ONLY ONE SELECTION PLEASE.

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

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

Learn more about each publication at www.awspubs.com

❑ **New Member** ❑ **Renewal**

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

Type of Business (Check ONE only)

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

Job Classification (Check ONE only)

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

Technical Interests (Check all that apply)

A ❑ Ferrous metals
B ❑ Aluminum
C ❑ Nonferrous metals except aluminum
D ❑ Advanced materials/Intermetallics
E ❑ Ceramics
F ❑ High energy beam processes
G ❑ Arc welding
H ❑ Brazing and soldering
I ❑ Resistance welding
J ❑ Thermal spray
K ❑ Cutting
L ❑ NDT
M ❑ Safety and health
N ❑ Bending and shearing
O ❑ Roll forming
P ❑ Stamping and punching
Q ❑ Aerospace
R ❑ Automotive
S ❑ Machinery
T ❑ Marine
U ❑ Piping and tubing
V ❑ Pressure vessels and tanks
W ❑ Sheet metal
X ❑ Structures
Y ❑ Other
Z ❑ Automation
1 ❑ Robotics
2 ❑ Computerization of Welding

Reading Section members and guests are shown during their tour of the Reading Tube copper-tube manufacturing plant.

FLORIDA WEST COAST

APRIL 8
Speaker: **Dale Ison**
Affiliation: Tampa Tank Inc.
Topic: Electroslag welding structural steel girders and beams
Activity: District 5 Director **Steve Mattson** presented the Section and District Educator of the Year awards to Chairman **Albert Sedory** with Hillsborough Community College, and the Section and District Dalton E. Hamilton CWI of the Year Awards to **Rick Vencis** with Ardaman & Associates, Inc.

SOUTH CAROLINA

MARCH 18
Activity: The Section members met at Trident Technical College in Charleston, S.C., to study ornamental ironworking techniques. **Jimmy Suggs** and **Mike DuBois** of the Philip Simmons Artist-Blacksmith Guild of South Carolina performed the demonstrations. The Guild, organized exclusively for educational purposes, is a source of information about blacksmithing for architects, interior designers, and the public, and facilitates training for aspiring smiths. The business meeting included taking nominations for Section officers, and presenting a special award to **Sergio Smith** for hosting the September program. District 5 Director **Steve Mattson** attended the program.

District 6

Kenneth Phy, director
(315) 218-5297
kenneth.phy@gmail.com

District 7

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

DAYTON

APRIL 14
Speaker: **Chris Small,** president
Affiliation: American Testing Services
Topic: Testing the integrity of supporting structures for amusement park rides
Activity: The program was held at American Testing Services in Dayton, Ohio.

Southwest Virginia Section members are shown at their March meeting.

Shown at the South Carolina Section program are (from left) Mike DuBois, Chairman Gale Mole, District 5 Director Steve Mattson, and Jimmy Suggs.

Shown are Ted Alberts (left), speaker Ben Grimmett, and Wayne Johnson, Southwest Virginia Section chairman.

Speaker Dale Ison (right) is shown with Al Sedory, Florida West Coast Section chair.

Al Sedory (left), Florida West Coast Section chair, receives two Educator Awards from Steve Mattson, District 5 director.

Speaker Chris Small (left) is shown with Jim Hannahs, Dayton Section secretary-treasurer.


Shown at the Mobile Section program are (from left) District 9 Director George Fairbanks, Brenda Bradley, Dick Corbin, and speaker Vic Matthews, AWS president.


Shown at the Mahoning Valley Section meeting are (from left) District 10 Director Rich Harris, Dave Hughes, speaker Jim Miller, Huck Hughes, and Carl Ford.


Shown at the Madison-Beloit Section vendors' night program are (from left) Dan Crifase, Chair Ben Newcomb, Jim Pfeil, Mike Kersey, Rob Stinson, and Larry Bower.


Larry Bower (left) is shown with Bryan Kwapis (center) and Ben Newcomb, chairman, Madison-Beloit Section, in April.


Mandy Knox hosted the Lakeshore Section members on a tour of the C. D. "Buzz" Besadny Fish and Wildlife Area facilities.

AWS President Victor Matthews takes a John Deere cart for a spin during the District 12 winter conference. See page 77 for more information and photos.

District 8

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joe.livesay@ttcc.edu

District 9

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

MOBILE

March 19
Speaker: **Victor Matthews,** AWS president
Affiliation: The Lincoln Electric Co.
Topic: Careers in welding
Activity: **Dick Corbin** received his Life Membership Certificate for 35 years of service to the Society. Treasurer **Brenda Bradley** was presented the Section Meritorious Award. District 9 Director **George Fairbanks** attended the meeting. The program, attended by 38 members and guests, was held at Saucy Q Bar BQ in Mobile, Ala.

District 10

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

MAHONING VALLEY

March 19
Speaker: **Jim Miller,** investment advisor
Affiliation: On Track Financial Services
Topic: Financial investment strategies
Activity: This was a joint meeting with members of the ASM International, Warren, Ohio, chapter. **Huck Hughes** and

Dave Hughes were presented District Meritorious Awards, CWI of the Year Awards were given to **John Bossone** and **Mark Hollenback,** and **Carl Ford** received the Mahoning Valley Section Meritorious Award. The meeting was held at Rusty's Southside Grill in Boardman, Ohio.

District 11

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

District 12

Sean P. Moran, director
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sean.moran@hobartbrothers.com

DISTRICT 12 Conference

February 13

Activity: The Madison-Beloit Section hosted the fourth annual District 12 winter conference at Rock River Hills Golf Club with tours of the John Deere Horicon Works, in Horicon, Wis. AWS President **Victor Matthews** attended. See page 77 for more information and photos.

LAKESHORE

April 9

Activity: The Section members visited C. D. "Buzz" Besadny Fish and Wildlife Area in Kewaunee, Wis. **Mandy Knox,** assistant naturalist guide, made a presentation on the facilities activities collecting eggs to promote Great Lakes trout and salmon propagation. The dinner was held at Birchwood Inn.

MADISON-BELOIT

March 11

Activity: **Dave O'Donnell,** director, process and product development, led the Section members on a tour of the Rath Gibson facility in Janesville, Wis., to see gas tungsten arc and laser beam welding of pipe, stress-relieving processes, and the methods used to ensure product quality. O'Donnell concluded the tour with a talk on the company's plants, uses for stainless steel tubing, and the concerns unique to laser beam welding. The meeting concluded with dinner at Damon's Restaurant in Janesville.

April 8

Activity: The Madison-Beloit Section members visited Blackhawk Technical College in Janesville, Wis., for a vendors' night and tour of the facilities. **Tony Stute,** a welding instructor at Madison Area Technical College, showed the attendees how to use the virtual weld training simulator used at his lab. **Rob Stinson** and **Mike Kersey** from Lincoln Electric, **Bryan Kwapis** from Miller Electric, and **Don Ash** from Jackson Safety Products displayed their gear and answered questions. Participating were Chairman **Ben Newcomb;** Racine Section Chair **Dan Crifase; Larry Bower,** Blackhawk Tech welding chair; 15 high school welding students; and three welding instructors.

Shown at the Milwaukee Section program are (from left) Roger Edge, Roger Warren, Chair Jerry Blaski, speaker Randall Counselman, Kenneth Karwowski, and Craig Wentzel.

Racine-Kenosha Section members toured the Wisconsin Energy P-4 power plant in April.

Shown at the Chicago Section board meeting are (from left) Chairman Hank Sima, Craig Tichelar, Pete Harris, Vicky Landorf, Jeff Stanczak, Chuck Hubbard, Marty Vondra, and Pete Host.

MILWAUKEE

March 19

Speaker: **Randall Counselman,** welding engineer

Affiliation: Oldenburg Group, Inc.

Topic: The Oldenburg Group, a supplier of components for the U.S. Navy, its refueling systems, cargo transfer systems, salvage cranes, military causeway systems, and array of handling systems for submarines and launch and recovery systems.

Activity: The Section met at Charcoal Grill & Rotisserie in New Berlin, Wis.

RACINE-KENOSHA

April 2

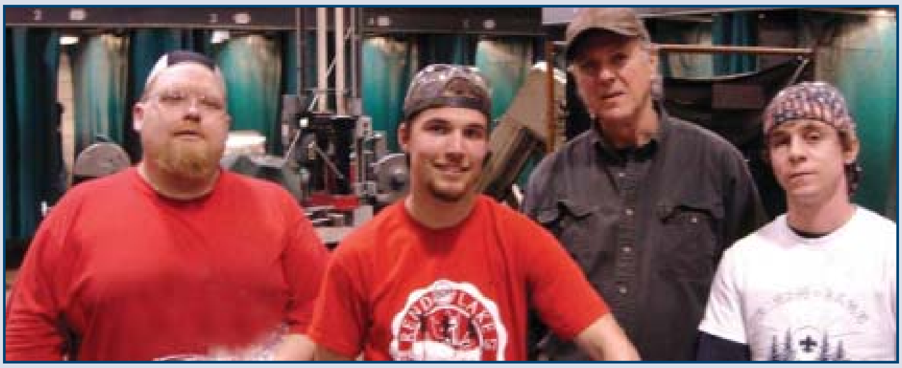
Activity: The Section members toured the Wisconsin Energy P-4 coal-fired power plant in Pleasant Prairie, Wis. **Jacqueline Hintz,** control operator, conducted the program.

District 13

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

Robert Gregory (left) receives the CWI of the Year Award from Bryce Kale, J.A.K. Section technical advisor.

Kerwin Brown (center), Peoria Section chair, poses with high school division welding contest winners Cameroon Vanvooren (left) and Jimmy Baxter.



Peoria Section Chair Kerwin Brown (rear), poses with (from left) Mike Kruzan, Zach Yaeger, and Shane Craft, winners in the college/trades welding contest division.

Shown at the Indiana Section program are (from left) Mike Anderson, David Jackson, Gary Tucker, Bill Davis, Chair Tony Brosio, Gary Dugger, Bennie Flynn, Rick Ferguson, and Eric Cooper.

Mike Anderson (left) receives the District Director's Award from Tony Brosio, Indiana Section chairman.

Tony Brosio (left), Indiana Section chairman, is shown with Dick Alley, a past AWS president.

CHICAGO

APRIL 15

Activity: Executive committee members Chairman **Hank Sima, Craig Tichelar, Pete Harris, Vicky Landorf, Jeff Stanczak, Chuck Hubbard, Marty Vondra,** and **Pete Host** met at Bohemian Crystal Restaurant in Chicago, Ill. Topics on the agenda included setting the technical meeting calendar for the coming year and making plans for the District 13 conference scheduled for June 5.

J.A.K.

NOVEMBER 24

Activity: **Bryce Kale,** Section technical advisor, visited **Robert Gregory** in Krebs, Okla., to present him with the CWI of the Year Award for outstanding service as a CWI while a member of the Joliet-Aurora-Kankakee Section. Gregory is currently a member of the Tulsa Section.

PEORIA and Illinois Central College Student Chapter

MARCH 19

Activity: The Section organized a welding contest for 16 high school students and 11 students in the college/trades division. The judges were **Marty Williams, Phil England, Kerwin Brown,** and **Dennis Ludwig.** The top welding contest performers included **Jimmy Baxter, Jake Bieze, Cameroon Vanvooren, Shane Craft, Zach Yaeger,** and **Mike Kruzan.**

District 14

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tparke@millerwelds.com

INDIANA

MARCH 28

Activity: The Section members held their annual awards-presentation meeting at Jonathan Byrd's Cafe in Greenwood, Ind. **Mike Anderson** was presented the District 14 Director's Award. Past AWS President **Dick Alley** presented **Tony Brosio** a plaque of appreciation for his year of service as chairman. The meeting included a review of plans for the Section's upcoming 31st Annual Mid-West Team Welding Tournament.

District 15

Mace V. Harris, director
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macevh@aol.com

NORTHWEST

MARCH 11

Speaker: **Damian J. Kotecki,** past AWS president

Dick Blaisdell addressed the Kansas City Section in January.

Affiliation: Damian Kotecki Welding Consultants, Inc., president
Topic: Technical seminar on welding stainless steels
Activity: The lecture was held in Brooklyn Park, Minn. The course subjects included welding metallurgy; martensitic, ferritic, austenitic, and duplex stainless steels; and precipitation-hardening stainless steels. District 15 Director **Mace Harris** participated in the activity.

District 16

David Landon, director
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dlandon@vermeermfg.com

KANSAS CITY

JANUARY 8
Speaker: **Dick Blaisdell**
Topic: Creating written welding procedures
Activity: **Carolyn Bunch** of the Youthful Offender Apprentice Training Program spoke about how it prepares inmates to enter the workforce. The meeting was held at Johnny C's in Kansas City, Mo.

MARCH 8
Speaker: **Gary Lewis,** director of business development
Affiliation: Superheat FGH
Topic: Heat treatment methods and their effects on weld quality
Activity: The program was held at KC Masterpiece Restaurant in Overland Park, Kan., for 21 attendees.

NEBRASKA

APRIL 16
Activity: The Section members toured the Drake Williams Steel fabrication plant in Omaha, Neb. **Todd Minor** and **Manuel Wheeler** conducted the tour.

District 17

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

Shown at the Kansas City Section program are (from left) Dennis Wright, Treasurer Jeff Hilfiker, Bob Worthington, speaker Gary Lewis, Dave McKenzie, Chairman Brian McKee, Secretary Sarah Hurt, and Mike Vincent.

Speaker Damian Kotecki (right) is shown with Mace Harris, District 15 director, at the Northwest Section seminar.

Speaker Gary Lewis (right) is shown with Mike Vincent at the Kansas City Section program.

Shown at the Nebraska Section program are (from left) Nick Weidenbach, Josh Mayne, presenters Todd Minor and Manuel Wheeler, and Rick Hanny.

Nebraska Section members toured Drake Williams Steel in April.

Shown at the East Texas Section program are (from left) Secretary Howard Record, Chairman Bryan Baker, and speaker Johnny Harvill.

Shown at the Tulsa Section welding contest are Tim Cruse (seated) and (from left) host Scott Sutherland, Jerry Knapp, and Ronnie Summerlin.

Houston Section Chair Jerry Koza Jr. (far right) is shown with scholarship winners Meredith Johnson and Paul Layman.

Shown at the Rio Grande Valley Section program are (from left) Robert Sacco, Guillermo Trejo, and Angie Gonzalez.

Bryan Baker (right) receives the chairman appreciation award from Howard Record at the East Texas Section program.

EAST TEXAS

April 16
Speaker: **Johnny Harvill,** welding engineer
Affiliation: Priefert Ranch Equipment
Topic: Automated welding applications
Activity: Secretary **Howard Record** presented **Bryan Baker** an appreciation certificate for his services as Section chairman. The program was held at LeTourneau University in Longview, Tex.

TULSA

February 9
Activity: The Section sponsored the Oklahoma SkillsUSA Regional District 1 welding contest for secondary and postsecondary students. The event was held at Tri County Technology Center in Bartlesville, Okla., hosted by **Scott Sutherland.** The welding judges were **Jerry Knapp, Ronnie Summerlin,** and **Tim Cruse.**

District 18

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

HOUSTON

April 15
Speaker: **Rodney D. Petrie,** trade development manager, special projects
Affiliation: Port of Houston Authority
Topic: Overview of the activities at the port
Activity: Chairman **Jerry Koza Jr.** presented $500 Section scholarships to local welding students **Meredith Johnson** and **Paul Layman,** both attending Lonestar College. The program was held at Brady's Landing in Houston, Tex.

RIO GRANDE VALLEY

April 8
Speaker: Chairman **George Baldree,** welding engineer

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Affiliation: Keppel-AmFELS
Topic: Electron beam welding
Activity: The recently chartered Rio Grande Section's bylaws were presented to the membership and approved. Plans were finalized to host and organize a Welding — The Gold Collar Career Day on May 27 at South Texas College Technology Campus in McAllen, Tex. Attending were **Robert Sacco,** a college trainer; **Guillermo Trejo,** training manager; and **Angie Gonzalez,** associate vice president corporate and community education at Texas State Technical College, Harlingen. Select Arc was celebrated for becoming the Section's first Corporate Sponsor. Thirty-eight people attended the meeting including a good mix of students, business representatives, and educators.

District 19

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ALASKA

MARCH 20
Activity: The Section held a program on bolts and the joining of various metal sections. Portland Bolt Co. contributed a video illustrating the manufacture and type of bolts and rolled vs. cut threads. **Charlie Engblom,** with the Ironworkers, spoke on the application of bolts in the erection of structural steel connections. Fastener and Fire demonstrated a Lejeune gun and offered hands-on trials for the attendees. QA Services provided a Skidmore-Wilhelm torque-tension tester. **Steve Lockman** detailed its uses on the job and in laboratories.

ALBERTA

FEBRUARY 25
Speaker: **Chris Vrolyk,** engineer
Affiliation: Qualimet Inc. (Edmonton)
Topic: A case study exploring the causes of failures in pipes welded using the submerged arc process
Activity: Section Chair **Matthew Yarmuch** presented Vrolyk a speaker-appreciation plaque. **Dale Harsula** received his Silver Membership Certificate for 25 years of service to the Society from **Kioumars Poorhaydari.** Student **Brian Hong** won the door prize, a copy of the AWS *Welding Handbook*. This meeting was held at the University of Alberta Faculty Club in Edmonton, Alb., Canada. The event was attended by 70 members and guests.

BRITISH COLUMBIA

MARCH 19
Speakers: **Mark Burke,** Indalco Alloys; and **Ken Mui,** Lincoln Electric Canada

Shown at the Alaska Section meeting are (from left) Mark Wood, David Gray, James Kane, and speaker Charlie Engblom.

Brian Hong (left) accepts the door prize from Matt Yarmuch, Alberta Section chair.

Speaker Chris Vrolyk (left) is shown with Matthew Yarmuch, Alberta Section chair.

Dale Harsula (left) receives his Silver Membership Certificate from Kioumars Poorhaydari at the Alberta Section meeting.

Jason Barna (right) is shown with Ken Johnson, Puget Sound Section vice chair.

Shown at the British Columbia Section meeting are (from left) Ken Mui, Eric Waterfield, and Mark Burke.

The Spokane Section members are shown during their tour of the Airway Heights facility in April.

Jon Osborne conducted the Spokane Section members' tour in April.

Kyle Coon straddles one of his choppers at the February Utah Section program.

Colorado Section members participated in a seminar conducted by District 20 Director Bill Komlos.

Shown at the Colorado Section program are (from left) Chair James Corbin, Glen Edwards and Stephen Liu with their Educator of the Year awards, presenter Bill Komlos, and past AWS president Bob Teuscher.

Topics: Burke spoke on manufacturing aluminum wire in Canada; Mui discussed the concerns unique to welding aluminum
Activity: Awards Chair **Steve Prost** presented **Pat Newhouse** with an appreciation award for serving as British Columbia Section chair. The program was held at Surrey Guildford Ramada Inn in Surrey, B.C., Canada.

PUGET SOUND

March 5
Speaker: **Jason Barna,** account executive
Affiliation: Farwest Steel
Topic: Making the steel products we use
Activity: The meeting was held at Rock Salt Steak House in Seattle, Wash.

SPOKANE

March 18
Activity: The Section hosted a student career night program in Spokane, Wash. The presenters included **Craig Dias** from Haskins Steel, **Nate Batson** from Spokane Industries, **Pat Perez** from Plumbers and Steamfitters Union, and **Phil Zammit** from Brooklyn Iron Works. Each speaker discussed details about his company and his personal career path. The focus of each talk was the importance of education, diligence, and the great potential awaiting those pursing careers in the welding and metalworking industries. The event attracted 28 students and instructors.

April 15
Activity: Forty Spokane Section members toured the Airway Heights plant in Spokane, Wash., to study its welding, hardfacing, and cutting operations. **Jon Osborne,** president, conducted the tour.

District 20

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

COLORADO

MARCH 12
Activity: **Bill Komlos,** District 20 director, conducted a special structural steel inspection seminar referencing AWS D1.1, *Structural Welding Code — Steel,* AISC *Steel Construction Manual,* and IBC, Section 1704. **Stephen Liu** and **Glen Edwards,** professors at Colorado School of Mines, were presented Educator of the Year awards. Liu received the District 20 award; Edwards was presented the Colorado Section award. **Bob Teuscher,** an AWS past president, attended the program. The event was held at Colorado School of Mines in Golden, Colo.

UTAH

FEBRUARY 18
Activity: Praxair, Salt Lake City, was the host and sponsor for the evening. Featured was Coonyz Customz Chopperz of Sandy, Utah. **Kyle** and **Shaun Coon,** owners, displayed their machines at various stages of assembly with a discussion and a question and answer period regarding bike manufacture and the welding involved. **Chris Vihnanek,** director, Met Fab Productivity, Praxair of Hillside, Ill., spoke on how to increase productivity in welding processes. The event attracted 52 attendees.

MARCH 17
Activity: The Utah Section members joined members of the local ASNT chapter to tour the ATK Launch Systems facilities in Clearfield, Utah. The presenters included **Bern Anderson, Jeremy Felker,** and **John Hartman.** The facility performs refurbishment, inspection, and testing on booster rockets for NASA's Shuttle program.

District 21

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

KERN

FEBRUARY 26
Activity: **John Lopez,** director, John Lopez Welding School, Bakersfield, Calif., invited the Section members to help him celebrate the opening of his new 5000-sq-ft facility housing a state-of-the-art classroom and 17 welding booths. Graduates of the school, **Adrianne Soto** and **Manuel Bravo,** made brief presentations. Lopez and his wife, **Nanette Lopez,** cooked and served the barbecue dinner. Chairman **Dave Ebenhoe** updated the group on AWS news. The evening concluded with a welding contest with prizes donated by **Gary Thompson** of Praxair.

Kyle Coon (right) is shown with Paul Dowding at the Utah Section program.

NEVADA

MARCH 19
Speakers: **Richard Samanich,** SCWI, Ninyo and Moore; and Chairman **Mark Hayes,** CWI, Clark County Building Dept.
Activity: The Section met with the Clark County Building Dept. of Development Services, Building Div. for a presentation on the verification of welding procedures for Clark County code compliance. Attendees received credits toward their nine-year CWI renewal. Sixty-five members attended. District 21 Director **Nanette Samanich** attended the program.

District 22

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

SAN FRANCISCO

APRIL 1
Speaker: **Michael Sturtz,** executive director
Affiliation: The Crucible, Oakland, Calif.
Topic: Building community through welding and the industrial arts
Activity: Sturtz discussed the operations of The Crucible, a nonprofit organization that offers various services and classes in welding, machining, blacksmithing, and other creative skills. The meeting was held at Spenger's Restaurant in Berkeley, Calif., for 50 members and six Laney College welding students.

Chris Vihnanek (left) accepts a speaker appreciation plaque from Paul Dowding at the Utah Section program in February.

John Lopez (left) poses with Gary Thompson at the Kern Section program.

Chairman Dave Ebenhoe addresses the Kern Section members.

Speaker Michael Sturtz is shown with Liisa Pine, San Francisco Section chair.

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Guide to AWS Services

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WEMCO — Welding Equipment Manufacturers Committee

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Note: *Official interpretations of AWS standards may be obtained only by sending a request in writing to the Managing Director, Technical Services. Oral opinions on AWS standards may be rendered. However, such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.*

AWS 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.

It is the intent of the American Welding Society to build AWS to the highest quality standards. Your suggestions are welcome. Please contact any staff member or AWS President Victor Y. Matthews, as listed on the previous page.

Nominees for National Office

Only Sustaining Members, Members, Honorary Members, Life Members, or Retired Members who have been members for a period of at least three years shall be eligible for election as a director or national officer.

It is the duty of the National Nominating Committee to nominate candidates for national office. The committee shall hold an open meeting, preferably at the Annual Meeting, at which members may appear to present and discuss the eligibility of all candidates.

To be considered a candidate for the positions of president, vice president, treasurer, or director-at-large, the following qualifications and conditions apply:

President: To be eligible to hold the office of president, an individual must have served as a vice president for at least one year.

Vice President: To be eligible to hold the office of vice president, an individual must have served at least one year as a director, other than executive director and secretary.

Treasurer: To be eligible to hold the office of treasurer, an individual must be a member of the Society, other than a Student Member, must be frequently available to the national office, and should be of executive status in business or industry with experience in financial affairs.

Director-at-Large: To be eligible for election as a director-at-large, an individual shall previously have held office as chairman of a Section; as chairman or vice chairman of a standing, technical, or special committee of the Society; or as a District director.

Interested persons should submit a letter stating which office they seek, including a statement of qualifications, their willingness and ability to serve if nominated and elected, and a biographical sketch.

E-mail the letter to Gricelda Manalich, *gricelda@aws.org,* c/o Gene Lawson, chair, National Nominating Committee.

The next meeting of the National Nominating Committee is scheduled for November 2009. The terms of office for candidates nominated at this meeting will commence January 1, 2011.

Honorary Meritorious Awards

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

William Irrgang Memorial Award

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

George E. Willis Award

Sponsored by The Lincoln Electric Co. in honor of George E. Willis, the award, adminstered by AWS, is given each year to an individual who promoted the advancement of welding internationally by fostering cooperative participation in technology transfer, standards rationalization, and promotion of industrial goodwill. It includes a $2500 honorarium and a certificate.

Honorary Membership Award

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

National Meritorious Certificate Award

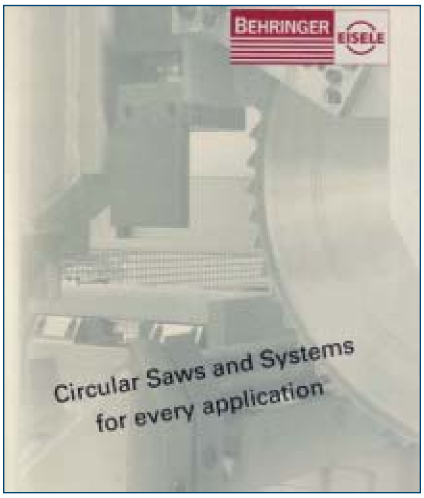
This certificate award recognizes the recipient's counsel, loyalty, and dedication to AWS affairs, assistance in promoting cordial relations with industry and other organizations, and for contributions of time and effort on behalf of the Society.

International Meritorious Certificate Award

This honor recognizes recipients' significant contributions to the welding industry for service to the international welding community in the broadest terms. The awardee is not required to be an AWS member. Multiple awards may be given. The award consists of a certificate and a one-year AWS membership.

NEW LITERATURE

Fume Control Guide for Engineers Released



A six-page, full-color, fold-out brochure illustrates and details the company's lines of industrial circular cold saws and miter saws for fine finish cutting of metals. Shown are semiautomatic and fully automatic models with high-precision linear guides and ball-bearing construction, hydraulic clamping, servo-driven axes for precise material positioning, models with precise ball screw spindles and fast servo-motors for precision cuts in seconds, and a circular cold saw for use with carbide-tipped blades. Technical data are provided in chart form for simplified comparison of the various models. Pictured options include electronic length-measuring system, roller conveyor with measuring system, bundle loading magazine, tiltable roller conveyor to sort trim cut and rest piece, belt conveyor with multiple sorting positions for use as an interface to deburring, signing, or robot systems, and chain conveyor models for longer pieces.

Behringer Saws, Inc.
www.behringersaws.com
(610) 286-9777

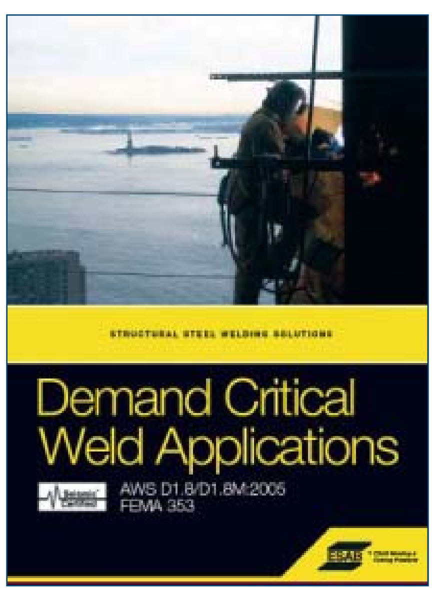
White Paper Details Metals Operations

The white paper, *Making the Grade in Metals,* outlines the firm's technology solutions in worldwide metal producing, forming, and fabricating operations. It discusses how its multiple companies operate together to manufacture the gear drives, clutches, brakes, couplings, and other power-transmission products used

throughout industry. Addressed are light- to heavy-duty applications where high-quality, rugged motion-control products are needed to ensure high productivity and reduce critical downtime. The brands included are Nuttall Gear, Delroyd Worm Gear, Wichita Clutch, Industrial Clutch, Warner Electric, Formsprag Clutch, Twiflex, Ameridrives, and T. B. Wood's. The PDF edition can be downloaded from the company's Web site.

Altra Industrial Motion
www.warnernet.com/litportal/markets.asp?mspid=12
(781) 917-0600

Guide to Seismic Certified Filler Metals Offered



The 44-page, full-color *Demand Critical Weld Applications* guide discusses the company's complete lines of Seismic Certified™ filler metal solutions from Atom Arc®, Coreshield®, Dual Shield®, and Spoolarc® with OK submerged arc fluxes. The products are compliant with AWS D1.1/D1.1M:2006, *Structural Welding Code — Steel,* AWS D1.8/D1.8M:2005 *Structural Welding Code — Seismic Supplement,* and FEMA 353: Part 1 Appendix A, Steel Moment — Frame Construction Guidelines for Seismic Applications. Charts detail product, classifications, test settings for heat input, shielding gas, current, voltage, polarity, weld position, pass/layer sequence, as well as mechanical properties and Charpy V-notch impact information. The guide can be downloaded from the Web site after signing in.

ESAB Welding & Cutting Products
www.esabna.com/seismic
(800) 372-2123

Guide Pictures Robotic Welding Equipment

The company has just released its new full-color *Automation System Selection Guide* designed for fabricators considering the purchase of a preengineered or custom-built robotic welding cell and companies looking to upgrade existing robotic systems. It folds out into a comprehensive poster of the company's welding systems, automation components, and

— continued on page 100

— continued from page 98

configurations. Illustrated are positioning systems, robots, custom systems, various options, fixed-table systems, and technical resources. The data provided include basic specifications, number of axes, payload capacity, reach, swing diameter and span, process capabilities, work-zone dimensions, weight capacity, and system shop footprints. Visit the Web site to download the PDF edition of Bulletin MC04-216, or call for a hard copy.

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

Poster Explains Tube Inspection Technology

The *Understanding Tube Inspection Technology* poster was designed by field experts to present tube inspection technologies in a concise and clearly illustrated manner. The basic concepts of eddy current testing, remote field testing, near field testing, magnetic flux leakage, and IRIS are explained simply and effectively. The technologies featured are typically used to inspect heat exchangers, feedwater heaters, and boilers in the power-generation industry. Visit the Web site to download the poster or send an e-mail request to *info@olympusNDT.com.*

Olympus NDT
www.olympus-ims.com/en/poster
(781) 419-3900

DVD Edition of Tool Design Textbook Released

The society has released a nine-DVD training program based on the *Fundamentals of Tool Design*, 5th edition, textbook. The program is developed for manufacturing educators and practitioners. It is intended to supplement training programs by providing an overview of design technologies and best practices. The DVDs can be used with companion free downloadable study guides and quizzes to reinforce students' understanding of the content. A copy of the textbook is included with the discs. The disc titles are Tool Materials, Cutting Tool Design, Fixture Design, Progressive Die Design, Gauging and Inspection Tool Design, Computer-Aided Design, Rapid Tooling Design, Composite Tooling Design, and Troubleshooting Tool and Die Making. The DVD set may be purchased online. List price for the set is $799, $699 to society members. Individual DVDs are sold at $110 list, $99 for society members. Use priority code 09PU23 on purchases before June 30 to receive a 20% discount.

Society of Manufacturing Engineers
www.sme.org/FTD
(800) 733-4763

DVD Offers Intro to Laser Safety and Hazards

The company has released the 2009 version of its popular laser safety training DVD titled *Mastering Light — An Introduction to Laser Safety & Hazards.* The 20-min-long program covers the basic fundamentals of laser safety including beam hazards, control measures, bioeffects, classifications, nonbeam hazards, and much more. The DVD is intended for use by laser safety officers to expand their knowledge and help them to better train others. The DVD may be ordered online or by phone. The price is $450 list, $400 for institute members.

Laser Institute of America
www.laserinstitute.org
(800) 345-2737

Armored Cable Installation Standards Updated

RV 1-2008, *Application and Installation Guidelines for Armored Cable (AC) and Metal-Clad (MC) Cable,* and RV 2-2008, *Application and Installation Guidelines for Nonmetallic-Sheathed (NM-B) Cable and Underground Feeder and Branch (UF-B) Circuit Cable,* have been updated to reflect changes in the National Electrical Code®. They contain information on the latest installation, application, and construction requirements for Types MC and AC cables. RV 2, last revised in 2005, focuses on Types NM-B and UF-B cables. Both standards may be downloaded free of charge from the Web sites shown. Printed copies of RV 1 and RV 2 may be purchased online or by phone for $69 and $62, respectively.

NEMA
www.nema.org/stds/RV1.cfm
www.nema.org/stds/RV2.cfm
(800) 854-7179

New Welding Faceshield Described in Product Sheet

A full-color product sheet illustrates and presents the features of the company's new ArcFlash™ faceshield product line. The models offer low-level arc flash protection featuring a specially formulated antifog window that provides superior color definition and physical protection that exceeds industry product standards. The sheet may be downloaded online.

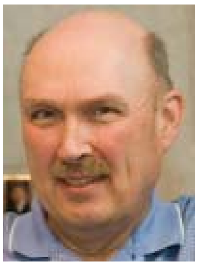
Sellstrom Mfg. Co.
www.sellstrom.com
(800) 323-7402

Weld Fume Extractors Pictured in Catalog

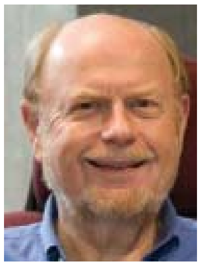
Recently updated, the company's catalog features its complete lines of portable and mobile welding fume extractors and an assortment of downdraft tables, ambient air cleaners, and related products. Visit the Web site to download the electronic version or order the print edition.

Ace Industrial Products
www.aceindustrialproducts.com
(314) 385-5178

Wagner Companies Name President-COO



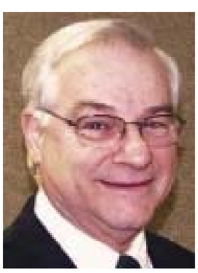
Richard Kettler



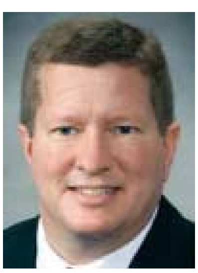
Robert Wagner

The Wagner Companies, Milwaukee, Wis., has appointed **Richard A. Kettler** president and chief operating officer of the metal railing components and systems manufacturing firm. In 2000, Kettler joined the company as operations manager then progressed to his previous position of executive vice president. He replaces **Robert A. Wagner** who will continue to serve as chairman and chief executive officer.

Hannay Reels Announces Sales Manager Changes



David Guilzon



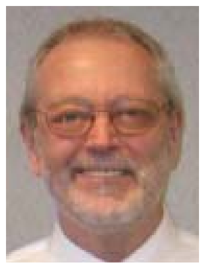
Denis Bleile

Hannay Reels, Westerlo, N.Y., has appointed **Denis Bleile** sales manager of the family-owned company. He replaces **Dave Guilzon** who has retired after holding the position for 12 years. Bleile brings 25 years of sales experience to the post.

EWI Technical Excellence Award Winner Announced

Edison Welding Institute, Columbus, Ohio, has named **Greg Firestone** to receive its second annual Technical Excellence Award. He is recognized for his work involving innovative tooling concepts combined with welding process controls to achieve high-performance welds in parts having varying cross sections. The award includes $1000 cash plus $10,000 of internal research development funding to pursue a research project of his choice.

Wall Colmonoy Fills Sales Director Post



John Lapping

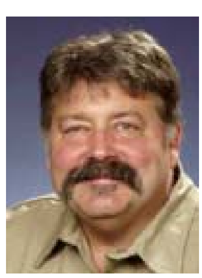
Wall Colmonoy Corp., Madison Heights, Mich., has appointed **John Lapping** director of international sales and marketing for the Alloy Products Group. With more than 25 years of experience in the thermal spray and high-temperature brazing industry, Lapping most recently worked for Hunprenco, UK, and previously seven years at Wall Colmonoy Ltd.

Rankin Industries Hires Sales Director

Rankin Industries, Rancho Cucamonga, Calif., a supplier of hardfacing and brazing alloys, has appointed **R. Lee Baker** director of sales. Previously, Baker was involved with wear-resistant alloys in managerial positions at The Lincoln Electric Co., Stellite Alloys, and Stoody Co.

Obituaries

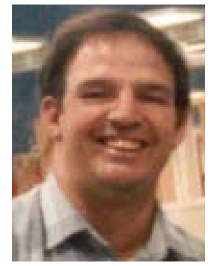
William 'Bill' West



Bill West

William L. West, 53, died February 1 in Mentor, Ohio. West was head of the welding school at The Lincoln Electric Co. An AWS member since 1998 with the Cleveland Section, he is survived by his wife, Joanne; children, Gina, Todd, Dennis, and Patrick; a brother, Joe; a sister, Patti Scharping; and three grandchildren.

Jerry Galyen



Jerry Galyen

Jerry Galyen, an AWS member since 1977, died April 1. He was a welding instructor at Pinellas Technical Education Center, Clearwater, Fla., campus. Galyen received his training in welding and metal fabrication at Pinellas Vocational Technical Institute. He also graduated from the National Aviation Academy where he obtained his helicopter and jet engine mechanic's license. While serving four years in the military, he saw duty in Vietnam and was awarded the Bronze Star. During his 35 years as a welding instructor, he served as an advisor for the Vocational Industrial Clubs of America and coordinated and administerd local and state contests. His students have won numerous national welding titles, plus awards at the 1991 International Championship Contest held in Amsterdam, The Netherlands. He served as a project director for the state of Florida's Vocational Instructional Material Acquisition System Project, and developed the tests currently administered to vocational students in the state. Galyen reviewed welding books from national publishers and coauthored the textbook, *Welding Fundamentals and Procedures.* In 1992, AWS awarded Galyen the Howard E. Adkins Instructor Membership Award for his outstanding teaching accomplishments. Galyen's students admired him for the way he kept them on track both inside and outside the welding environment. He saw the best in them, steering them in the right direction, pushing them to go the extra mile, and helping them to believe in themselves. Eighteen of his students won gold medals in Florida's National Vocational Industrial Clubs of America (VICA) competitions, and 14 went on to win the gold at the national competition level. Galyen established a Wall of Fame at the school that stands as a permanent testimonial to the phenomenal success his welding students have achieved in the VICA competitions and the Int'l Vocational Training Competition. He was a good man, a group of former students said, a good friend, role model, mentor, and father figure to so many. "He touched lives in such a way that his passing has left many people wondering how to say goodbye," wrote the former students. "We don't," they concluded. "Every time a welding job gets done with great precision, with every job well done, with every fond memory of where we started and who was responsible, we are actually raising up Jerry Galyen."♦

COMPANY PROFILES

Alcotec Wire Corporation

Founded in 1984

Alcotec Wire Corporation, is an organization focused on the production of quality aluminum products for the welding, brazing, and metalizing industries. We are a customer oriented and responsive company, run by dedicated employees with a concentrated focus on the manufacture of aluminum welding wire and the processes used to convert it into your welded structure products.

See our affiliate ads on page 5, 25

2750 Aero Park Drive, Traverse City, MI 49686; (231) 941-4111; www.alcotec.com

ArcOne Company

Founded in 1992

ArcOne has pioneered a wide variety of auto darkening welding helmets, inverter power sources, and NIOSH approved PAPR and SAR respiratory and safety products. Every product that ArcOne develops is carefully controlled at its modern facility located in Taunton, Mass. At ArcOne we are committed to providing products with a higher value, and lower list price. ArcOne: "Where Quality meets affordability without compromise."

See our ad on pages 27

**ArcOne Div. of A.C.E. Intl.
85 Independence Drive Taunton, MA 02780; (800) 223-4685; FAX: (508) 884-9666; customerservice@aceintl.com**

Arcos Industries, LLC

Founded in 1919

Arcos Industries, LLC manufactures a comprehensive line of superior quality bare wire and covered welding electrode products. The wide range of consumables includes high alloy, stainless steel and nickel alloy electrodes. Arcos electrodes meet or exceed a number of demanding military and nuclear applications.

See our ad on page IBC, 69

One Arcos Drive, Mt. Carmel, PA 17851; (800) 233-8460; FAX: (570) 339-5206; kfreed@arcos.us; www.arcos.us

Astro Arc Polysoude, Inc.

Astro Arc Polysoude provides advanced orbital and mechanized welding solutions. Announcing the opening of our Enfield, CT weld demonstration facility in June 2009, our second USA location providing improved proximity to our eastern customers. Our latest advancements in narrow-gap welding have landed several large projects for orbital and mechanized weld systems for the power generation industry. See what we can do for you.

See our ad on page 11

**Astro Arc Polysoude, Inc.
24856 Avenue Rockefeller
Valencia, CA 91355; (661) 702-0141
sales@astroarc.com
www.astroarc.com**

Atlas Welding Accessories, Inc.

Founded in 1939

From the original Dual tool Tomahawk, patented in 1939, the company today manufactures 28 models of weld cleaning hammers, and proprietary products including welding positioners, pipe stands, and the Pipemate. Products are sold through welding distributors nationally. Our 400-page distributor catalog offers 7,000 welding and safety items.

See our ad on page 23

501 Stephenson Highway, Troy, MI 48099; (248) 588-4666; FAX: (248) 588-2706; www.atlaswelding.com

Bishop-Wisecarver Corporation

Bishop-Wisecarver manufactures and distributes linear actuators, linear guides, linear slides, and linear motion components. Designed to withstand critical and extreme conditions, our components and systems provide complete versatility for a broad range of applications and industries. Our expert team of engineers is available to assist with custom linear motion solutions.

See our ad on page 2

**2104 Martin Way, Pittsburg, CA 94565
(925) 439-8272; (888) 580-8272;
FAX: (925) 439-5931
sales@bwc.com
www.bwc.com**

Bohler Welding Group USA, Inc.

With its strong brands, Bohler Welding Group USA provides its customers with a broad range of products and solutions-based services. Experience and expertise are embodied by everything from steel smelting to customer applications. Over 100 Years of Tradition. The secret of our success is knowledge of materials. We have played an essential part in molding the "World of Welding" with new products, materials and processes over the decades. Put your trust in a reliable, serious partner. We are not only a producer, but also a development, technology and service partner for our customers.

See our ad on page 9

**Bohler Welding Group USA, Inc.
10401 Greenbough Drive,
Stafford, TX 77477
(281) 499-1212; (800) 527-0791
FAX: (281) 499-4347
www.bohlerweldinggroupusa.com**

BUG-O Systems

Founded in 1948

BUG-O Systems, a division of Weld Tooling Corporation, is a manufacturer of a modular systems of drives, carriages, rails and attachments designed to automate welding guns, cutting torches and other hand-held tools.

See our ad on page 12

**161 Hillpointe Drive,
Canonsburg, PA 15317;
(800) 245-3186 ext.1904;
FAX: (412) 331-0383
www.bugo.com**

COMPANY PROFILES

Commercial Diving Academy (CDA)

Founded in 1995

CDA is an outstanding training facility located in Jacksonville, FL. In addition to air/mix gas training, the Academy offers advanced specialty training in underwater welding/burning, non-destructive testing Levels I &II and dive medical technician to name a few. All programs meet or exceed the ACDE /ANSI standards for commercial diver certification. Dormitory style housing and a meal plan are available. Financial aid is available for those who qualify.

See our ad on page 59

8137 N. Main St. Jacksonville, FL 32208; (888) 974-2232; (904) 766-7736; FAX: (904) 766-7764; www.CommercialDivingAcademy.com

Computer Engineering

Founded in 1986

For over 23 years, CEI has developed software for the welding and pressure vessel industries. Our welding software complies with AWS D1.1 and/or ASME Section IX, and employs the highest level of Code-Checking available on the market today. In addition to our industry leading welding software, we have engineering calculation programs for designing pressure vessels in accordance with Section VIII Division 1, and software for form submittal in compliance with the ASME and National Board.

See our ad on page 22

509 NW 5th Street, Blue Springs, MO 64014; (800) 473-1976; FAX: (816) 228-0680; sales@computereng.com www.computereng.com

COR-MET, Inc.

Founded in 1972

COR-MET Inc. is a World Leader in alloy specialty flux core wire, coated stick electrode, alloy TIG and MIG products. Recognized in the welding industry for product development, alloy metallurgy, and engineering research. COR-MET specializes in manufacturing nickel, cobalt, stainless steel, tool steel, alloy ateel, hardsurfacing, forge die repair products, and maintenance/repair alloys.

See our ad on page 65

12500 E. Grand River, Brighton, MI 48116; (800) 848-2719; FAX: (810) 227-9266 www.cor-met.com

Diamond Ground Products

Founded 1992

Diamond Ground Products specializes in GTAW and plasma arc welding electrodes. Their tungsten grinders are well known for precision and ease of use. Other offerings include raw tungsten and preground electrodes CNC ground to customer specifications. Applications for the electrodes include manual, automatic, orbital and robotic TIG and plasma arc welding.

See our ad on page 31

2550 Azurite Cir., Newbury Park, CA 91320; (805) 498-3837; FAX: (805) 498-9347; sales@DiamondGround.com; www.diamondground.com

Divers Academy International

Founded in1977

Learn commercial diving and how to weld underwater. Our unique 5-month program offers multiple high-level certifications. Students train in our modern training facility and deep-water quarry in southern New Jersey, near Atlantic City. Make big bucks and add zest to your career. Commercial divers maintain, repair, inspect and construct pipelines, oil platforms, bridges, tunnels and the like. We give you all the skills to work in this exciting world.

See our ad on page 29

Lakeside Business Park 1500 Liberty Place Erial, NJ 08081 (800) 238-DIVE; FAX: (856) 404-6104; Tamara@diversacademy.com www.diversacademy.com

Electron Beam Technologies, Incorperated

Founded in 1962

Electron Beam Tech. with it's 70,000 sq. feet of manufacturing facility provides a variety of products to the welding industry. Through OEM applications it's electron beam, cross linked, composite welding cable, trademarked POLY XL®, is known for superior durability and design in all welding applications. Through welding distributors, Electron Beam is known for simplicity in it's bulk electrode handling equipment. The original with wire transfer conduits, QCC® and ERC®, provide smooth, continuous electrode feed. Coupled with Fast 'N Easy® accessories and clear Dura Domes®, customers easily connect any bulk packaged electrode to their wire feeder. Installation is "Fast 'N Easy".

See our ad on page 73

1275 Harvard Drive Kankakee, IL 60901 (815)935-2211; FAX: (815) 935-8605; www.electronbeam.com

ESAB Welding & Cutting Products

Founded in 1904

Started in 1904 by Oscar Kjeilberg when he submitted a hand-written patent for a covered electrode, ESAB has always blazed new trails with new products, processes, and innovative solutions for welding and cutting. With over 100 years in the welding and cutting business, ESAB is still an industry leader, and one of the world's largest producers of equipment and filler metals.

See our ad on page 5

411 S. Ebenezer Road., Florence SC 29501 (800) ESAB-123 www.esabna.com

COMPANY PROFILES

Fischer Engineering Company

Founded in 1976

Fischer Engineering Company began by offering Welding Engineering and Testing services to local clients. It soon recognized that its mission was to." Help its customers meet codes and standards" During the intervening years, it has developed testing equipment and materials that have enabled it to fulfill its mission throughout the US and abroad. Most recently it has been approved to CE mark its core products for sale in Europe.

See our ad on page 61

8220 Expansion Way
Dayton, OH 45424,
(937) 754-1750;
FAX: (937) 754-1754;
www.fischerengr.com

GEDIK Welding

Founded in 1963

GEDIK Welding is the largest producer-exporter in the welding sector in Turkey. Its very wide range of welding consumables of the main brand GeKa comprise flux-coated arc welding electrodes (mild steel, cellulosic, cast iron, stainless steel, hardfacing, nonferrous), arc welding MIG/MAG wires and TIG rods, submerged arc welding wires, flux-cored arc welding wires, nonferrous welding wires/rods as well as special-purpose welding consumables besides welding fluxes. The company's welding power sources vary as MIG/MAG and TIG welding machines, welding rectifiers as well as inverter-type and submerged arc welding power sources.

See our ad on page 33

Ankara Cad. No.306 Seyhli
Pendik 34913 Istanbul/TURKEY
90 216 378 5000; FAX: 90 216 378 7936
www.gedikwelding.com

Gullco International Inc.

Founded in 1954

Gullco International serves the entire world market through its strong world wide distributor network. With high quality automatic welding machines for weld automation and cutting automation products. Gullco International is engaged in a continuous research and development program to provide weld automation equipment and systems geared to the fast changing needs of the welding industry.

21568 Alexander Road;
Cleveland, OH 44146
(440) 439-8333; FAX: (440) 439-3634;
ussales@gullco.com

Heck Industries, Inc.

Founded in 1966

Heck is still a family owned and operated company proudly manufacturing superior bevelers in the United States. Heck bevelers can be found anywhere in the world. The company offers a complete line of plate bevelers, including 7 hand-held models, 7 power feed and 5 bench-top versions.

See our ad on page 72

P.O. Box 425, Hartland, MI 48253
(810) 632-5400;
FAX: (810) 632-6640;
www.heckind.net

Hobart Institute of Welding Technology

Founded in 1930

Our staff of seasoned professionals offers you advanced training in all major welding processes. Services include 1- to 36-week skill-development courses for the beginners, as well as certifications and/or technical training for welders looking to advance their skills. Customized training for your corporate welding needs is available on- or off-site. A wide selection of world-class welding training and educational materials are available for training or reference use.

See our ad on page 73

400 Trade Square E., Troy,
OH 45373; (800) 332-9448;
FAX: (937) 332-5200;
www.welding.org

Hodgson Custom Rolling Inc.

Hodgson specializes in heav-plate rolling, thick-plate forming, and manufacturing of heavy steel plate and plate products with 130,000 sq. ft. under roof and ASME certified, whether a single prototype, or multiple units, component parts for pressure vessels or heavy industrial applications, from cylinders, rings, truncated cones, to structural forms including the stringers for spiral staircases, Hodgson Custom Rolling can help solve your plate problems.

See our ad on page 15

5580 Kalar Rd., Niagara Falls,
On., Canada L2H 3L;
(905) 356-8132
FAX: (905) 356-6025;
hodgson@hcrsteel.com;
www.hcrsteel.com

Kalamazoo Machine Tool

Founded in 1986

Kalamazoo Machine Tool is a market leader in metal cutting saws for industrial applications and offers a broad range of metal cutting sawing machines. Kalamazoo Machine Tool operates a 18,000 sq foot facility where machines and parts are shipped daily. 12 district sales offices control over 300 local distributors. Kalamazoo Band saws are proven manufacturing machines, Kalamazoo Cold saws are robust for the toughest jobs and our High Speed Circular Saws make non ferrous jobs a breeze.

See our ad on page 31

6700 Quality Way
Portage, MI 49002
(269) 321-8860;
FAX: (269) 321-8890;
wesaw@kmtsaw.com

Midalloy

Founded in 1985

See our ad on page 59

630 Axminister Drive
Fenton, MO 63026;
(636) 349-6000;
FAX: (636) 349-2240;
www.midalloy.com

COMPANY PROFILES

The Lincoln Electric Company

Founded in 1895

The Lincoln Electric Co. is a world leader in the design, development and manufacture of arc welding products, robotic arc welding systems, and plasma and oxyfuel cutting equipment. With more than 100 years in the industry, Lincoln Electric has built a reputation for providing quality products and cutting-edge technology. Technical representativesare available globally to provide innovative solutions.

See our ad on page OBC

22801 St. Clair Ave., Cleveland, OH 44117-1199; (216) 481-8100; FAX: (216) 486-1751; info@lincolnelectric.com; www.lincolnelectric.com

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Founded in 1983

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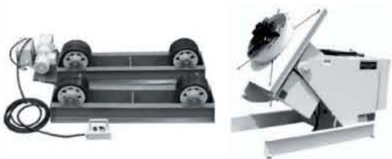

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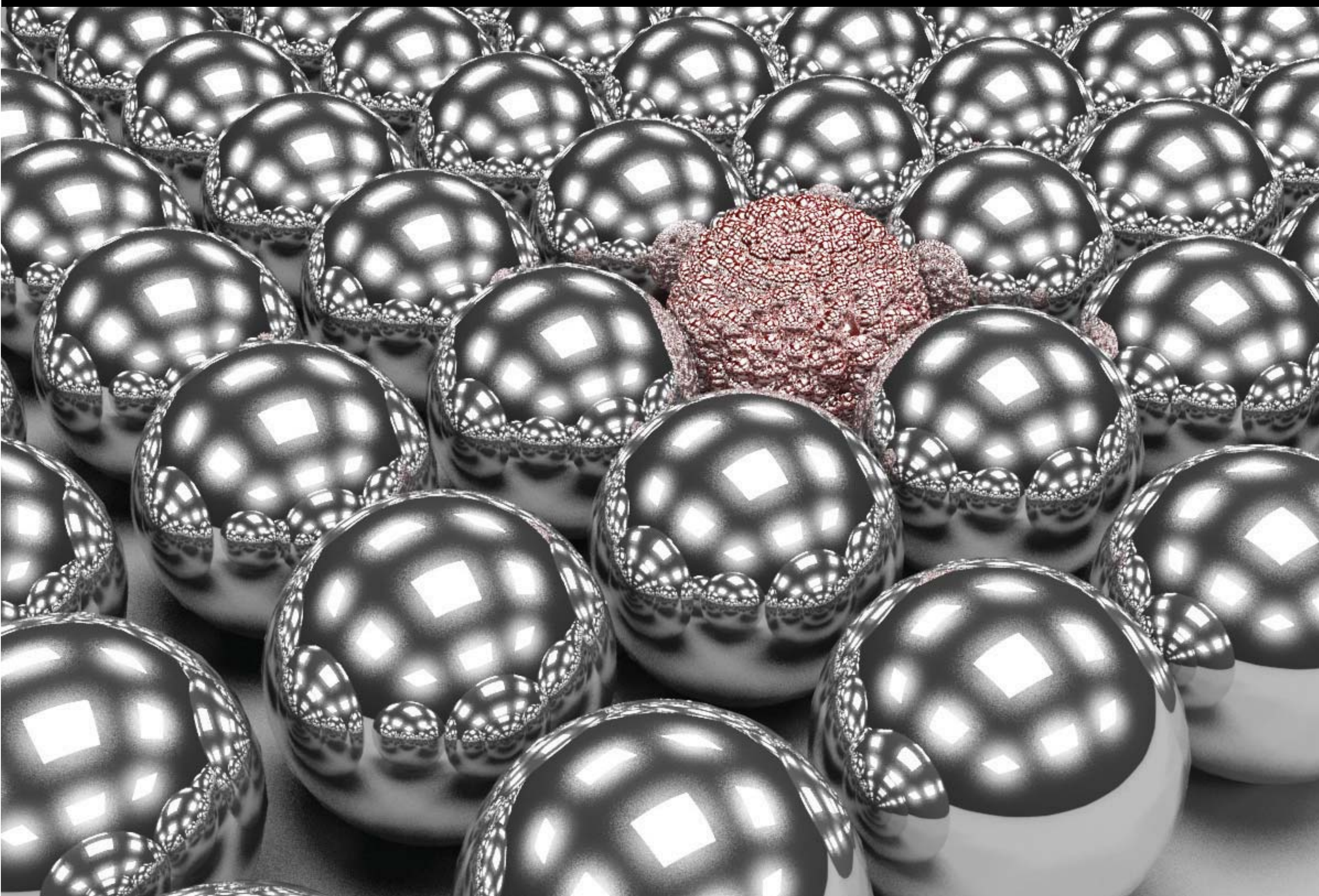

SUPPLEMENT TO THE *WELDING JOURNAL*, JUNE 2009
Sponsored by the American Welding Society and the Welding Research Council

Vision-Based Spatter Classification for Contaminant Detection

Optical monitoring with a high-speed camera is used to evaluate the relationship between spatter and contaminants, such as oil and paint

BY G. SCHWAB, J. P. H. STEELE, AND T. L. VINCENT

ABSTRACT

This paper presents a new method for measuring and classifying spatter in gas metal arc welding (GMAW) by optical monitoring of the weld pool and surrounding area via a high-frame-rate camera. Image processing and tracking algorithms are described that extract and classify individual spatter events from raw camera images. This new sensor is then used to investigate the relationship between workpiece contamination and weld spatter.

Introduction

Spatter can be defined as the ejection of molten material from the weld pool during the welding process. Generally spatter is a signal that the process parameters (including materials, wire, and gasses) may not be optimal. Spatter mechanisms have been studied by a number of researchers (Refs. 1–7). Most of the attention has been on short circuit gas metal arc welding (GMAW) (Refs. 1–3) because of the level of spatter typically involved. Spatter has also been investigated for shielded metal arc welding (SMAW) and flux cored arc welding (FCAW)(Refs. 4, 6). In the case of FCAW, as in the case of short-circuit GMAW, arc stability was shown to be an important factor in the generation of spatter. Spatter is an important factor in most welding processes because of the cost of subsequent removal of the spatter and the potential for the spatter to cause in-service defects (Ref. 6), i.e., spatter can become nucleation sites for pit corrosion and microcracks. However, spatter can have other causes and be an indicator of poor weld quality. It is our hypothesis that spatter can signal the existence of weld contamination, and moreover, that the observed properties of the observed spatter can be useful for contaminant identification. Thus while previous work on the identification, quantification, and classification of spatter has been focused on the mechanisms within the welding process that cause spatter, this work is focused on the identification and classification of weld spatter as an indicator of the presence of containments. As welders know, if the arc comes in contact with external contaminants, it is often the case that the amount and type of spatter will change. Developing a method for identifying and quantifying those changes is the long-term goal of this project.

This paper discusses an image-based method for monitoring spatter in a GMAW process. In the work presented here, a CCD camera is used to monitor the weld pool and surrounding area. Spatter is identified and tracked so that the number of individual spatter events can be determined. Qualities of the spatter, such as size, direction, and velocity, are extracted. Here the spatter monitoring method is applied in a series of experiments using bead-on-plate gas metal arc welding of A36 steel. Oil and paint are intentionally introduced as contaminants, and the differences in the quantity and behavior of the generated spatter are observed.

KEYWORDS

CCD Camera
Gas Metal Arc
Optical Monitoring
Sensors
Spatter
Weld Pool

Other work has utilized cameras as a sensor for robotic welding (Refs. 8–12), but primarily for the purpose of measuring weld geometry or joint tracking. None has considered spatter monitoring. One of the intended outcomes of this research is to develop a new method for fault detection in GMAW that can be applied in real-time to reduce rework, and improve quality and productivity.

Vision-Based Spatter Classification

Experimental Hardware and Example Data

The laboratory setup for the experiments consists of a FANUC ARC Mate 100i robot, a Lincoln Electric Power Wave 455 power source, and a Tregaskiss welding gun. In order to obtain images of the weld pool and surrounding area, a Basler A504k high-speed camera was mounted to the robot arm, as shown in Fig. 1. The camera was attached at a point such that the backplane of the camera was 0.3 m from the tip of the welding gun and positioned to view an area of about 150 × 115 mm around the weld pool. An acrylic encasement protects the camera from spatter. The camera acquires images at up to 400 frames per second with an exposure time of 45 μs. Only very bright objects are visible at such short exposure times. A wide-angle lens (28 mm) was used to image the weld pool and plate, providing the ability to track spatter for a longer period of time. Because we are interested in imaging a large area around the weld arc, interference from the arc does not play a large role, and image acquisition does not need to be synchronized to the weld process. The images from the camera are transferred to the computer using two PCIe-1429 frame grabber boards manufactured by National Instruments. The image recording and processing takes place on a dual Xeon machine, using the

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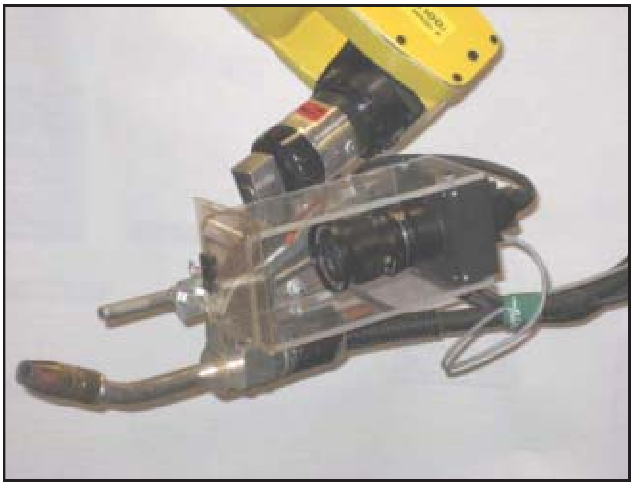

Fig. 1 — Spatter detection camera. A Balser A504k high-speed camera is mounted on the arm of the robot, about 300 mm from the welding gun tip.

National Instruments Vision Assistant 7.1 combined with Labview 8.20. The captured sequence of images is then post-processed to extract spatter events. An industrial version of this sensor could utilize efficient image processing implemented in hardware or field programmable gate array (FPGA) to enable real-time data processing, but this was not implemented in our prototype system.

An example of the raw data captured by the camera is shown in Fig. 2. The images are shown in inverted intensity so bright objects will show up as dark spots in these images. This is done here so that the spatter can be more easily picked out by the human eye; it is not part of the image processing for spatter tracking. Spatter in this figure appears as small, round, black objects; however, the images also contain the arc light and reflections of the arc light from the weld pool and welding fumes. In this figure three consecutive images are shown, taken at intervals of 2.5 ms. Note that the small dark spots that represent spatter move outward from the large annulus that is located at the welding arc to the edge of the image. By comparing the size of the spatter objects between images, and using our expectations for spatter behavior, one can mentally link together an object from each image that we expect corresponds to the same physical object, and thus isolate a single spatter event. The objective of this paper is to describe an automated method for processing the images to achieve the same result.

In order to be more precise in our language with discussing the various manifestations of spatter, the following terminology is used. The ejection of material from the weld pool and its subsequent flight is called a spatter event. Note for this work we assume that only one object is ejected per event. A feature (i.e., blob) in the camera image is called an object. That is, a spatter event is the physical manifestation of spatter in the real world, while a spatter object is what is recorded on the camera when the spatter event occurs. We further refine our nomenclature concerning spatter objects to distinguish between different points in the track estimation process. Those objects that pass through initial filtering via image processing are called potential spatter objects (or potential objects). The potential spatter objects that are selected to be part of a track by a tracking algorithm are detected spatter objects (or detected objects). A collection of detected spatter objects created by the same spatter event is a spatter track.

The goal of the data processing is to determine the number and character of the spatter events, where the spatter characteristics of interest include the amount of material ejected (size), the velocity, and the direction of flight. Since a single spatter event may cause a varying number of spatter objects depending on the velocity and temperature/brightness of the spatter, counting spatter events provides a more accurate characterization of spatter activity than simply counting the raw number of objects in each image. In addition, while image processing may remove the majority of spurious, nonspatter related objects, some may still be passed on as possible spatter objects. By linking objects into tracks, spurious objects are more easily identified.

In the next section, we discuss our proposed method for spatter monitoring in detail. First, some simple image processing is done to determine the location and size of potential spatter objects in the image. This information is then collected over a sequence of images and processed by a spatter tracker to determine which group objects correspond to one spatter event.

Image Processing and Spatter Tracking

The raw data collected by the camera is a 1280 × 1024 matrix of 8-bit unsigned integers, with small values corresponding to dark areas and large values corresponding to bright areas. The objective of the image processing step is to identify the locations in the image that correspond to small, round, bright objects. Image processing begins by quantizing pixels values to either one (bright) or zero (dark), via a preselected threshold, which is based on the overall intensity of the image, and is used to separate all pixels as either black or white. Because the welding arc and weld pool are always in the same location in the image, due to the camera's position being fixed relative to the welding gun, all pixels within the arc and weld pool are set to zero. Reflections of the arc off of welding vapors can cause a region of the image to contain a large number of isolated bright pixels. Since the objective of the image processing is simply to find potential spatter objects, rather than filter out noise, the quantized image is morphologically processed by a dilation operator to connect speckled areas into contiguous bright regions (Ref. 13). The structuring element for the dilation operator was a circle with a radius of 3 pixels, and thus the smallest object in the processed image will have a 3-pixel radius. This groups artifacts such as vapors into a single object without greatly affecting the true spatter image objects. The image artifacts will be removed either by shape classification, or by the tracking algorithm discussed later.

Since spatter objects should appear as approximately circular objects in the camera image, a measure of roundness is introduced by calculating the area and circumference of each object. The radius is then calculated from each using the formulas for the area and circumference of a circle. When the two radii are similar, the object is considered a potential spatter object and retained for further classification; otherwise it is disregarded from further processing.

The potential spatter objects are then classified according to size. Objects with an area of less than 35 pixels are considered small (0.7 mm diameter), those between 36 and 80 medium (0.7 to 1.3 mm), and those above large (greater than 1.3 mm). The sizes in mm correspond to a distance from the camera of about 300 mm.

After image processing, the image location, size, and associated image number for potential spatter objects are passed to a tracking algorithm. The purpose of the tracking algorithm is to aggregate raw spatter objects together into a track representing a single spatter event, as well as determining the velocity and direction of the spatter. Given an initial spatter object, a reasonable algorithm would be to connect this object to the closest object in the next frame that is farther away from the weld pool. However, there can sometimes be multiple reasonable choices. An example of the challenges in determining spatter tracks is shown in Fig. 3. Both the left and right images show the potential spatter objects for the same 30-image sequence, annotated by the image number that the object appears in. The tracks for

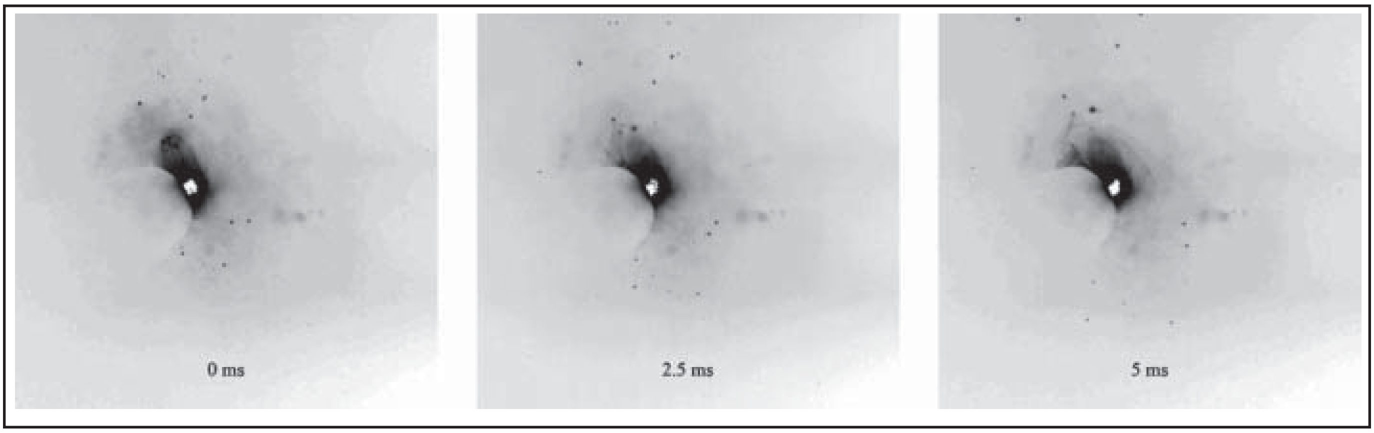

Fig. 2 — Inverse intensity image sequence during spatter event. Black points correspond to bright features. The large dark spot in the center is the weld arc. The white spot in the middle of the arc is an image artifact. The sequence progresses at 400 Hz from left to right.

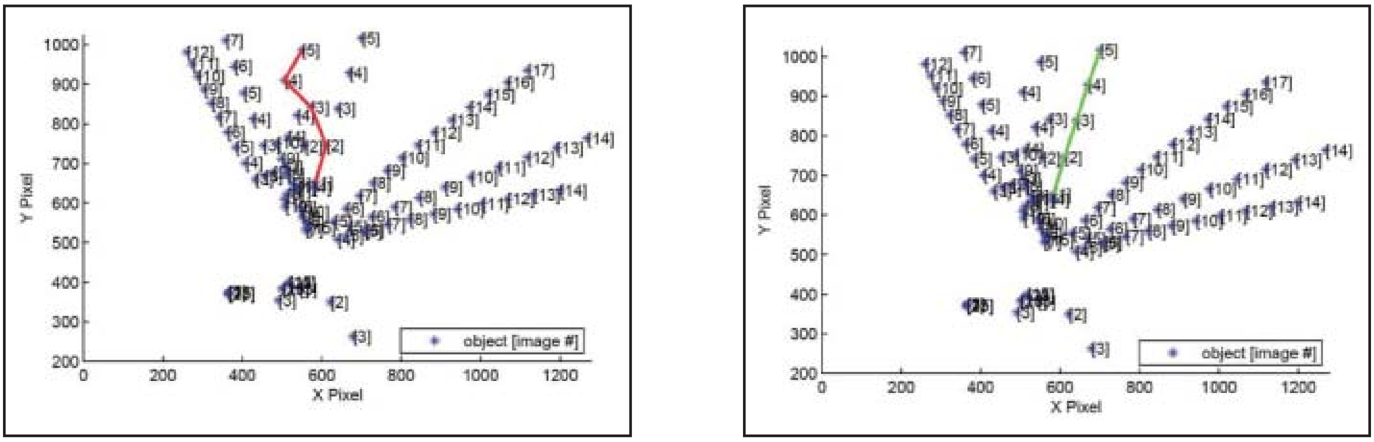

Fig. 3 — Illustration of track selection. The left and right images show potential spatter objects over a sequence of 30 frames, annotated by the image number that they appear in. The red line for the left image and green line on the right image connect potential spatter objects that occur in sequential frames. Although both tracks may be possible, the trajectory in green is much more likely.

many different spatter events can be visually detected, which can be generally segregated by time and distance. Two different choices for linking potential spatter objects into tracks are illustrated by the red line in the left image and green line in the right image. Note that both the red line and the green line connect objects that are close both in time and space. Thus, even if objects are only linked to other objects in neighboring frames that are within a fixed distance, there may be several different choices available for linking. This is especially true for slower frame rates, which allow spatter to have a greater distance of travel between frames. However, it is fairly easy (for a human) to judge that the green trajectory is much more likely to correspond to an actual spatter track than the red trajectory.

Further complicating the problem is that each potential track cannot be considered in isolation. Given the 2-D location and size of potential spatter objects over a series of image frames, a decision needs to be made regarding the disposition of each object. There are several possibilities. If the potential spatter object is thought to be caused by a spatter event, it can be linked to another object that is nearby in a neighboring frame. On the other hand, if the potential spatter object is though to be a false detection, it can be left out of a track. Once a decision has been made for each object, a complete decomposition of the potential spatter objects has been obtained. However, for the types of images created by spatter, many different decompositions may be possible. Choosing which objects belong with which track is at the heart of the problem of multiple target tracking, which is of great importance in applications such as tracking unknown aircraft using radar. Our approach uses a standard probabilistic method (Refs. 14–16), where the decision to create a track is based on the observed congruence with models of the spatter behavior and imaging process. That is, given our models, we calculate the probability that a particular decomposition is correct. The spatter and imaging models are described in more detail below. The estimated "best" decomposition is chosen as the one that maximizes this probability, i.e., the Maximum *A Posteriori* (MAP) criterion. The details of the algorithm are covered in Ref. 17, but an overview is given here.

Because spatter is a transient event, our problem is amenable to a semibatch approach. The image data are split up into groups of M sequential frames, with each group considered separately; spatter events that span two different sections will be combined later. Each frame within a group is indexed by the integer k, which runs from 1 to M. Thus, the time at which an image is taken, relative to the start of the sequence, is $t = kT_S$ where T_S is the sample rate of the camera (T_S = 1/400s in our case). In each group, decompositions of the potential spatter objects in the images are considered. Potential objects are linked together into tracks, such that no

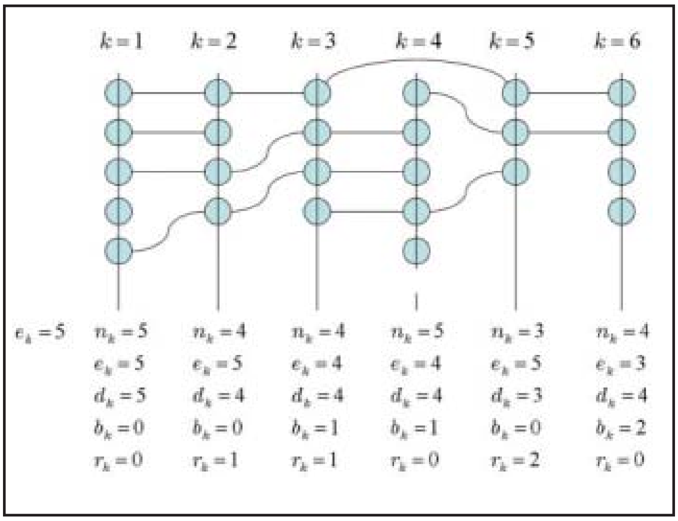

Fig. 4 — Example decomposition. Each vertical line represents a time at which an image was taken and each circle stands for a potential object. The links indicate a track, and a set of tracks is a decomposition.

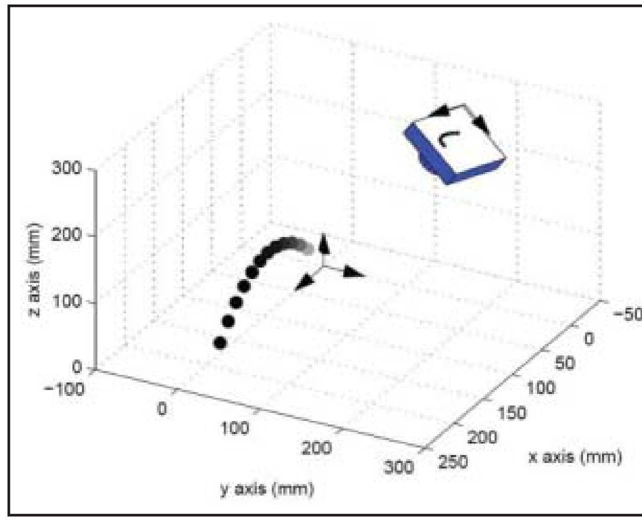

Fig. 5 — Illustration of spatter path and imaging process. The world coordinate system is centered at the weld pool. The camera observes this process at a fixed position and orientation relative to the world coordinates.

object is contained in two tracks. Figure 4 shows an example of such a decomposition. Each vertical line represents a separate image frame and each circle stands for a potential object. The objects are linked by horizontal lines to indicate a track, and a set of tracks is a decomposition. Thus, horizontal lines that connect objects into a track are analogous to the lines drawn in Fig. 3, but in Fig. 4, the position of the objects in the image is no longer shown, just which object corresponds to a particular frame. Note that a track may skip an image, denoting a missed detection, and that some objects are not linked, denoting a false detection. The variables below each line characterize the track decomposition and are used to determine the likelihood of that decomposition. The calculation of this likelihood is described next, and the discussion of these variables follows.

Let Z be the set of data for the section (the location and frame number of all potential objects), and let D denote a decomposition of that data into tracks and false detections (a particular choice for horizontal lines in Fig. 4). The probability that D is correct given the data Z (that is, the *a posteriori* probability) is denoted $P(D|Z)$. By Bayes's Rule (Ref. 18), this probability can be calculated as

$$P\left(D|Z\right)=\frac{1}{c}P\left(Z|D\right)P\left(D\right) \tag{1}$$

where $P(Z|D)$ is the probability of the observed data given the decomposition is correct, and $P(D)$ is the *a priori* probability of decomposition D occurring. The constant c scales the probability distribution so that it integrates to one; however, when maximizing the probability function, this scale factor is irrelevant.

This can be interpreted as follows: There are two aspects by which a particular decomposition is judged — the likelihood of the individual tracks within a decomposition, and the likelihood of the detections implied by the decompositions, such as the number of missed detections, false detections, and track starts and stops. Both of these are necessary, as there is a tradeoff between how closely tracks will fit the spatter behavior and the chosen number of tracks and false detections. For example, consider a group of frames that observes a single spatter event, resulting in a single arc of potential spatter objects. Will our algorithm link these objects together into a track? Because there are always uncertainties, disturbances, or noise that cannot be modeled deterministically, one would get the best fit to the spatter behavior model by linking just two spatter objects, and calling all other objects false detections. Linking all the objects together will result in a track that has a slightly less good fit to the model, and thus a slightly lower conditional probability $P(Z|D)$. However, if the corresponding reduction in the number of false detections results in a much higher probability of the decomposition $P(D)$, and thus an increase in $P(D|Z)$, our algorithm will decide to (correctly) link all other objects together into a track. Thus, our objective will be to maximize the product of the track and decomposition probabilities. Note that in practice, the natural log of the probability functions is utilized in order to improve numerical stability (Ref. 16).

In order to describe in more detail the calculation of $P(Z|D)$ and $P(D)$, the following are defined. Suppose there are N tracks. For track i connecting ℓ_i objects across several frames, we define the matrix

$$Y_i=\left[y_1\; y_2 \cdots y_{\ell_i}\right]^T \tag{2}$$

where $y_j = [u_j\; v_j]^T$ is the pixel location in the image of the jth object in the track. For image number k in the group, additional variables are defined that characterize the likelihood of the types of objects in this image, specifically

$$D_k=\left[n_k\; e_k\; d_k\; b_k\; r_k\right]^T \tag{3}$$

where the definitions for these variables are given in Table 1. Note that the values of these variables are listed in the bottom of Fig. 4 for that particular example.

Table 1 — Definition of Variables that Characterize a Decomposition

n_k	Number of observations for image k
e_k	Number of tracks for image k – 1
d_k	Number of detections for image k (number of circles for image k with lines to either the left or right)
b_k	Number of new tracks for image k (number of circles for image k)
z_k	Number of tracks terminated for image k (number of circles for image k – 1 with a line only to the left)

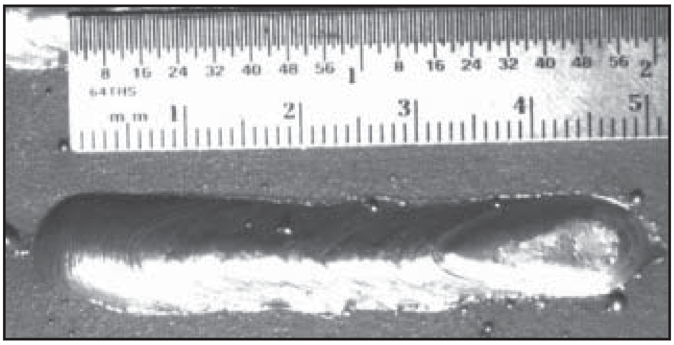

Fig. 6 — Constant voltage reference weld.

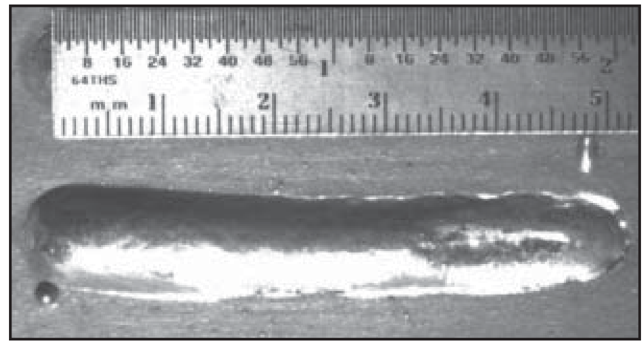

Fig. 7 — Pulsed reference weld.

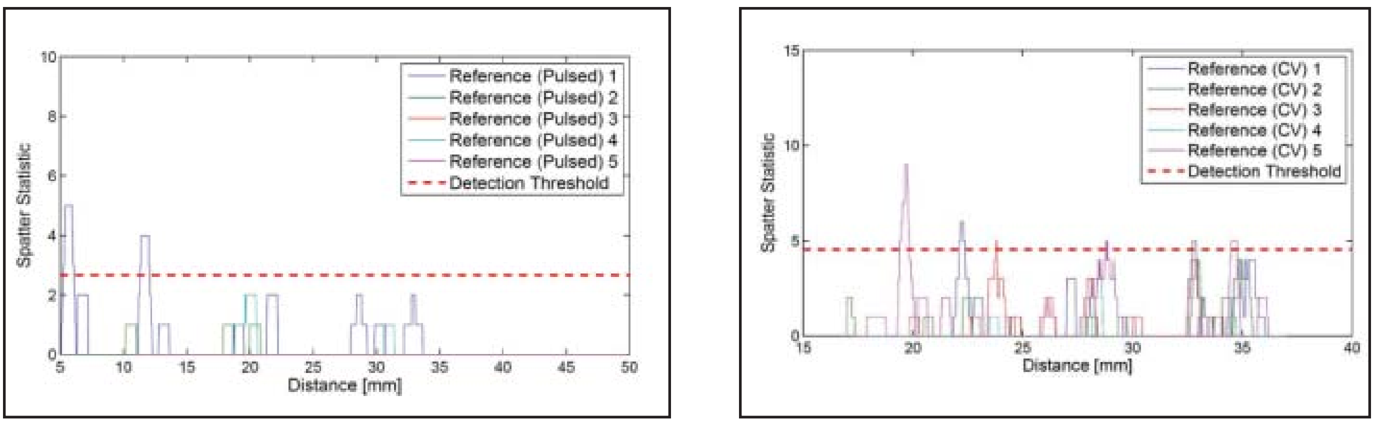

Fig. 8 — Nominal spatter behavior. Plot of the spatter statistic vs. torch position relative to the start of the weld. A — Constant voltage process; B — pulsed process.

a priori Decomposition Probability

The form of the *a priori* decomposition probability density *P(D)* depends on the characteristics of the spatter events (e.g., how many and how they are distributed in time) and the imaging/image processing system (e.g., number of false and missed detections, and their distribution in time) .A complete characterization of *P(D)* for any one system could be time consuming to obtain, but for the purposes of spatter tracking, only an approximate model is necessary.

For our implementation, it is assumed that the number of new spatter events over each time interval T_s follows a Poisson distribution with mean λ_b. Defining b_k to be the number of spatter events initiated during image k, the probability density for b_k is given by

$$p_b(b_k) = e^{-\lambda_b}\left(\frac{\lambda_b^{b_k}}{b_k!}\right) \qquad (4)$$

Similarly, the number of false detections for image $f_k = n_k - d_k$ for image k are assumed to follow a Poisson distribution with mean λ_f.

Furthermore, we assume that the probability of an existing track terminating at image k is p_z, and the probability of the track being detected at image k is p_d. The probability of observing r_k terminations and d_k detections is then, respectively

$$p_z(r_k) = \binom{e_k}{r_k} p_z^{r_k}(1-p_z)^{e_k - r_k}$$

$$p_d(d_k) = \binom{e_{k+1}}{d_k} p_d^{d_k}(1-p_d)^{e_{k+1} - d_k}$$

If the spatter events, track terminations, false detections, and missed detections are independent, then the probability of observing the decomposition D_k for the image at time *t* is

$$p(D_k) = p_b(b_k)\,p_f(n_k - d_k)\times \\ p_z(r_k)\,p_d(d_k) \qquad (5)$$

Under the additional assumption that the events at different times are independent, the probability distribution for the complete decomposition *D* is given by

$$p(D_k) = \prod_{t=1}^{M} p(D_k) \qquad (6)$$

Track Probability

The conditional probability $P(Z \mid D)$ is based on a ballistic model for the spatter droplet, and a pinhole camera model. Let

$$x = \left[x_x \; x_y \; x_z\right]^T \qquad (7)$$

be the location of the spatter in a coordinate system with origin in the center of the weld pool and the *z* axis pointing upward. (Since the weld pool moves much more slowly than the spatter, this can be considered a fixed coordinate system.) Assuming viscous damping, gravity, and a random disturbance force *w*, the free flight motion of spatter can be described by

$$\ddot{x} + \gamma\dot{x} = -g + w \qquad (8)$$

γ represents the damping coefficient, g = [0 0 9.81]′ is gravitational acceleration. The parameters are normalized by the mass of the droplet. Since the spatter is

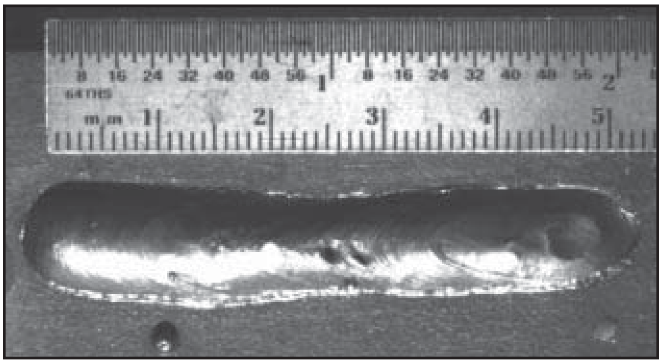

Fig. 9 — Weld bead after constant voltage weld over 0.15-mm paint contamination.

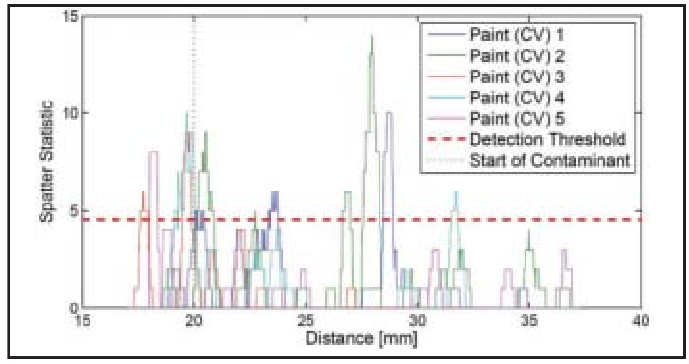

Fig. 10 — Plot of the spatter statistic vs. welding gun position relative to the start of the weld for 0.15-mm paint contamination, constant voltage weld. The start of the contaminant is indicated by the vertical dotted line.

observed only at discrete moments in time, we utilize a discrete time model that is equivalent at the sample times $t = kT_S$. With a state vector z_k containing the position and velocity at time kT_S, that is,

$$z_k = \left[x(kT)^T \quad \dot{x}(kT)^T \right] \tag{9}$$

and assuming that w is constant over the sampling time interval, the equivalent discrete time model can then be written as

$$z_{k+1} = \begin{bmatrix} I & \frac{1}{\gamma}\left(1-e^{-\gamma T_s}\right) I \\ 0 & e^{-\gamma T_s} I \end{bmatrix} z_k - \begin{bmatrix} \frac{1}{\gamma} T_s - \frac{1}{\gamma^2}\left(1-e^{\gamma T_s}\right) I \\ \frac{1}{\gamma}\left(1-e^{-\gamma T_s}\right) I \end{bmatrix} g + w_k \tag{10}$$

where $w_k = w(kT_S)$ and I is the 3×3 identity matrix. It is assumed that w_k is a zero mean, Gaussian white noise random sequence with covariance QT_S. To simplify notation, Equation 10 will be written as

$$z_{k+1} = g\left(z_k\right) + v_k \tag{11}$$

An example of a spatter path is shown in Fig. 5, with the camera represented by the blue rectangular solid. The image of the spatter path is placed on the back of the camera.

This three-dimensional path is then transformed into a two-dimensional image using an ideal camera projection model. The camera projection model converts the calculated 3-D points into the 2-D pixel locations of the image plane. As shown in Fig. 5, the camera lies at a fixed position and orientation relative to the world coordinate system located at the weld pool. A camera coordinate system is attached to the camera, with x and y axes parallel to the image plane, and the z axis pointing outward along the center axis of the camera lens. The rotation R and translation t that maps the representation of points in the world coordinate system to the camera coordinate system can be obtained using a camera calibration method (Ref. 19). Once in the camera coordinate system, points are then projected into the image plane using the camera's focal length f, image size and image center c_0. As only integer numbers of pixels are possible, the results of this transformation are rounded to the nearest integer. The observation model for spatter is given by

$$y_k = p\left(Rx_k + t\right) + c_0 + n_k \tag{12}$$

where p is the perspective projection,

$$p(x) = \begin{bmatrix} f\dfrac{x_x}{x_z} \\ f\dfrac{x_y}{x_z} \end{bmatrix} \tag{13}$$

and n_k is the observation noise. It is assumed that n_k is a zero mean, Gaussian white noise random sequence with covariance C. For simplicity, the observation model (Equation 12) will be notated as

$$y_k = h\,(z_k) + n_k \tag{14}$$

Finally, the initial state is assumed to follow

$$z_1 = e_1 \tag{15}$$

where e_1 is a zero mean, Gaussian random variable with covariance P_1.

With the spatter model defined by Equations 11, 14, and 15, the conditional probability of observing object track given that the track decomposition is correct can be approximately computed using a (smoothing) Extended Kalman Filter (Ref. 20), which finds $z_1, z_2, \ldots, z_{\ell_i}$ to minimize

$$L\left(z_1, z_2, \ldots z_{\ell_i}\right) = \left(z_1 - \hat{z}_1\right)^T P_1^{-1}\left(z_1 - \hat{z}_1\right) + \sum_{k=1}^{\ell_i}\left(y_k - h\left(z_k\right)\right)^T C^{-1}\left(y_k - h\left(z_k\right)\right) + \sum_{k=1}^{\ell_i - 1}\left(z_{k+1} - g\left(z_k\right)\right)^T \left(QT_s\right)^{-1}\left(z_{k+1} - g\left(z_k\right)\right) \tag{16}$$

subject to the constraints defined by Equa-

Table 2 — Algorithm Parameters

M	Q	C	P_1	λ_b	λ_f	p_z	p_d
30	20	1	10^5	0.1	0.01	0.16	0.9

Table 3 — Baseline Parameters

Process	Voltage/Trim	WFS	Travel Speed	Standoff	Frame Rate/s
CV	28 V	325 in./s	6 mm/s	17 mm	400
Pulsed	1.2	275 in./s	6 mm/s	12 mm	200

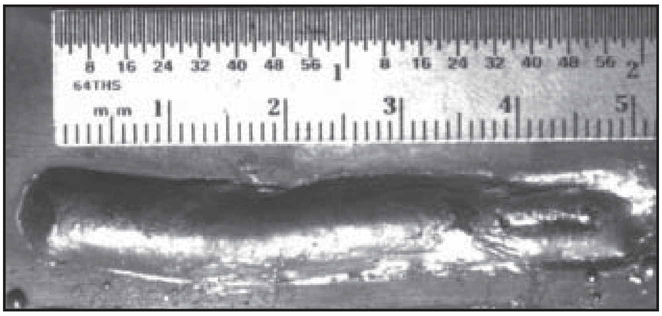

Fig. 11 — Weld bead after pulsed weld over 0.15-mm paint contamination.

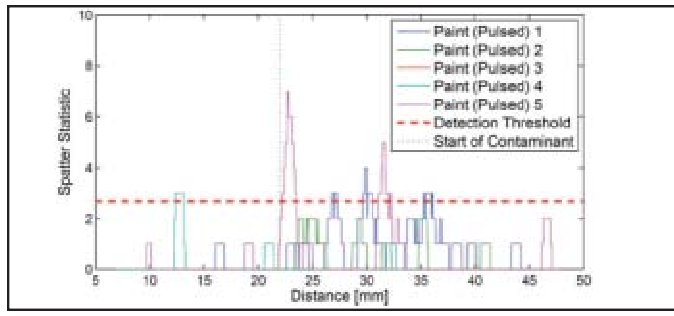

Fig. 12 — Plot of the spatter statistic vs. welding gun position relative to the start of the weld for 0.15-mm paint contamination, pulsed weld. The start of the contaminant is indicated by the vertical dotted line.

tions 11 and 14 (with appropriate modifications for missed detections). Let $\hat{z}_t^i, P_t^i$ be the resulting estimate and (approximate) error covariance, and set

$b_t^i = C\hat{z}_t^i, B_t^i = CP_t^iC' + R.$ The track probability is then given by

$$p(Y_i) = \prod_{k=1}^{N_i} N\left(y_{t_k}^i \middle| b_{t_k}^i, B_{t_k}^i\right) \tag{17}$$

where $N(x|\mu,\Sigma)$ denotes a Gaussian distribution with mean μ and covariance Σ. The probability of the observed data given decomposition D is then the product of the probabilities for the individual tracks.

$$p(Z|D) = \prod_{i=1}^{N} p(Y_i) \tag{18}$$

Data Processing

Given the decomposition metric defined by Equation 1, data processing for each group of frames consists of linking potential spatter objects into tracks, and searching for the decomposition with the highest probability. The choices of parameters for our implementation are given in Table 2. Since the number of possible tracks scales factorially with the number of objects, practical application requires avoiding linking objects that have an obvious low probability of being in the same track, a process that is called gating. For the spatter tracking applications, the gating constraints placed on object linking are the following:

- Only link to objects in the next or subsequent frame (allow only one missed detection in a row).
- Only link to objects located less than d pixels away in the next frame, or $2d$ pixels away in the subsequent frame.
- Only link to objects of the same size class (small, medium, or large).

Other gating constraints are possible, such as limiting links to an arc centered at the weld pool, but were not included in our off-line implementation. With proper gating, the computational expense of the maximum-likelihood tracking algorithm can be quite modest compared to the raw image processing needed to extract potential spatter objects. Indeed, in most frames, there will be few objects that need to be considered. It is possible that simply counting raw potential spatter objects could be used for diagnosis, but since the number of spatter events is more directly connected with the physical process, it is an advantage to pursuing the spatter events approach. In addition, just using the raw count would not provide any information about the velocity of the spatter objects. In the work presented here, the velocity of large spatter objects varied with the type of contaminant. Thus velocity could potentially be important to the diagnosis.

The search proceeds in three stages. First, in the initialization stage, objects are chosen as potential track seeds. In order to reduce the number of other object satisfying the gate constraints, seed objects are chosen outside of a circle centered at the weld pool, where the distance between tracks is larger. Tracks are then iteratively extended off of these seed objects and continuing along objects satisfying the gating constraints of the last object in the track. New objects are accepted if they are not part of another track, and the net a-posteriori decomposition probability increases when they are part of a track.

Once track initialization has been attempted from all seed objects, a refinement stage occurs. There are five operations that occur on tracks in the refinement stage. The result of these operations is accepted if it results in an increase in the *a posteriori* decomposition probability.

- Extend forward: An object that does not belong to another track and satisfies the gating constraints of the last object in the track is linked.
- Extend back: An object that does not belong to another track and for which the first object in the track satisfies the gating constraints is linked.
- Split: A track is split into two tracks.
- Merge: The end of one track is linked to the beginning of another track that satisfies the gating constraints.
- Removal: The links to a track that is 3 objects or less are removed.

These operations are randomly applied to links until either no further improvement is achieved, as measured by a certain consecutive number of rejected operations, or a fixed number of attempts have been tried.

Finally, after each group was processed, tracks that ended at the last image in the group, or began at the first image of the group, were compared against neighboring groups to determine if they could be connected across group boundaries.

Experimental Procedure

The objective of the development of the spatter tracking algorithm is to determine if spatter is a useful metric for the identification of contaminants in welding. To demonstrate its potential, a series of bead-on-plate experiments was performed on nominal and contaminated material, using both a constant voltage and pulsed welding process. In this section is described the weld process settings, baseline spatter rate, and process for creating contaminated weld plates.

Establishing the Nominal Weld Process

To create the nominal weld process, settings were found for both constant voltage and pulsed processes that yielded a good weld with a smooth, even surface with no cracks, no visible porosity or void spaces, no undercut along the edge, and a shallow toe angle. The frame rate of the camera was also varied between the two processes. The constant voltage (CV) process generated more spatter, and a

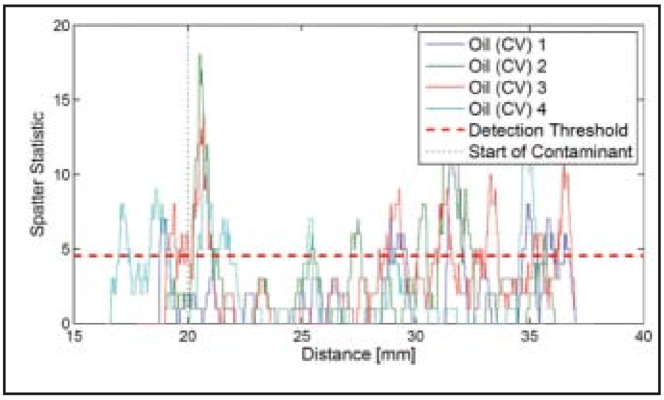

Fig. 13 — *Plot of the spatter statistic vs. welding gun position relative to the start of the weld for heavy oil contamination, constant voltage weld. The start of the contaminant is indicated by the vertical dotted line.*

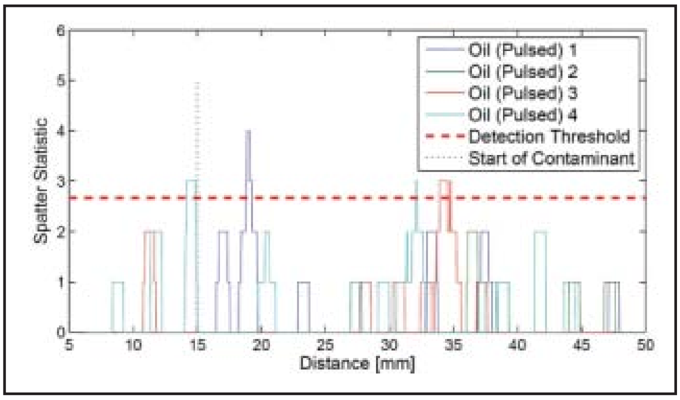

Fig. 14 — *Plot of the spatter statistic vs. welding gun position relative to the start of the weld for heavy oil contamination, pulsed weld. The start of the contaminant is indicated by the vertical dotted line.*

higher frame rate simplified the processing by limiting the travel distance of spatter objects. The optimal parameters found are displayed in Table 3. Note that different camera frame rates were chosen for the two different processes. A lower frame rate increases the length of weld covered by a fixed number of frames, but makes the spatter tracking more difficult, as spatter will move father between frames. Thus, a higher frame rate produces more data, but reduces the search space for establishing spatter tracks. Within this tradeoff a frame rate can be chosen to reduce the computational load. Constant voltage weld processing had a higher amount of spatter and required the higher frame rate to process the data.

Figures 6 and 7 show examples of welds created using a constant voltage process and a pulsed process, respectively. As the available gas mixture of 75% argon and 25% CO_2 was not ideally suited for the pulsed process, the appearance of those welds is not optimal.

A certain level of spatter is present even in the absence of contamination. This level varies with the type of process used. For example, in pulsed welding the amount of spatter created is generally significantly less than in constant voltage welding. In order to determine whether the observed increase in the spatter level was statistically significant, a baseline level had to be found. Based on preliminary analysis of the data, the number of spatter events larger than 1.3 mm had the largest variation between processes, and thus, it was postulated that this contained information relevant for fault detection. Thus, we chose the statistic to monitor as the number of spatter events larger than 1.3 mm in diameter that occur in a window of 30 frames centered around the current time. A window of 30 frames corresponds to a welding gun travel distance of about 0.5 mm along the weld at 400 ft/s frame rate (the travel speed was 6 mm/s).

Assuming that spatter events at each frame are independent of each other and follow a Poisson distribution with parameter λ, the distribution of the spatter statistic, at a fixed time will also be Poisson with expected value 30λ. Thus, the probability distribution for s, the number of spatter events in the window, is

$$p_s(s) = 30\lambda^s \frac{e^{-30\lambda}}{s!} \tag{19}$$

Five welds were performed on uncontaminated plates for both constant voltage and pulsed welding processes. The parameter λ was determined by finding the average number of events per frame for all reference welds (of the same frame rate and for the same process). A nominal spatter level was set as the 99.9% level of the Poisson distribution. That is, the nominal spatter level was set such that the nominal process will have a spatter statistic below this level for 99.9% of the time. The nominal spatter detection levels were found to be 4.54 events for the continuous voltage process, and 2.67 events for the pulsed process. Plots of the spatter events for the nominal processes are shown in Fig. 8.

Table 4 — Experimental Results for the Constant Voltage Welding Processes

Cont.	Events	Avg. Vel.	Max. Vel.	Avg. Size
Oil: light	259.8	18.2	77.5	62.5
Oil: heavy	408.5	16.3	95.5	67.8
Paint: one layer	306.0	20.9	79.5	61.9
Paint: two layers	203.8	20.8	76.0	66.9
Paint: three layers	189.8	19.2	71.6	65.17
Reference	127.0	23.7	79.2	59.7

Table 5 — Experimental Results for the Pulsed Welding Process

Cont.	Events	Avg. Vel.	Max. Vel.	Avg. Size
Oil: light	33.3	38.1	140.4	82.1
Oil: heavy	44.8	37.4	82.7	76.7
Paint: one layer	19.2	45.3	82.2	76.2
Paint: two layers	24.4	30.8	83.9	82.7
Paint: three layers	30.8	27.7	72.1	94.3
Reference	19.3	42.2	112.8	75.7

Preparation of Contaminated Plates

In order to obtain realistic conditions, mild steel plates with a thickness of 9 mm for constant voltage welding and 3 mm for pulsed welding were prepared with the different contaminants.

Paint

For paint, the contaminant was applied in a one-in.-wide area perpendicular to the travel direction of the welding gun. The paint was applied with a foam brush. In order to obtain different thicknesses, one layer was applied, given time to dry and then another layer was applied over it. The resulting total thickness was measured using a dial indicator mounted on a linear positioner. One layer had a thickness of roughly 0.03 mm, two layers about 0.06 mm, and three layers about 0.15 mm.

Oil

As oil remains in liquid state and tends to spread out over the plate, it was not possible to guarantee an exact amount per area. To be as consistent as possible, a fixed number of drops of oil were applied to the plate and spread out over the desired area with a brush. The experiment was carried out immediately after this application.

Results and Discussion

Five welds were performed for each level of paint contaminant, and four welds were performed for each type of oil contaminant. During the weld, 1200 image frames were collected and analyzed for spatter events. The number of spatter events (that is, number of tracks) was tabulated, along with size of the object in the track in pixels, and the velocity of the track across the image in pixels per second as measured by the first two objects in the track. Statistics of the results are given in Tables 4 and 5. To eliminate the influence of stationary objects that prevail for several frames, tracks that have a pixel velocity of zero were removed. These objects could be reflections of the arc off of fumes or the part itself, and since their position in the image frame is variable, they cannot be removed by masking in the same way as was done with the arc itself. This filtering process is enabled by estimating the track velocity. Note also that the average velocity of the objects varies with contaminant type. Although the velocity was not included as part of our spatter statistic, this would be an interesting area for future investigation.

For the constant voltage process, an increase in spatter events is evident for all contaminated welds, with the largest increase for heavy oil contamination. Interestingly, while at least 1.5 times greater than the number of spatter events in the reference (no contamination case), the number of spatter events seems to decrease with increasing layers of paint. The average spatter size is fairly consistent, but does appear to increase slightly for higher levels of contamination.

The pulsed wave process also shows an increase in spatter events for all contaminated welds except for one layer of paint. Note that the number of spatter events is much smaller than for the constant voltage process. In this case, spatter events increase with increasing levels of contamination, along with a general trend of larger spatter objects.

In the next sections, the spatter behavior is examined in more detail for the highest levels of contamination.

Paint

Of the two contaminants examined in the constant voltage process, paint was the one that caused the most severe observed changes to the weld bead. However, the severity of the reaction depended heavily on the thickness of the paint. It is likely that thin layers of paint vaporized before interaction with the weld pool could occur. However, for the thickest application (0.15 mm) enough paint remained to react violently with the molten metal, causing explosions in the pool that led to the ejection of large amounts of material as well as gas bubbles that solidified, causing porosity. Figure 9 shows an example of a weld over three layers of paint with visible porosity. The contaminated area starts about 21 mm into the weld. A change in the spatter level could be observed during the welding process as soon as the weld pool reached the contaminated area. In addition, a large amount of solidified spatter was found on the plate after the completion of the welds.

Figure 10 shows the measured spatter statistic for welds contaminated with a 0.15-mm layer of paint. The solid red line indicates the 99.9% limit that was calculated using the reference runs. The contaminant begins at about 20 mm for each run, and is indicated with a vertical dotted line. A good correspondence between the crossing of the limit and high values of the spatter statistic can be seen.

When using a pulsed welding process, the influence of paint contamination on the quality of the weld was much less significant. Even with three layers of paint, no visible porosity could be achieved. However, this may be primarily due to the difference in the thickness of the plates. As the pulsed process was not hot enough to achieve good fusion on 9-mm plates, 3-mm plates were used. As the heat capacity of these plates is much lower, it is suspected that they heat up much faster, allowing for the contaminant to vaporize before reaction with the weld pool takes place. Figure 11 shows an example of a weld with contamination from three layers of paint. The paint starts at about 20.5 mm.

Figure 12 shows the spatter statistic for paint contamination for the pulsed process. Generally, the amount of spatter created in pulsed welding is much lower than that created in constant voltage operation. For the pulsed process, the probability of detection is not as high as in the constant voltage case.

Oil

While oil contamination did cause an increase in the overall spatter level, it did not create obvious changes in the solidified weld bead, even with severe contamination. Some beads do show slight cases of necking. However, similar to paint contamination, in the constant voltage runs large amounts of solidified spatter were found in the vicinity of the weld beads, indicating a reaction of the contaminant with the weld pool. Spatter levels increased for all sizes from small to large spatter and were greatest for this type of contamination. Plots of the spatter statistic for the constant voltage process are shown in Fig. 13, and for the pulsed process in Fig. 14. Again, the increase in spatter activity is most evident in the constant voltage weld process.

Conclusions

In this paper, a method of identifying spatter events and tracking spatter objects has been presented. Counting the frequency of spatter events has been shown to be an indicator of the presence of contaminants, i.e., oil and primer paint of excessive thickness. In addition, the number of spatter events of specific size appear to vary as a function of the contaminant type.

The purpose of this research was primarily to prove the concept of contaminant detection based on spatter detection. While this has been achieved, more research is necessary to develop the system into a true contaminant classification system for practical use. In the current configuration, the image processing and spatter tracking are done post-process, but significant optimizations could be applied to be able to process the data online. For example, the algorithms that have been developed to identify and quantify the spatter events could be transferred to field programmable gate arrays (FPGAs). By doing so, the processing time is reduced orders of magnitude, thus making real-time detection possible. The long-term goal of this research is to develop an online weld quality monitor, for automated welding processes, that would identify the presence of containments in real-time, alert supervision, and halt the process, if appropriate, thus reducing or eliminating bad welds and costly rework. While the vision system used in this research was both expensive (~$3000) and too intrusive into the welding gun/workpiece workspace, the long-term plan is miniaturization of the camera to be less intrusive. This plan is supported by recent hardware developments in cameras and imaging, such as cell phone and car backup cameras. This work helps pave the way for online vision-based monitoring of welding processes in automated workcells — a development that will help productivity and quality.

Acknowledgment

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Ductility-Dip Cracking Susceptibility of Nickel-Based Weld Metals: Part 2 — Microstructural Characterization

Ductility-dip cracking in Ni-Cr-Fe weld metals was attributed to grain boundary sliding in the temperature range from approximately 750° to 1150°C

N. E. NISSLEY AND J. C. LIPPOLD

ABSTRACT

Part 2 of the investigation of the ductility-dip cracking (DDC) susceptibility of Ni-Cr-Fe filler metals describes experiments and characterization designed to provide a better understanding of the DDC mechanism. The strain-to-fracture (STF) DDC susceptibility varied significantly with only minor changes in composition and was influenced by the solidification microstructure. Optical metallography, electron backscatter diffraction (EBSD), thermodynamic calculations, and heat treatments were used to better understand microstructural factors that influenced susceptibility to DDC.

The DDC cracking susceptibility was compared with thermodynamic calculations to better understand how carbide precipitation affects grain boundary sliding and the mechanism for DDC. Macroscopic grain boundary locking occurs in alloys that form interdendritic MC-type carbides at the end of solidification. A significant decrease in the DDC susceptibility was found in alloys with Mo and Nb additions that resulted in a dense distribution of skeletal MC-type carbides. The carbide morphology and distribution affects boundary migration and results in wavy or tortuous grain boundaries that mechanically lock the grain boundaries and oppose the sliding that promotes cracking. Microscopic grain boundary locking occurs in alloys that form intergranular $M_{23}C_6$ carbides. The distribution, morphology, and precipitation kinetics of these carbides affect their ability to limit grain boundary sliding.

Solutionizing and subsequent precipitation heat treatment improved the resistance to DDC. This resistance was attributed to microstructure homogenization, and $M_{23}C_6$ precipitation that resulted in reduced grain boundary sliding. In one Filler Metal 52M alloy, the elongated intergranular $M_{23}C_6$ carbides promoted dynamic recrystallization during STF testing that was attributed to particle stimulated nucleation (PSN).

Based on this investigation, DDC in Ni-Cr-Fe weld metals is clearly attributed to grain boundary sliding in the temperature range from approximately 750° to 1150°C. The precipitation of MC-type carbides at the end of solidification results in pinning of the migrated grain boundaries that make these boundaries "tortuous" and resistant to sliding. In addition, the precipitation of $M_{23}C_6$ carbides in the solid state provides additional microscopic locking of the boundaries that further improves resistance to DDC.

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Introduction

In Part 1 of this investigation, the ductility-dip cracking (DDC) susceptibility of Ni-Cr-Fe filler metals was evaluated using

KEYWORDS

Ductility Dip Cracking
Nickel-Based Alloys
Precipitation Heat Treatment
Grain Boundary Sliding
Weld Process Simulation
Strain-to-Fracture Testing

the strain-to-fracture (STF) Gleeble-based testing technique (Ref. 1). Part 2 of this investigation focuses on the mechanism of DDC in these weld metals. Numerous mechanisms for DDC have been proposed for multiple alloy systems and include sulfur embrittlement (Refs. 2, 3), grain boundary sliding (Refs. 3–7), and $M_{23}C_6$ precipitation-induced cracking (Ref. 8). The lack of consensus on the mechanism for DDC is due to multiple contributing factors that add to the complexity of DDC in different alloy systems. This complexity limits the use of some testing techniques where there are too many uncontrolled variables and limited options for a systematic evaluation. The Gleeble-based STF test has demonstrated significant advantages for assessing DDC susceptibility, including 1) a reproducible starting microstructure, 2) a single testing temperature that isolates the DDC-susceptible temperature field, 3) control of strain at the test temperature, and 4) can be used for both on-heating and on-cooling tests (Refs. 5, 9).

Based on previous research, there is a lack of consensus on the effect of composition on DDC susceptibility. Dix and Savage reported that in Inconel® X-750, carbides appeared to inhibit grain boundary sliding, which improved the ductility, and they found no evidence of embrittlement due to carbide precipitation (Ref. 7). Rhines and Wray reported that grain boundary shearing in Monel® was the cause of the DDC, and boundary orientation was important (Ref. 10). Similarly, Ramirez and Lippold reported evidence of grain boundary sliding in FM-52 and 82 and proposed that it was caused by a creep-like mechanism associated with grain boundary sliding (Refs. 11, 12). Haddrill and Baker reported that in 25-Cr/20-Ni stainless steels, increased carbon reduced DDC susceptibility, and concluded that the cracking could not be caused by strain-induced precipitation (Ref. 13). Arata et al. reported that an increase in carbon reduced cracking in stainless steels

WELDING RESEARCH

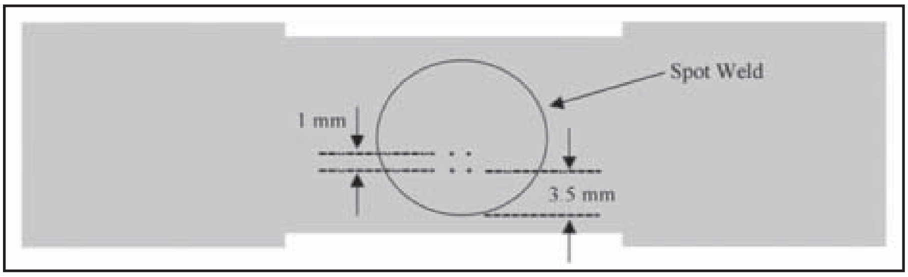

Fig. 1 — Schematic showing the location of the four indentions forming a 1- × 1-mm square inside the spot weld on the STF sample. The indentions were used to locate the same area for EBSD scans before and after STF testing and were located 3.5 mm from the edge of the spot weld. (Not to scale.)

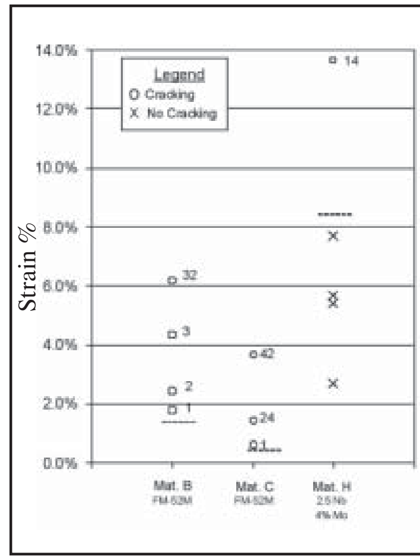

Fig. 2 — STF test results for baseline testing at 950°C for experimental FM-52M compositions. An "x" represents a tested sample with no DDC cracking and an "o" a sample with DDC cracking. The number next to the circle is the number of DDC cracks found in the sample. Materials B and C are experimental heats with the same target composition except for boron, and material H has higher Mo and Nb.

Table 1 — All-Weld-Metal Compositions (wt-%) of the Three Experimental Alloys that Were Further Evaluated

	Mat. B (FM-52M)	Mat. C (FM-52M)	Mat. H (N/A)
Ni	59.54	60.38	53.87
Cr	30.06	29.5	30.18
Fe	8.22	8.04	8.2
Nb	0.83	0.82	2.48
C	0.02	0.03	0.021
Mn	0.80	0.77	0.8
Si	0.001	0.001	0.001
P	0.003	0.004	0.004
Si	0.09	0.12	0.2
Cu	0.02	0.01	—
Al	0.11	0.12	0.04
Ti	0.22	0.19	0.2
Mo	—	—	4
B	0.003	0.001	0.001
Zr	0.01	0.008	0.007

and attributed this to $M_{23}C_6$ carbides restricting grain boundary mobility. However, Young et al. tested a number of Ni-Cr weld metals and concluded that DDC was caused by $M_{23}C_6$ precipitation-induced cracking (Ref. 8). Zhang et al. reported that in Invar®, grain boundary sliding coupled with intergranular precipitates and serrated grain boundaries led to the observed DDC cracking (Ref. 14). Lin and Cola reported strain concentration at grain boundaries of FM-52 weld metal and proposed that the difference in ductility between the grain interiors and boundaries may account for the DDC cracking (Ref. 15).

Collins et al. found that additions of sulfur and/or hydrogen increased the susceptibility to DDC in FM-82 (Refs. 16, 17). Ramirez and Lippold reported that in FM-52 and 82 sulfur affected cracking but bulk sulfur levels were not sufficient to define DDC susceptibility (Ref. 11). Nishimoto et al. reported that in Alloy 690, sulfur and phosphorus had an embrittling effect on grain boundaries but reported a recovery with lanthanum additions (Refs. 3, 18, 19). Capobianco and Hanson proposed that for FM-52, the ductility-dip may be caused by the combined effect of sulfur embrittlement and local stress from $M_{23}C_6$ carbide precipitation (Ref. 20). Young et al. concluded that DDC in their Ni-Cr alloys was not controlled by grain boundary impurity segregation of sulfur (Ref. 8). In Invar, Matsuda et al. found that sulfur, oxygen, nitrogen, and aluminum promoted DDC while silicon and manganese inhibited DDC (Ref. 21). Nishimoto et al. found that the sulfur embrittlement of grain boundaries in Invar was accelerated by reheating during multipass welding (Ref. 2).

There have been numerous reports where Nb and/or Ti carbonitrides in Ni-based alloys have altered the grain boundary morphology and decreased the DDC susceptibility (Refs. 8, 11, 12, 22–28). This seems consistent with the extensive cracking observed in commercially pure nickel 200 reported in Part 1, which is essentially free of carbides (Ref. 1).

Several authors have reported that in Ni-based alloys the orientation of the boundary and the applied strain affected cracking (Refs. 12, 16, 23, 24, 26) and Kikel and Parker reported that rotating the weld 90 deg to the applied strain reduced DDC (Ref. 23). Davé et al. found that "special" grain boundaries in Alloy 690 were less susceptible to DDC than random boundaries (Ref. 29). Collins et al. observed that DDC only occurred along random, high-angle boundaries (Ref. 24).

Significant heat-to-heat variation continues to be reported, that, based upon our current understanding of the DDC mechanism, could not have been predicted solely by composition (Refs. 16, 25, 28). Additional understanding of the effect of bulk composition on ductility-dip cracking susceptibility is needed to understand and avoid cracking in the future.

Experimental Procedures

In Part 1, eight experimental Ni-Cr-Fe alloys were prepared and tested for DDC susceptibility with the STF test (Ref. 1). Based upon these results, materials B, C, and H (Table 1) were selected for further microstructural evaluation to better understand the factors affecting DDC susceptibility. Materials B and C are experimental Filler Metal 52M (FM-52M) alloys and material H is a FM-52M-like alloy with additions of 2.5% Nb and 4% Mo. FM-52M (AWS A5.14, ERNiCrFe-7A) is a second-generation welding wire for joining Alloy 690 in nuclear applications where SCC and DDC resistance are required.

In the present work (Part 2), all of the alloys were evaluated before and after STF testing using optical microscopy, scanning electron microscopy (SEM), and electron backscattered diffraction (EBSD). The microstructural observations were compared with solidification and equilibrium thermodynamic calculations and with the STF testing results. Based upon these observations, samples were heat treated to alter the as-welded carbide distribution and then STF tested to better understand the effect of carbide precipitation on DDC susceptibility.

Microstructural Analysis

Samples prepared for optical and electron microscopy were mechanically polished through 3 μm diamond paste and then electropolished prior to each scan to expose a clean surface. Electropolishing was performed with a Struers LectroPol-5 using Struers A2 polishing solution and developed operating parameters (39 V, ~1.7 A/cm², 3 cm² mask, 18 flow, 22°C, 15

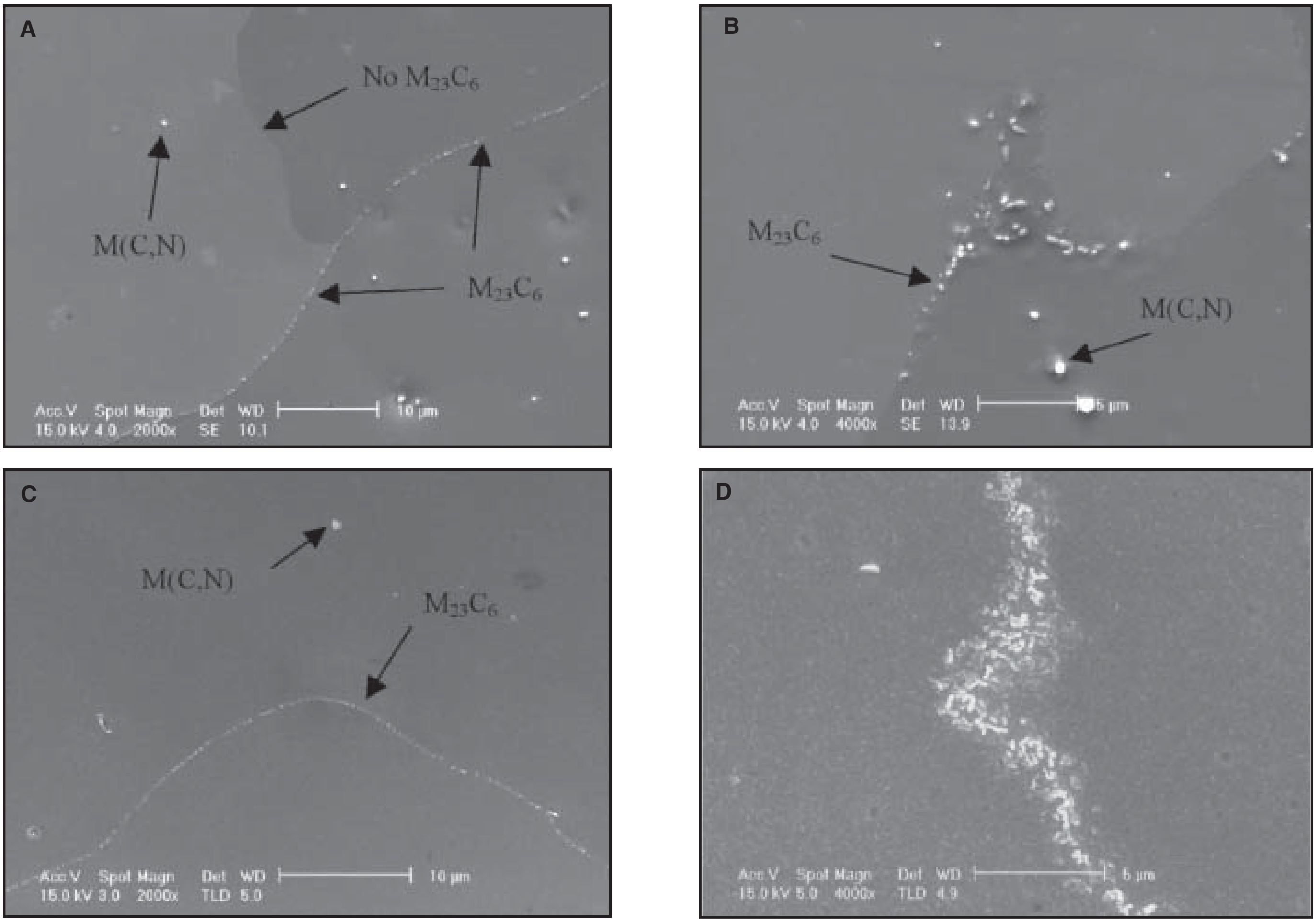

Fig. 3 — Material B sample showing the as-welded (spot weld) microstructure (A and B) and the STF tested (950°C) microstructure (C and D). M(C,N) carbides are visible in the interdendritic regions in both cases while the $M_{23}C_6$ carbides were found on select boundaries as welded and on almost all boundaries after STF testing.

s) (Ref. 5). Electropolishing was found to be beneficial as it produced a deformation-free sample surface required for EBSD but did not etch away the carbides, leaving them exposed above the surface. Samples were etched with a 10% chromic acid solution at 1.5 to 2 V for 30 s when required.

Strain-to-fracture testing was completed on-heating using standard testing procedures detailed in Part 1 (Ref. 1). On-cooling STF tests were not completed during this study due to the additional test variables that are introduced (e.g., peak temperature, cooling rate) and the fact that a significant number of cracks are observed in these alloys on-heating at low levels of strains. Standard STF spot welds with a 12.7-s downslope time were used for all reported data. Samples were heated in the Gleeble to the test temperature, held for 10 s, and strained different amounts. After cooling to room temperature, the strain and number of cracks were determined with the aid of a binocular microscope at magnifications up to 30 X. The results of the test are plotted on a temperature-strain plot with the number of cracks beside each point. The STF results include the threshold strain and the transition to gross cracking. The threshold strain is defined as the lowest strain over the entire DDC temperature range at which the material begins to crack. While the complete on-heating DDC temperature range was not tested for these alloys due to a limited number of samples, the use of the term threshold strain in this paper is used to describe the minimum strain at which the samples started cracking at 950°C. Other STF tests to date on FM-52 and FM-52M alloys (Refs. 9, 27, 30) have shown that 950°C can provide a reasonable estimate of the threshold strain for these alloys. The transition to "gross" cracking is defined as the strain where cracking becomes so abundant that cracks begin to grow and connect, making accurate crack counting difficult. The gross cracking transition can be defined when the slope of the number of cracks from one sample to the next exceeds approximately 10 cracks per percent strain.

Electron microscopy was performed with three separate scanning electron microscopes for imaging, EDS chemical analysis, and EBSD (Ref. 31). All SEM imaging and EDS analyses were performed at 15 keV, and EBSD was performed at 25 keV. Quantitative analysis of carbides with the EDS data was limited due to the size of the electron beam interaction volume. The EBSD data collection and analysis was performed with the EDAX TSL OIM™ software.

Deformation

Electron backscattered diffraction was performed before and after STF testing with a modified sample geometry. While the total STF sample length was reduced to 3.75 in. (9.5 cm) to accommodate the space limitations of the EBSD chamber, the gauge length and spot weld remained the same (Ref. 5). After the sample was prepared according to the standard polishing and etching procedure described previously, a set of four Vickers microhardness indentions were made on the sample surface with the use of a microme-

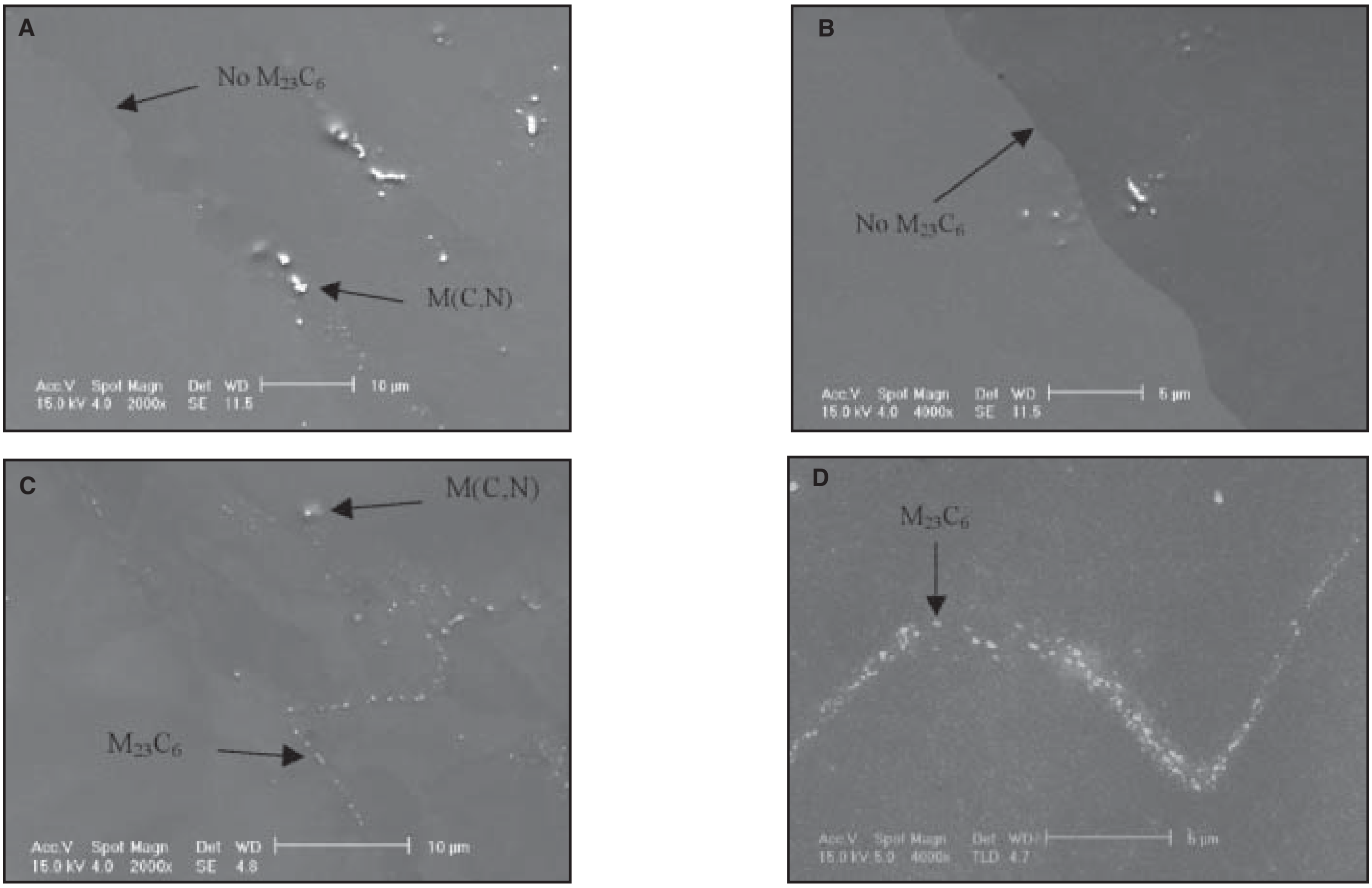

Fig. 4 — Material C sample showing the as-welded (spot weld) microstructure (A and B), and the STF tested (950°C) microstructure (C and D). M(C,N) carbides are visible in the interdendritic regions but no $M_{23}C_6$ carbides were found as welded and only sporadically after STF testing.

ter-controlled stage to form a 1-mm square inside the spot weld. The indentions allowed for the same location to be identified before and after STF testing on the sample in the tilted and polished condition that was required for EBSD — Fig. 1. The spot welds were typically 10 to 11 mm (0.41 to 0.45 in.) in diameter and the four indentions were located 3.5 mm (0.14 in.) from the edge to avoid the elongated columnar grains that formed near the edge of the spot weld and any abnormality that might exist in the center. The sample was then electropolished for 10 s to remove the etching effects, but leaving evidence of the Vickers indents and allowing for location identification for EBSD. Collected EBSD scans were 0.75-mm (0.3-in.) square with a 2-µm step size and centered inside the four microhardness indentions. Following the before-STF EBSD scan, the sample was STF tested, electropolished again for 10 s to remove the thin oxide layer, and then rescanned.

This technique provided information on how the microstructure accommodated the strain during the STF test and gave insight into what effect the starting microstructure had on DDC susceptibility. This technique was successful up to strains of approximately 4%. As the strain exceeded 5%, the amount of surface deformation was sufficient to prevent acquisi-

Table 2 — Results of Microstructural Analysis Compared with JMatPro-Ni v. 7 Thermodynamic Solidification Calculations* for Materials B, C, and H (Ref. 5)

	Material B		Material C		Material H	
	Spot Weld	STF	Spot Weld	STF	Spot Weld	STF
M(C, N)	0.5–2 µm Fig. 3A Predicted*	0.5–2 µm Fig. 3B	0.5–2 µm Fig. 4A Predicted*	0.5–2 µm Fig. 4B	1–5 µm Fig. 5A Predicted*	1–5 µm Fig. 5B
$M_{23}C_6$	Sporadic on GBs <0.5 µm	Consistent on GBs <0.5 µm	None Observed	Inconsistent on GBs <0.5 µm	None Observed	Sporadic on GBs <0.5 µm
Delta	N/A	N/A	N/A	N/A	Possible Predicted*	Possible
Laves	N/A	N/A	N/A	N/A	Possible Predicted*	Possible
Sigma	N/A	N/A	N/A	N/A	Possible Predicted*	Possible

*Note:"Predicted" indicates that the phase was present in the JMatPro calculations. "Possible" indicates that the EDS methods used were not sufficient to differentiate between the different phases.)

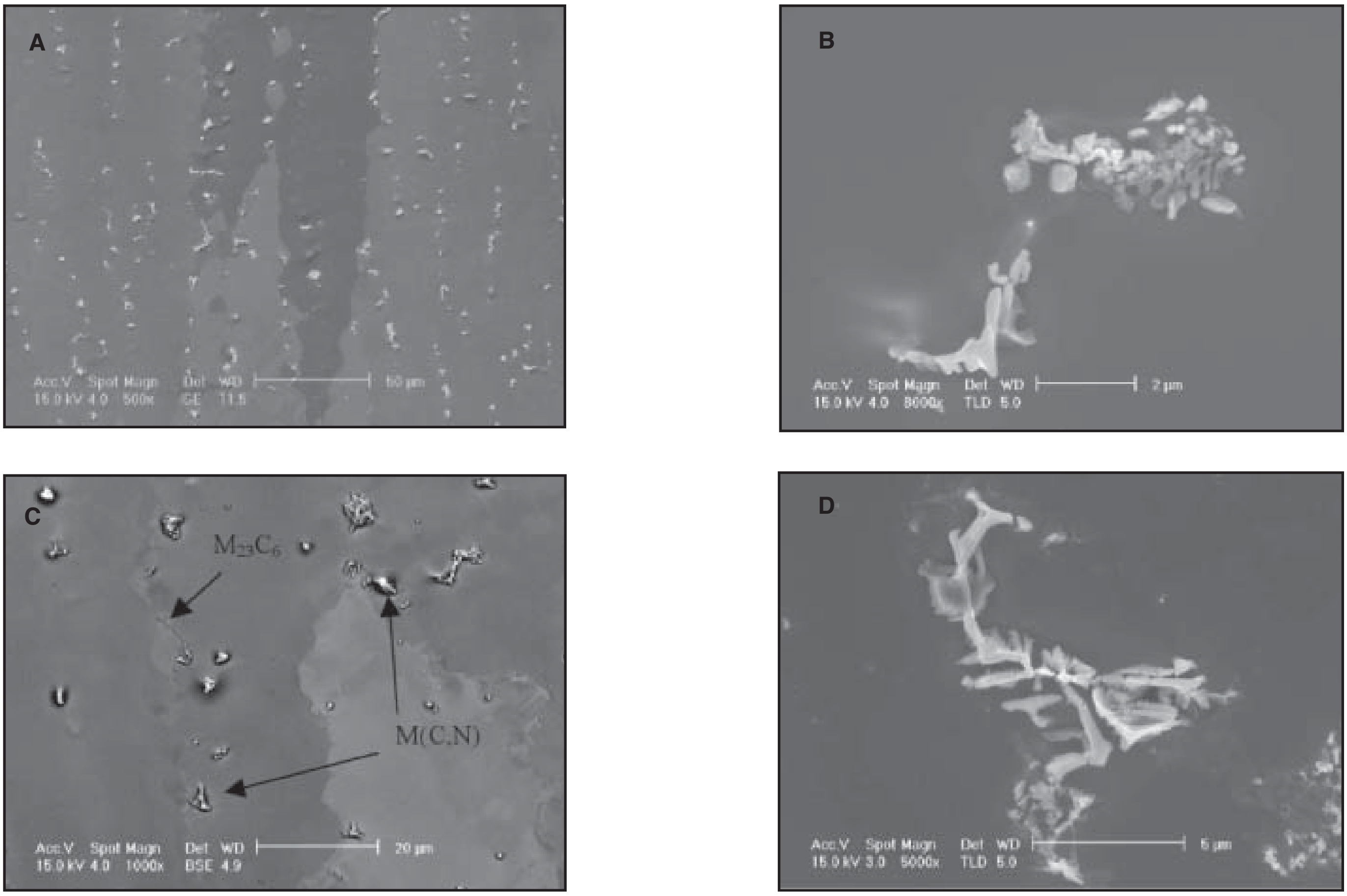

Fig. 5 — Material H sample showing the as-welded (spot weld) microstructure (A and B) and the STF tested (950°C) microstructure (C and D). Large M(C,N) carbides are visible in the interdendritic regions that resulted in wavy or tortuous grain boundaries.

tion of the EBSD diffraction pattern on heavily deformed portions of the sample.

Grain reference orientation deviation (GROD) plots were used to evaluate orientation differences within individual grains. The average orientation within a given grain was calculated and all points within the grain with the same orientation as the average were colored blue (0-deg deviation). As the angular deviation of the points increased from the average orientation, the color transitioned through green, yellow, orange, and red (16-deg deviation). The before and after GROD plots are insightful when evaluating how deformation is accommodated within a material. Additional information on the EBSD and GROD procedure can be found elsewhere (Ref. 5).

Carbide Engineering

JMatPro-Ni v. 7 by Thermotech Ltd. was used for all thermodynamic calculations. The nickel database included the following elements: Ni, Al, Co, Cr, Cu, Fe, Hf, Mn, Mo, Nb, Ru, Re, Si, Ta, Ti, V, W, Zr, B, C, N, and O. Any elements not listed in Table 1 were not used in the calculation except nitrogen, which was assumed to be 0.002 wt-%. Three primary types of calculations were performed: stable and metastable phases, solidification, and phase transformation (CCT/TTT) calculations (Ref. 5).

Sample heat treatment prior to STF testing was conducted with the Gleeble to alter the carbide type, size, distribution, and morphology. Samples were prepared using the same procedures used for STF testing but no mechanical force applied during heating. A solution annealing heat treatment at 1275°C for 1 min was used in conjunction with $M_{23}C_6$ carbide precipitation heat treatments at 700°C for 5 and 3.75 h for materials B and C, respectively. These temperatures and hold times were based upon thermodynamic calculations using JMatPro-Ni v. 7. The precipitation heat treatment temperature was selected to minimize grain growth while keeping the heat treatment times reasonable. Samples were heated to temperature at 100°C/s and afterward were allowed to free cool to room temperature without any external mechanical loading.

Results and Discussion

Based upon the STF results of Part 1 (Ref. 1), materials B, C, and H were selected for further evaluation to provide additional insight into the DDC mechanism. While both materials B and C had similar compositions (with the exception of a small difference in boron content), their DDC resistance varied significantly — Fig. 2. While both alloys cracked at relatively low threshold strains (< 1.5%), the additional strain required to transition to gross cracking varied significantly. Material B transitioned to gross cracking above 5% while material C transitioned around 1.5% strain. Material H was selected due to its high threshold strain (~8%) and general resistance to gross cracking (>14% strain).

Microstructural Analysis

Microstructural analysis was performed before and after STF testing on materials B, C, and H to better understand the effect of the microstructural evolution and carbide morphology on DDC suscep-

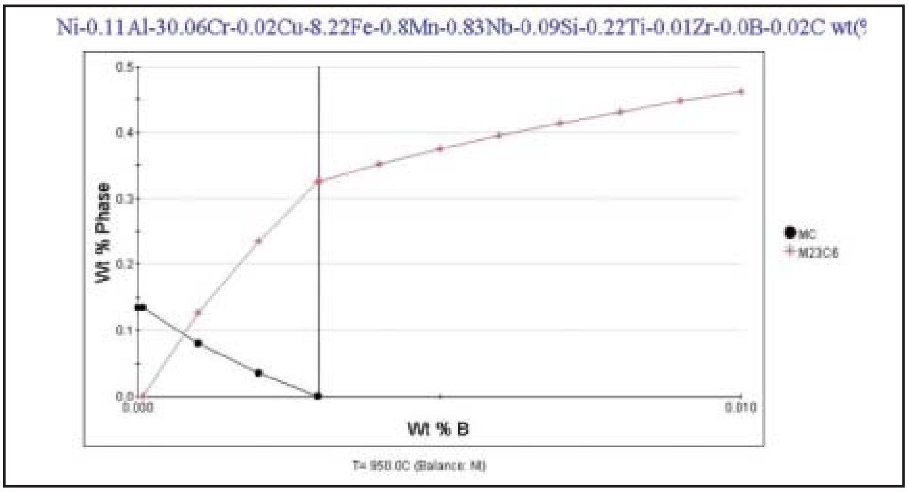

Fig. 6 — Effect of boron content (0 to 0.01 wt-%) on equilibrium carbide stability in material B at 950°C. The nominal boron composition of material B is marked as a vertical line at 0.003 wt-%.

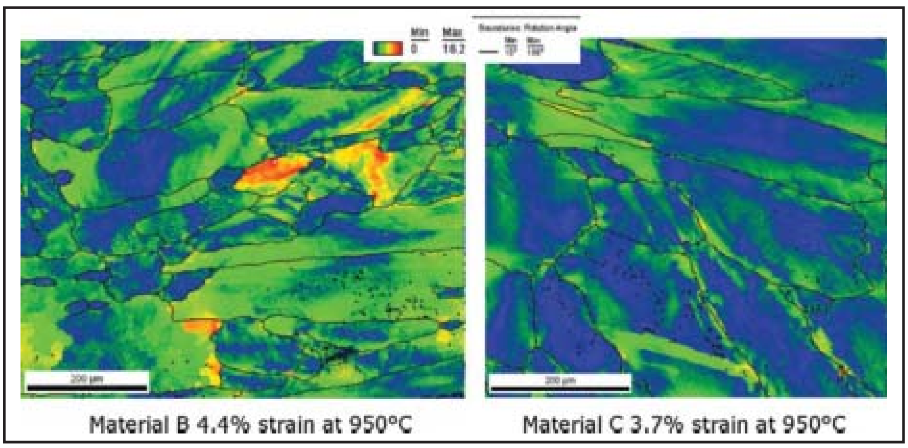

Fig. 7 — Grain reference orientation deviation plot of EBSD scan of materials B and C after STF test at 950°C. Blue indicates point with an orientation close to the average orientation of that particular grain while yellow and red indicate greater crystallographic deviation. The black lines represent high-angle (>10-deg) grain boundaries.

tibility. EDS was used for qualitative chemical analysis of the carbides in these alloys and those results were compared with the analysis of similar alloys completed previously (Ref. 26). The results of the carbide analysis from the microstructural characterization of materials B, C, and H are summarized in Table 2 along with the thermodynamic solidification and equilibrium JMatPro-Ni calculations (Ref. 5).

In the as-welded condition, electron microscopy of materials B and C revealed 0.5 to 1 µm Nb- and Ti-rich M(C,N) intragranular carbides that were sparsely dispersed through the microstructure. These intragranular carbides were not typically observed pinning grain boundaries as their size and distribution were inadequate to have a significant effect on the boundary migration at elevated temperatures — Figs. 3A and 4A. Cr-rich $M_{23}C_6$-type intergranular carbides were observed on the majority of grain boundaries in material B but the grain boundaries in material C were clean and practically free of carbides in the as-welded condition — Figs. 3B and 4B. In material B, the intergranular carbides were <0.5 µm in size and while carbides were observed on the majority of boundaries, the number of carbides varied from boundary to boundary and some of the boundaries remained free of carbides.

The as-welded microstructure of material H contained numerous larger 1- to 5-µm M(C,N) carbides that form along the solidification grain boundaries at the end of solidification and were found to be effective at pinning migrated grain boundaries — Fig. 5B. The morphology of some of the interdendritic carbides were difficult to characterize as the particles had a skeletal structure and were often composed of groups of smaller carbides agglomerated together (Ref. 5). JMatPro-Ni calculations of phase stability in material H included Delta, Laves, and Sigma phases, which were noted on Table 2 as "predicted." As these phases are Ni rich or Cr rich, they were difficult to distinguish from the gamma substrate with EDS and were therefore noted in Table 2 as "possible." Intergranular $M_{23}C_6$ carbides were not observed along the grain boundaries of material H in the as-welded condition.

The microstructures of materials B, C, and H were then evaluated after STF testing at 950°C and approximately 1% strain. In all three materials, the larger intragranular M(C,N) carbides appeared unchanged in either size or distribution — Figs. 3C, 4C, and 5C. In materials B and C there was an increase in the number of chromium-rich $M_{23}C_6$-type carbides observed along grain boundaries after STF testing — Figs. 3D and 4D. Almost all of the boundaries in material B were decorated with the intergranular carbides with some of the carbides displaying a slightly elongated morphology. In material C, the distribution of intergranular carbides was not as consistent as in material B and some boundaries remained free of carbides. In material H, some $M_{23}C_6$ precipitation was observed (Fig. 5C) but these carbides were not as apparent as in materials B and C.

In both materials B and C, a significant number of new carbides precipitated on the grain boundaries when the samples were strained at temperature during STF testing. STF samples that were heated to 950°C, and not strained, precipitated significantly fewer new carbides. This distinction becomes important when evaluating strained samples or real multipass weldments for the presence of intergranular carbides as the carbides may not have been present prior to strain. In material B there were more intergranular carbides before STF testing and are believed to have provided resistance to boundary sliding, contributing to the improved DDC resistance observed in this alloy.

Boron is known to increase the thermodynamic phase stability and precipitation kinetics of $M_{23}C_6$ and boron segregation to grain boundaries likely contributed to the improved stability of $M_{23}C_6$ over MC in material B (Refs. 32, 33). JMatPro-Ni calculations of equilibrium phase stability for the material B composition with different boron levels is shown in Fig. 6 and is consistent with the microstructural observations for materials B and C. By "engineering" the boron- and carbide-forming elements in these alloys, an improvement in DDC resistance appears to be achievable through the controlled precipitation of $M_{23}C_6$ along migrated grain boundaries in the as-welded microstructure. To further investigate this effect, tests to alter the grain boundary carbides were designed using a combination of heat

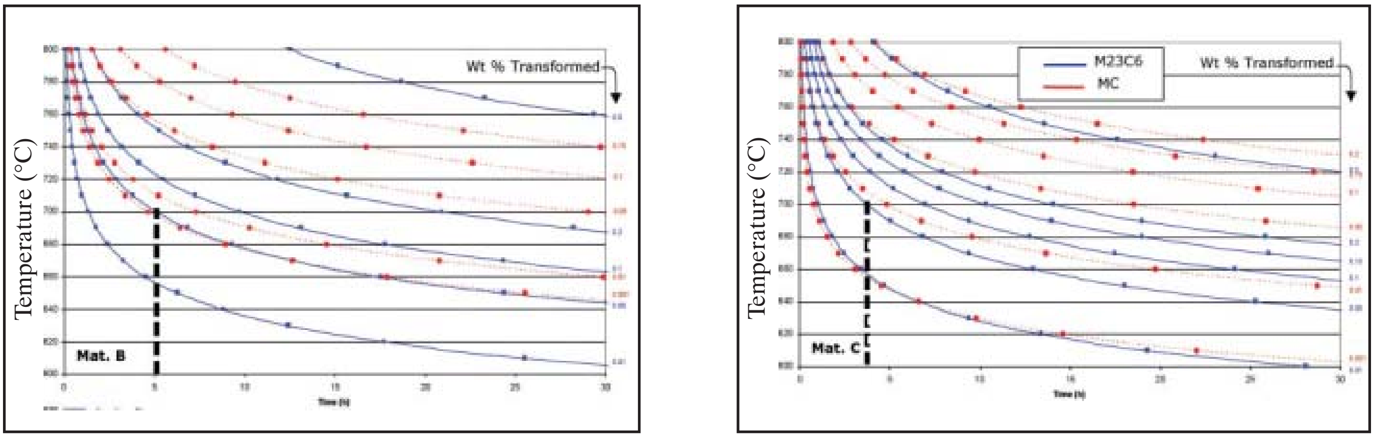

Fig. 8 — Series of overlaid TTT curves for materials B and C showing percent transformed for MC and $M_{23}C_6$ precipitates for different times and temperatures.

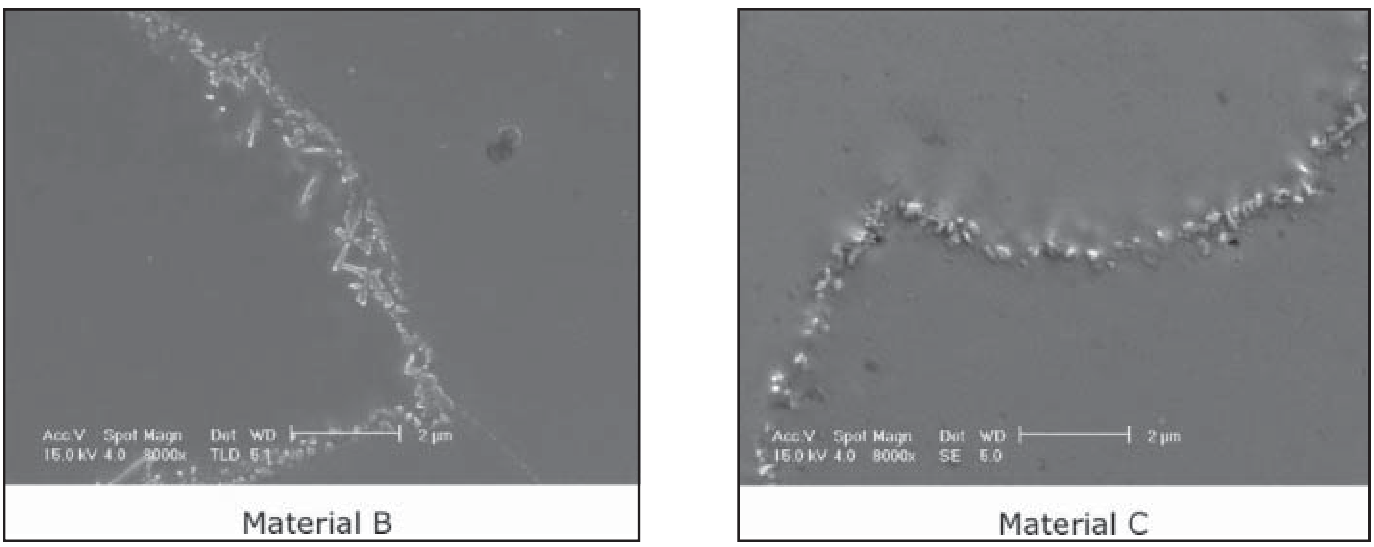

Fig. 9 — $M_{23}C_6$ carbide precipitation in materials B and C after a solutionizing heat treatment (1275°C for 1 min) followed by a precipitation heat treatment (700°C for 5 and 3.75 h, respectively).

treatment and controlled deformation.

Deformation

Carbide Engineering and Microscopic Boundary Pinning

To better understand how strain is accommodated within each material and how it is affected by the starting microstructure, EBSD scans of materials B and C were performed before and after STF testing (Ref. 5). EBSD GROD (grain reference orientation deviation) plots are developed using EBSD orientation data to evaluate the orientation relationship within a given grain. By calculating the average orientation within the grain and assigning a color gradient to graphically show deviations from that average orientation (0 deg blue, 4 deg green, 8 deg yellow, 12 deg orange, 16 deg red), a better understanding of how the grain is accommodating strain was obtained. For example, if an area within a grain of a before-STF plot is blue and the same area of the after-STF plot is yellow, this area has the same relative misorientation and therefore deformed together. However, areas within a grain that were originally all blue, but after deformation now include a transition from blue to yellow, have presumably deformed at the location of the transition. Since most of the as-welded scans were primarily blue with 10–25% green (Ref. 5), misorientation transitions from blue to yellow or green to yellow in the after-STF scans can be assumed to be the result of deformation at the color transitions. It is important to remember that since the average orientation is recalculated for each grain (outlined with black lines that define >10-deg point-to-point misorientation), care should be taken when interpreting data between grains.

EBSD GROD plots in Fig. 7 were strained to 4% (±0.5%) and demonstrate the generally observed trend in materials B and C that more misorientation transitions (i.e., blue to yellow) are located near grain boundaries in material C indicating more intergranular deformation while the transitions tended to occur more within the grains in material B indicating more intragranular deformation. There are still considerable deformation gradients within individual grains of B, but they are not as localized around grain boundaries or triple points as was found in C. Additional examples of strain effects using this technique are available elsewhere (Ref. 5).

Since grain boundary $M_{23}C_6$ carbides precipitated during STF testing for both materials B and C, the difference in deformation location appears to be controlled by the $M_{23}C_6$ carbides in material B that form in the as-welded condition (before testing). The presence of these carbides is believed to cause microscopic pinning of the grain boundaries, which thereby limits grain boundary sliding and promotes intragranular deformation.

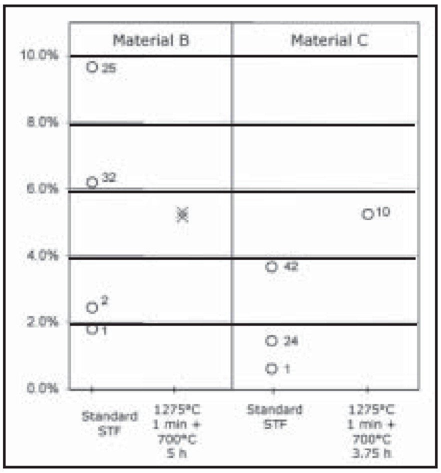

Fig. 10 — STF results for materials B and C (12.7-s downslope) heat treated at several different conditions and compared with standard STF samples (results from Fig. 2). An "x" represents a tested sample with no DDC cracking and "o" a sample with DDC cracking. The number next to the circle is the number of DDC cracks found. The two blue "x" points in material B indicate samples that dynamically recrystallized during STF testing.

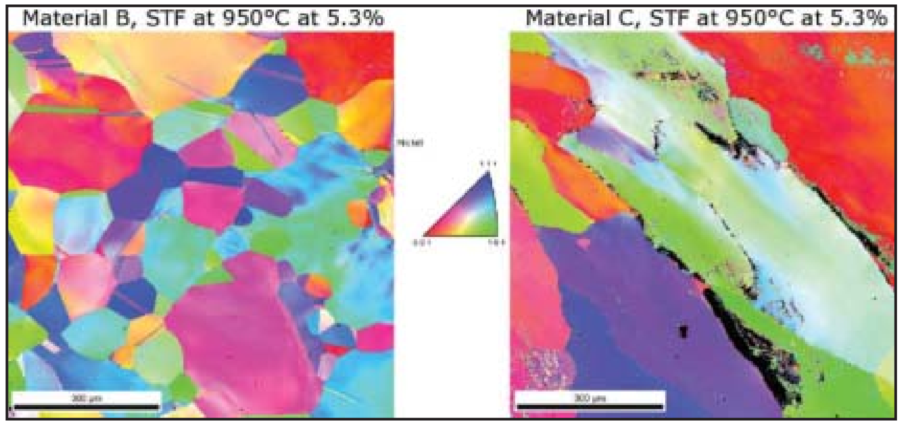

Fig. 11 — Inverse pole figure plots of EBSD data showing samples of materials B and C that had been (precipitation) heat treated and STF tested at 950°C. The recrystallized microstructure in material B had smaller grains and three (60-deg) twin boundaries throughout the structure.

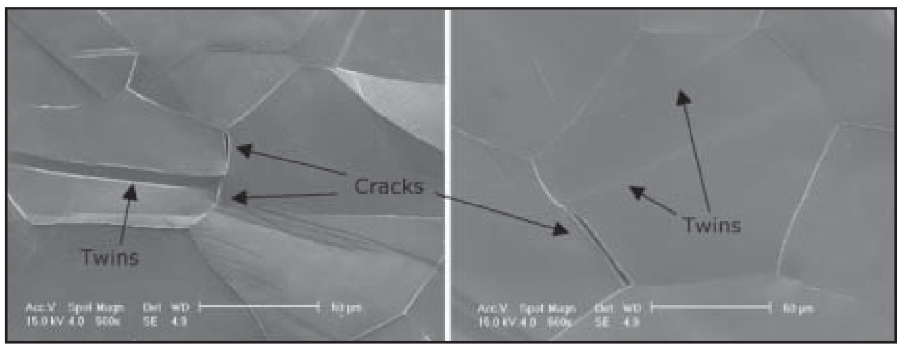

Fig. 12 — SEM image of the surface of an as-tested, dynamically recrystallized material B sample tested at 950°C and 5.3% strain where small cracks formed along the grain boundary between a triple point and a twin boundary.

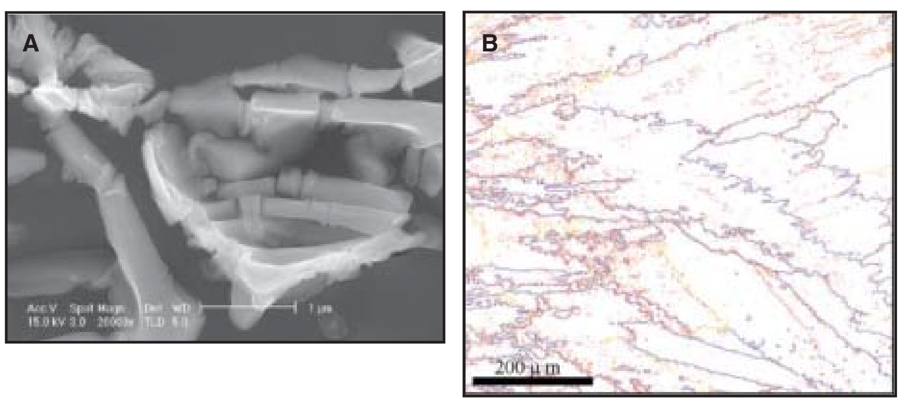

Fig. 13 — SEM image of a skeletal carbide (A) found in material H and a grain boundary map from EBSD data showing the tortuous boundaries that result (B). The 2- to 15-deg boundaries are displayed red, 15- to 55-deg and 65- to 180-deg boundaries are blue, and 55- to 65-deg boundaries are yellow.

To better understand this microscopic pinning effect by grain boundary carbides, several heat treatments were devised to alter the carbide size and distribution. Samples were tested with combinations of solutionizing and precipitation heat treatments based upon JMatPro-Ni calculations (Ref. 5). Samples of materials B and C in the as-welded condition where solution heat treated in a protective argon environment at 1275°C for 1 min to dissolve most of the carbides and then allowed to free cool (approximately 30°C/s to 1000°C and 20°C/s from 1000° to 800°C) to room temperature. The peak temperature of 1275°C was selected as it was approximately 50°C below the melting temperature of both materials B and C. Based upon several trials, a hold time of 1 min maximized the amount of MC-type carbides that dissolved without significantly affecting the grain structure. Following this heat treatment, both materials were found to have a few small (<1 μm) MN-type precipitates remaining. Consistent with the as-welded microstructures, sporadic $M_{23}C_6$ carbides formed during cooling along grain boundaries in material B but not in material C.

Following the initial solution heat treatment, samples of materials B and C were given subsequent precipitation heat treatments at 700°C for times of 5 and 3.75 h, respectively, to precipitate approximately 0.05 wt-% $M_{23}C_6$ based upon JMatPro-Ni TTT calculations shown in Fig. 8. Following the precipitation heat treatment, $M_{23}C_6$ carbides were found along grain boundaries (Fig. 9) with a greater density than observed in the standard as-welded samples — Figs. 3B and 4B. However, some of the boundaries remained relatively carbide free (<10% in material B and ~50% in material C) even after the heat treatment. The carbides in material B were generally elongated while those in material C were more symmetrical.

Subsequent STF testing of the heat-treated samples resulted in an increase in the cracking resistance of both materials B and C — Fig. 10. The STF results of material C in the precipitation heat-treated condition are similar to material B in the standard as-welded STF condition. The similarity between the grain boundary carbide distributions of these two microstructures before STF testing is in good agreement with the STF results and the microscopic boundary sliding mechanism. However, it is unclear to what extent this mechanism could be used in welds as the grain boundary carbides in these alloys become thermodynamically unstable above approximately 1100°C (Ref. 5). The kinetics of formation, therefore, becomes important in multipass welds where thermal cycles are relatively short and time to re-form these carbides is limited.

As discussed earlier, boron plays a key role in the kinetics of dissolution and formation of the $M_{23}C_6$ boundary carbides and was found to have an effect on the DDC susceptibility in the alloys studied in this work (Ref. 1). In the materials evaluated in Part 1, increases in boron lead to an increase in the transition to gross cracking and based on the microstructure analysis of material B and C is related to the accelerated formation of intergranular $M_{23}C_6$. However, the effect that bulk composition has on the formation of different types, sizes, and morphologies of carbides and their subsequent effects on DDC in these alloys is complex and care should be taken to avoid an overly simplistic view of the boron effect. Additional work is required to further investigate the effect of boron and its interaction with other elements in these and other alloy systems (Ref. 5).

Recrystallization

The decrease in the number of cracks in the precipitation heat-treated material B samples was also accompanied by recrystallization in the spot weld during STF testing at 950°C and approximately 5% strain — Fig. 11. The recrystallization is believed to have resulted from particle-stimulated nucleation (PSN) as a result of the distribution of the elongated $M_{23}C_6$ carbides along the boundaries. To date, no other FM-52M-like alloys have recrystallized during STF testing at 950°C and while PSN is typically observed with larger precipitates (>1 µm) (Refs. 34, 35), the manner in which the $M_{23}C_6$ carbides clustered (Fig. 9) together may have reduced the critical particle size for PSN to occur (Refs. 34, 35). While no cracks were found after STF testing using the standard optical approach at 30× magnification and therefore reported as no cracking in Fig. 10, several small cracks (<50 µm) were observed along grain boundaries in the SEM — Fig. 12. When the material dynamically recrystallized, some of the new grain boundaries that formed would have been carbide free and therefore more susceptible to DDC. Any subsequent strain would lead to a DDC response similar to material C, which was relatively free of intergranular carbides in the as-welded condition. However, the resulting recrystallized microstructure formed Σ3 twin boundaries that were found to blunt subsequent DDC crack propagation — Fig. 12. This observation of crack blunting by twin boundaries is consistent with previous results (Refs. 29, 36).

Macroscopic Boundary Pinning

STF testing of material H revealed a significant resistance to DDC without the presence of $M_{23}C_6$ precipitates on grain boundaries — Fig. 2. This high resistance to DDC was attributed to the larger 1 to 5 µm skeletal carbides located throughout the microstructure. The dense distribution and large surface area of these carbides were highly effective at pinning boundaries, resulting in extremely irregular or "tortuous" boundaries — Fig. 13. This macroscopic boundary pinning has been reported previously in FM-82 alloys, although to a lesser extent (Refs. 11, 24) and acts to mechanically lock the boundaries and improves the DDC resistance by promoting intragranular deformation rather than grain boundary sliding. The macroscopic boundary locking in material H has been the most effective method for improving the DDC resistance in these FM-52M-like alloys.

Summary

The results of this work have led to the following observations regarding the effect of microstructure on DDC. Macroscopic grain boundary locking occurs when interdendritic carbides are effective at pinning grain boundaries during solidification and the resulting tortuous boundaries improve resistance by mechanical locking boundaries, resisting grain boundary sliding and subsequent DDC cracking. When strain is applied to these interlocked grains, boundary sliding becomes much more difficult due to the various boundary geometries (Fig. 13B), resulting in an increase in intragranular deformation. The effectiveness of these carbides decreases as their size, surface area, and density decrease. It should be noted that this mechanism does not improve the actual boundary strength but increases the strain required for cracking at grain boundaries (Refs. 28, 37). To date, the compositional modifications to Filler Metal 52 in material H (2.5% Nb and 4% Mo) and the resulting macroscopic grain boundary locking have been the most effective method for improving the DDC resistance in these FM-52M-type alloys.

Samples with grain boundary $M_{23}C_6$ carbides that formed before STF testing were more resistant to cracking when compared to samples that were free of grain boundary carbides. This appears to be due to microscopic grain boundary locking where the presence of carbides along the boundary increases the resistance to grain boundary sliding, leading to increased intragranular deformation. Even a moderate number of these carbides in the as-welded condition appears to increase the cracking resistance and may be sufficient in some applications where overall weld restraint is low. Since these intergranular carbides form in the solid state and often appear only after straining at temperature, their presence in a cracked sample may not indicate they formed before cracking or were beneficial in any way. The effectiveness of this mechanism is largely dependant upon the carbide dissolution and precipitation kinetics. Boron appears to be effective in this regard by increasing the stability of the carbides and may also contribute to the observed elongated morphology that was observed in material B. While not as effective as the macroscopic boundary locking mechanism, alloy optimization through this mechanism may be useful in applications where heat-to-heat composition variations produce inconsistent DDC results and even a small increase in DDC resistance (1–2% strain) may be sufficient to avoid cracking.

Certain carbide distribution and morphologies could lead to recrystallization by PSN (Refs. 34, 35, 38) resulting in a smaller grain size, dislocation annihilation, and Σ 3 twin boundaries; all of these increase the resistance to cracking. Even if complete recrystallization does not occur, partial recrystallization (the formation of some new grains along previous grain boundaries) would effectively break up the continuous crack path and improve resistance by eliminating long and straight boundaries. The effectiveness of these observations appears to be directly related to the quantity and morphology of the intergranular carbides. It has been proposed that the onset of ductility recovery at the higher temperature range of the ductility-dip temperature range is the result of recrystallization (Refs. 6, 9–11, 39). These PSN recrystallization results are consistent with the increased DDC resistance in those observations, that is, recrystallization results in an increase in ductility. However, in the case of PSN in Alloy B, recrystallization will only occur one time as the precipitates along the grain boundary that are required for PSN, only formed with an extended heat treatment. Further work is required to determine if the PSN mechanism may be reduced to practice as no filler metal compositions tested to date have produced the required grain boundary carbides in the as-welded condition.

The increase in the DDC resistance observed in material B appears to be related to the precipitation of $M_{23}C_6$ carbides in the as-welded condition — Fig. 3B. There is no evidence of a deleterious effect that may be caused by the subsequent precipitation of intergranular carbides that precipitate during straining — Fig. 3D. As such, the results of this work support a mechanism for DDC in these alloys that is associated with grain boundary sliding and the ability of intergranular $M_{23}C_6$ carbides to resist sliding, as opposed to the precipitation-induced cracking mechanism proposed by Young et al. (Ref. 8).

Conclusions

The results of this work have led to the following conclusions regarding the mechanisms that affect susceptibility to ductility dip cracking (DDC) in high-chromium Ni-based alloys.

1. Microscopic grain boundary pinning by intergranular carbides improved DDC resistance in the STF test when the carbides are present along migrated grain boundaries in the weld metal prior to the application of the strain.

2. Macroscopic grain boundary pinning by MC carbides that form at the end of solidification was found to prevent the migration of grain boundaries and resulted in tortuous boundaries that significantly improve resistance to DDC.

3. Precipitate engineering via heat treatment resulted in dynamic recrystallization by PSN and Σ3 twin boundary formation that improve the resistance to DDC.

4. DDC is an elevated-temperature grain boundary sliding mechanism. Such sliding can be opposed macroscopically by the formation of tortuous grain boundaries via a grain boundary pinning mechanism. Grain boundary sliding can also be reduced by the formation of grain boundary carbides in the solid state through appropriate alloying or by heat treatment.

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