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AWS can help you career with a variety of resources and opportunities unparalleled in the industry. AWS will help you do your job better - more quickly, more accurately and with the latest industry information available anywhere. AWS Members receive key benefits that help them in today's competitive market. Some of the benefits include discounts on welding equipment/tools of the trade, subscription to the award-winning Welding Journal, up to 90% off an AWS technical publication when you join, a 25% Discount on AWS Publications, discounts on AWS Conferences, AWS Certification and AWS Education programs, networking opportunities, access to the Members’-only Web Site, access to a health insurance program, discounts on auto & home insurance and more.

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Become part of a world-renowned organization. AWS provides students with a variety of resources and opportunities unparalleled in the industry. AWS knows that students are the future of the industry. For this reason, we offer a deeply-discounted Student Membership. Student Memberships start at just $15 a year.

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Join More Than 2,000 Companies and Educational Institutions. Become part of the Society committed to helping your organization grow. AWS offers Corporate Memberships for companies small or large, as well as Educational Institutions. AWS will provide your business or school with the tools you need to make an impact in the industry. Show your customers your commitment to excellence, and stand out from the competition by becoming an AWS Corporate Member. An AWS Member Specialist can help you determine which of the five different AWS Corporate Memberships fit your organization best.

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Lincoln Electric Awarded $1 Million to Install Wind Turbine

Ohio Governor Ted Strickland recently announced 25 Ohio solar and wind projects will receive more than $13 million in grants funded through the American Recovery and Reinvestment Act’s State Energy Program. This news was publicized on Nov. 29 at Lincoln Electric’s Automation Center of Excellence, Cleveland, Ohio.

Included among these projects are Lincoln Electric’s wind turbine installation. The company will install a 2.5-megawatt turbine that will generate approximately 10% of the electrical needs for the company’s Cleveland manufacturing operations.

“We are excited to have this opportunity under Ohio’s energy program to demonstrate the value of wind energy by investing in our own installation,” said Lincoln’s Chairman and CEO John Stropki. “This project is a continuation of other Lincoln environmental, health, and safety (EHS) programs and green initiatives currently underway in our manufacturing operations to improve our costs and protect our environment. Not only will the wind project provide long-term benefits by reducing our energy costs, it will also showcase the unique benefits that Lincoln products and welding solutions provide to wind tower manufacturers to improve their quality and lower their costs.”

Thermal Spray Groups Team Up to Promote the Technology to Industry

The International Thermal Spray Association (ITSA), Fairport Harbor, Ohio, and the ASM Thermal Spray Society (TSS), Materials Park, Ohio, have started a cooperative effort to promote the adoption of thermal spray technology throughout industry.

“Right now, the turbine market stands alone in the depth and breadth of thermal spray applications, yet the technology has the potential to provide similar advantages to many other industries that have yet to effectively explore its potential,” said ITSA President Daniel C. Hayden, president of Hayden Corp. and managing partner of Hayden Laser Services, LLC.

While showing continuous growth in turbine technology and other main market segments, these organizations recognize there are additional opportunities for expanding thermal spray usage within existing industrial markets and through global expansion.

“Thermal spray has significant potential for the oil and gas industry and chemical applications, and we are seeing increased global usage particularly in Asia. Together, our two organizations are better positioned to identify these opportunities and encourage thermal spray use,” said TSS President Mitch Dorfman, Sulzer Metco (U.S.) Inc.

Also, discussions between the ITSA and TSS executive management teams have led to an agreement in principle to explore other opportunities for both organizations. Regular meetings are under way for looking at how they can support each other in event planning and outreach to designers to grow new markets and applications.

Hypertherm Named Best Large Company to Work for in New Hampshire

Hypertherm, Hanover, N.H., a designer and manufacturer of advanced plasma cutting systems for use in various industries, has been selected by Business New Hampshire Magazine as the Best Large Company to Work for in New Hampshire. Judges cited Hypertherm’s respect for its associates, no layoff policy, and creative strategies the company is taking to keep everyone employed. Rather than cutting back, Hypertherm has continued to offer its channel partners a high level of support through the current economic downturn.
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AWS Energizes the World

Education is the foundation of our lives, beginning with learning to crawl, then progressing to taking our first steps. As with crawling and walking, some of the basics come naturally and some require the guidance of a teacher or mentor. We are fortunate to have an education system that teaches us to read, write, and equate. These skills are basic, the start of our formal education. To advance in life, and eventually decide on a career, further education is needed regardless of which path we choose. The American Welding Society can help us advance our education in welding through many programs. Scholarships and fellowships are available to students attending technical schools or universities working to advance their knowledge of welding. Local Sections offer student and career nights as a form of mentoring and motivating, and many offer their own scholarships.

Career choices are as varied as we are as individuals. What is your interest? To have a successful career, do something that you like. Learn the skills required for you to grow in ability and responsibility. If your interest is in welding, our industry covers a broad spectrum of employment options; the choices are almost endless. The American Welding Society offers training seminars and examinations for certification in education, inspection, sales, radiographic interpretation, fabrication, and supervision, and is continually developing new programs. Enrich your career by becoming a certified professional.

All areas of commerce need your help. Utility, manufacturing, medical, government, infrastructure, transportation, marine equipment, and vessel building, and my personal favorite, the oil and gas industry, need welders and certified welding professionals. If you are seeking a solid career with future growth and opportunity, look at the American Welding Society online (www.aws.org/jobfind) for employer advertisements. Many times I have heard the terms “building block” or “stepping stone” used to define the opportunities in welding. Your career growth can be constant and the only limitation is your imagination.

As you become successful in your career become a volunteer. Do you know that the American Welding Society’s standards, certifications, and many other publications are developed, written, and maintained by volunteers? So many unheralded men and women give their precious time to support these activities. Check out the index of AWS D1.1, Structural Welding Code — Steel, and look at the list of volunteers who involved. These volunteers started their career the same way in which you began or will begin yours, with an education.

Internationally the American Welding Society continues to grow with 10,434 out of 60,050 (17.4%) of our members living in Europe, Asia, Africa, South America, Australia, and other countries of the world. Of our 31,078 Certified Welding Inspectors, 9,561 (30%) are international. Translation of our publications and standards continues. The Welding Journal en Español and the material we supply to the Indian Welding Journal are just the beginning of our international publications. The annual American Welding Society Weldmex Show will be held this year in Mexico City. In addition, several AWS staff members and current and past AWS Board members serve on the board or as committee chairs for the International Institute of Welding.

The American Welding Society is growing in both membership and in international recognition. It is the premier welding-related association in the world. As countries emerge in commerce and quality of life, they seek to improve the education of their people and quality of their products. More and more see the value of the products and services that you as members of the American Welding Society have developed. AWS is indeed energizing the world.

John C. Bruskotter
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United Spiral Pipe Dedicates New Facility

United Spiral Pipe LLC, a joint venture of United States Steel Corp., POSCO, and SeAH Steel Corp., dedicated its new spiral welded pipe manufacturing facility in Pittsburg, Calif. It is expected to provide about 120 full-time manufacturing jobs.

The facility features pipe making and coating capabilities that will produce, at its peak, 300,000 net tons of line pipe per year to meet the anticipated demand in North America for spiral welded pipe due to natural gas and oil transmission projects. Also, it will produce pipe with outside diameters ranging from 24 to 64 in. and implement an automated two-step welding process.

Customer representatives, project contractors, and elected officials marked the occasion and heard remarks by Nancy Parent, the City of Pittsburg’s mayor; B. W. Koo, Korean consul general; John P. Surma, U. S. Steel's chairman and CEO; J. Y. Chung, POSCO’s chairman and CEO; W. H. Lee, SeAH’s chairman and CEO; and M. S. Lee, United Spiral Pipe’s president.

Community Colleges Offer Midnight Classes to Help Meet Welding Needs

With no more room in the welding lab at Community College of Allegheny County’s (CCAC) West Hills center in Oakdale, Pa., administrators took the next step — adding time. The result is a welding study course throughout the spring semester from 11 p.m. to 3 a.m., Monday to Thursday.

“With welding in such high demand in southwestern Pennsylvania, and limited lab space at our facilities, expanding to the midnight welding course only made sense,” said John Ginther, welding instructor and head of CCAC’s welding program. “It also provides an alternative for students who might prefer the late-night classes to traditional classroom hours. They may have jobs, may have trouble finding daytime child care, or may simply be night owls. And since many welders will eventually work the night shift, the timing of the course is also good preparation for their future careers.”

This midnight welding course incorporates the same curriculum as CCAC’s other welding certificate courses. It comprises...
A spring welding course at the Community College of Allegheny County (CCAC) will be held in the late night/early morning hours. As shown above, instructor John Ginther (right), head of the college’s welding program, teaches students. (Photo courtesy of CCAC.)

six separate classes from Jan. 25 to June 21, including welding fundamentals, advanced welding, blueprint reading for welders, prep for welding certification, gas metal arc and gas tungsten arc welding processes, plus brazing. Also, CCAC will offer a workforce fast-track welding class in the summer at more traditional hours. The college’s Web site is at www.ccac.edu.

“We’ve had such a positive response to it,” Ginther added, and he anticipates the 16 spots, ensuring each student will have their own station to learn at, will be filled up soon. “Our goal is to get people back to work.”

In a similar move, midnight welding classes started at Clackamas Community College (CCC) in Oregon as an experiment last spring. It added late night classes two nights a week because the welding shop was at capacity during daytime.

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“Instead of turning people away, we opened up new sections late at night because we thought it might work for some people, and it has,” said CCC welding instructor John Phelps.

The classes have been so well received the college has expanded offerings during the 10 p.m. to 2 a.m. slot from two nights a week to four. Students can choose from five midnight welding classes, ranging from introductory courses to special projects. According to Phelps, these students include people who are changing careers as well as those trying to increase their skills.

For more information, contact Public Information Officer Janet Paulson at jpaulson@clackamas.edu.

Central Piedmont Community College Receives Congressional Awards

Central Piedmont Community College (CPCC), Charlotte, N.C., will receive $525,000 in funding from the federal government to help establish the Carolina’s Energy Training Center (CETC). This center will include training and lab facilities that will train today’s workforce to meet the needs of the Charlotte region’s energy economy during the 2010 fiscal year. Also, the funding will help CPCC purchase lab equipment and develop training programs creating career pathways for high school graduates and displaced workers seeking careers in the energy sector including conventional and alternative fields.

Some of the initiatives that make up or will comprise the CETC include a certified American Welding Society (AWS) test center; welding AAS degree, diploma, and short term certificates; pathways to employment program in welding to reach out to under-utilized populations; 6-month certified welder short program in pipe and plate welding; developing certificates in nondestructive examination (NDE) associate program; and short-term NDE certificates. Additionally, stainless steel pipe/plate welding programs, a fast-track diploma program for nuclear NDE technicians, and orbital welding operations and maintenance are in development.

North Carolina Congressional members, including Representatives Mel Watt and Larry Kissell, plus Senator Kay Hagen, played a critical role in securing these appropriations.
U.S. Navy Commissions Northrop Grumman-Built USS New York

USS New York (LPD 21) sails past the Statue of Liberty as it arrives in New York City for commissioning. (Photo courtesy of the U.S. Navy.)

The Northrop Grumman-built amphibious transport dock ship USS New York (LPD 21) has been commissioned at a U.S. Navy ceremony in New York City. Its bow stem contains 7.5 tons of steel recovered from the World Trade Center. The ship is named in honor of the victims and heroes of the 9/11 terrorist attack.

Industry Notes

- Volkswagen recently accepted applications online for about 1200 production jobs including welding, body, paint shop, and assembly positions at its new plant in Chattanooga, Tenn.
- Timberland PRO launched a new program, “Stay On Your Feet,” and Web site, www.stayonyourfeet.com, where visitors can learn about its Endurance workbook, search for sector-specific jobs, and tell their story for a chance to win these boots.
- Plasker, Clawson, Mich., a manufacturer of air-filtration products, has a preferred supplier agreement with Mazak Optonics, Elgin, Ill., a specialist in CO2 laser cutting processes.
- Dynamic Materials Corp., Boulder, Colo., acquired 100% stock in LRI Oil Tools Inc., Alberta, Canada, and intends to make an extra contribution of about $2.2 million into this business.
- Mandina's Inspection Services, Inc., has unveiled Mandina-NDT.com, a site to train inspection personnel in methods such as ultrasonic, magnetic, penetrant, and phased array testing.
- Arc Welders, Inc., Ashland, Va., donated $10,000 to the Eastern Shore Community College Foundation. It will be distributed in $500 scholarships per year to a student displaying standards of excellence in the college's electronics program.
- Airgas, Inc., Radnor, Pa., acquired Fitch Industrial & Welding Supply with locations in Oklahoma and Wichita Falls, Tex., plus the assets and operations of Tri-Tech featuring locations in Florida, Georgia, and South Carolina.
- LA-CO Industries, Delaware, acquired the majority ownership of Intrama S.A.S., Blyes, France, an industrial marking products manufacturer and distributor.

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For info go to www.aws.org/ad-index
Dry Underwater Welding Technology Dives to New Depths

Neptune Marine Services Ltd., Perth, Australia, recently announced its patented NEPSYS® dry underwater welding technology has been qualified to -70 m of seawater (msw) during research and development testing at the National Hyperbaric Centre in Aberdeen, Scotland. With the system, portable, custom-designed welding habitats are secured to the weld area to create a fully enclosed and controlled environment that isolates the weld zone. Proper welding conditions are created and maintained within the habitat via the continuous delivery of heated inert gas that prevents quenching and provides even thermal distribution.

The qualification was achieved on two welds the company completed to specifications related to potential client requirements and conventional applications. Lloyds Register independently witnessed and passed the welds following nondestructive examination and mechanical testing to the Class A requirements of AWS D3.6M:1999, Specification for Underwater Welding. The NEPSYS R&D test program also resulted in the achievement of subsea base metal preheat to 150°C and postweld dehydrogenation, processes that can be critical in achieving optimal metallurgy in certain materials.

“This most recent development to -70 msw, along with our qualification earlier this year for the North Sea project that we are currently involved with, will provide much greater scope for the technology to be applied to oil and gas infrastructure situated in areas of deeper water including the Gulf of Mexico, North Sea, South America (Brazil), and Middle East,” said Christian Lange, Neptune’s managing director and CEO.

RathGibson Tubing Installed in Turkey Geothermal Power Plant

RathGibson recently supplied tubing for installation in Turkey’s first private geothermal power plant, Salavalti Dora – 1. The welded tubing was installed in the plant’s geothermal wells and heat exchangers.

RathGibson manufactures welded, welded and drawn, and seamless stainless steel, nickel, and titanium tubing.

Heat exchangers containing the tubing were supplied to the plant’s private developer, Menderes Geothermal Elektrik Uretim, A.S. For the 800-m-deep geothermal wells, RathGibson supplied 316L stainless steel welded coiled tubing through the mechanical engineering firm, Sinerji Mekanik, who assisted in the wells’ design. The welded coils will be used to inject dosage inhibitor chemicals in the wells.

ACD Opens Gases Service Center in India

Shown at the ACD-India grand opening ceremony in Vadodara are (from left) Jim Estes, managing director, ACD; Arun Kumar, director, CDS; Bala Krishnan, head — turbomachinery, ACD-India; H. P. Shashishekhar, managing director, Rhine Engineering; and Nikhil Patel, senior manager, Rhine Engineering.

ACD, Santa Ana, Calif., recently opened its newest service center in Vadodara, Gujarat, India. The location was chosen to accommodate the company’s industrial gas customers throughout India.

ACD-India’s facility is located on 17 acres and houses up-to-date repair equipment and spare parts inventories for the complete line of ACD cryogenic pumps and turboexpanders.

ACD designs and manufactures cryogenic centrifugal and reciprocating pumps and turboexpanders for the air-separation, industrial gas distribution, alternate fuels, and petrochemical markets. It includes 14 sales offices and service and repair facilities throughout the world.
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The iconic styling of the “Satellite” is the inspiration behind our new Optrel e600 Auto-darkening Welding Helmet line. With a continuous spherical design and no flat surfaces for hot spatter and slag to rest, the Optrel e600 is one of the only welding helmet designs recommended for overhead welding. We’ve combined this proven helmet design with years of research and feedback to create a new generation of superior products for the expert welder.

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For more information, call 1-800-682-0839 or visit www.optrel.com www.sperianprotection.com
A long-time AWS member, who has been in the engineering and manufacturing field for more than 30 years, comments on the economy.

There are only two forms of our economy that generate real dollars. They are as follows:

1. **Agriculture** (farming). The creation of a commodity through natural resources, to be purchased in real dollars or bartered, which propagates human existence.

2. **Manufactured goods**. The creation of material goods necessary to our existence and survival. This is accomplished by taking natural resources and adding labor (the “man” of manufacture) to create, if you will, an instrument or tool to enhance our existence that in turn can be purchased in real dollars or bartered.

In both cases we are taking natural resources and changing them into tangible goods by the application of labor. No other form of our economy is capable of doing this. Therefore, all other forms of our economy are nonproductive in the true sense of the word. They are services.

Because a service economy is nonproductive, it must rely on a truly productive economy for the valued real dollars to survive. Without these real dollars, the service economy can only support itself falsely for a short period of time before financial collapse occurs.

What do we see? We see a nation and many states with a depressed manufacturing base, companies lost in these locales by financial failure or relocation. We see many towns in much the same condition, financially depressed and near failure. We see staggering federal, state, and town deficits. We have seen the service sector of our economy, which we were led to believe was our saving grace, now facing failure upon failure.

We are seeing unprecedented unemployment in the manufacturing sectors increasing. We are seeing rapidly growing unemployment in the “infallible” service sector.

It is time for us, our elected officials, and select economic advisors to wake up to the fact that our mere existence and prosperous survival depends solely on a manufacturing-based economy by which all other economies can survive.

Without manufacturing, our services fail and our towns and states will continue to be in a deficit condition and ultimately fail.

Raising taxes on either the town, state, or federal level is not the long-term solution. Raising taxes on an already struggling manufacturing base is not the solution. Creating new or reviving existing revenue streams through a manufacturing-based economy is the solution. Generating new real-dollar revenue streams is the solution.

Thirty years ago, the scale of economy was in a reasonably balanced state. This was a period during which we had a much stronger and diversified manufacturing base. Take a college education for example — a young person could work at a manufacturing plant for a summer job and be able to save enough money to pay for nearly a full year’s education at a state college as a day student. Today that is not even remotely possible.

Contrary to what we have been led to believe, a general studies bachelor of arts college degree is not the solution to our economic prosperity and growth. It is not the magic bullet to solve all of our financial woes at home or to ensure the prosperity of our towns, states, and federal governments. Why? Because the majority of those college educations serve the service sector.

Not everyone is college material and as seen in today’s economic climate, a college education is not what is separating those with or without jobs. Success and financial security come from perseverance, plain old hard work, and practicing financial responsibility. This statement is not intended to diminish the importance of continued education. However, it is emphasized that a continued education is indeed critical. Whether it’s in the trades or a college education in the sciences, it can be applied to propel our prosperity forward, and that is paramount.

What we need to do is to start thinking about how can we reengineer a “real dollars” economic base. How can we ensure that our future economic stability is controlled with sound financial responsibility? We need to provide a vehicle of solid and fairly distributed economic growth, a manufacturing-based economy that expands prosperity with real dollars. When the economy begins to rebound, where are these people going to find jobs? We need to rethink our future education goals.

History shows that the time-proven manufacturing-based economy provided a great deal of distributed wealth and prosperity to the American people.

Lee A. Warncke, CMfgE
Orange, Conn.
At last there’s a D1 for strengthening and repairing existing structures

Since the first D1 standard in 1928, the AWS D1 structural welding series has provided a consensus of the finest minds in the industry on the most reliable approaches to welding new structures.

Now there is a D1 that provides the same guidance for repair, corrective issues, and strengthening of existing steel structures. AWS D1.7/D1.7M, Guide for Strengthening and Repairing Existing Structures, is invaluable to the engineer who is obligated under D1.1 Clause 8 to plan for projects that involve strengthening and repairing.

Preview and order your AWS D1.7 by visiting www.awspubs.com, or call 888-WELDING for information on all of AWS’s structural welding codes.
Friends and Colleagues:

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

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

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

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

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

Sincerely,

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

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

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

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

III. NUMBER OF COUNSELORS TO BE SELECTED
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, 2010
CLASS OF 2011
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
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AWS Member No.

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SUBMISSION DEADLINE JULY 1, 2010
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Q: We are fabricating a boom from 15-5PH stainless steel, which will be heat treated to the H1100 condition after all welding is finished. We want to weld some attachments of 304L stainless to the boom, using pulsed gas metal arc welding (GMAW-P). Would ER309L be the appropriate filler metal?

A: The 15-5PH is a martensitic precipitation hardening (PH) stainless steel. It is essentially a modification of the older 17-4PH stainless in which chromium is reduced and nickel is increased to reduce or eliminate ferrite bands in the steel plate structure, thereby improving the through-thickness strength and ductility. It is specified in the AMS 5862 standard. This steel is normally supplied in “Condition A,” which consists of annealing at about 1050°F (565°C) followed by air cooling to ambient temperature, which causes the steel to transform to martensite. In that condition, it is readily weldable because the martensite is low in carbon content, typically around 0.04%. All martensitic PH stainless steels, in Condition A, can be aged to much higher strength by a heat treatment at around 900°F (480°C) (Condition H900). In 15-5PH stainless steel, the precipitates are mainly copper, and, formed at 900°F, these precipitates retain coherency with the martensite matrix, and the coherency produces strain fields around the copper precipitates that remarkably harden the steel. The H1100 condition is an aging treatment at 1100°F (595°C), usually for about 4 h, which overages the precipitates (renders them at least partially incoherent) to reduce the strength but increase the toughness of the steel.

Table 1 shows the properties of 15-5PH stainless steel after a variety of heat treatments. It can be noted that there is a significant decrease in strength going from Condition H900 to Condition H1100. In fact, the minimum yield strength under Condition H1100 is only slightly higher than under Condition A. However, the ductility under Condition H1100 is considerably higher than that under Condition A, which is normally the main reason for selecting Condition H1100.

Since 304L is an austenitic stainless steel, the joint is one of dissimilar metals, so it is rather normal to think of using a 309L filler metal. But this is not the best choice for filler metal.

My concern with ER309L as a filler metal is the H1100 heat treatment. This is in the temperature range where ferrite tends to transform to sigma phase. ER309L tends to produce rather high ferrite content (on the order of 12% or so) in its weld metal, and the ferrite is quite high in chromium, so it readily transforms to sigma. I think ER308L is a better choice because its weld metal tends to lower ferrite content than that of the ER309L, and the ferrite is lower in chromium, so it does not transform as quickly or as extensively to sigma. Furthermore, ER308L is lower in cost than ER309L.

Table 2 indicates typical chemical compositions of 15-5PH and 304L base metals, and a typical composition of ER308L filler metal. These values can be used to predict microstructures according to the WRC-1992 Diagram, as is done in Fig. 1. As would be expected, the 15-5PH composition plots in Fig. 1 to the left and below the martensite boundary, indicating that this material would be virtually all martensite. Although 15-5PH plots...
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The Mission of the AWS Foundation: is to meet the needs for education and research in the field of welding and related joining technologies.

We greatly appreciate the hundreds of individuals and companies who support the industry's future by contributing to the Foundation's educational programs, which provide scholarships and fellowships to students pursuing a career within welding or related materials joining sciences.
A: We in the engineering community are sometimes accused of reading too much into a question. A classic example is to ask a group of people at what temperature water boils. The answer you’ll hear from most of them is 212°F, while the engineers will ask, “At what pressure?” However, in this case, what appears to be a relatively simple question actually has the potential for a fairly complex answer.

As you mentioned in your question, DP590 is one of many in a newer family of steels that are generally identified by the all-encompassing term Advanced High-Strength Steel or more often just by the abbreviation AHSS. However, before discussing AHSS, it is important to take a small step back and briefly mention a few things about steel in general so as to better understand how these new materials fit into the overall picture.

The first item to consider is how steels are classified. For our purposes, three methods of classification will be used to describe AHSS.

Mechanical or Forming Properties: This classification method details the steels’ various properties such as total elongation or work hardenability.

Metallurgical Designation: The microstructures that compose the steel.

Strength: A material’s strength may be measured several ways. For our purposes only two are necessary: the yield strength and the ultimate tensile strength. As the strength of steel covers a very wide range, the International Iron and Steel Institute (IISI) has broken this important metric into four groups.

The second item to consider is how steel gets its strength. There are several approaches toward making a high-strength steel and each one has its benefits and limitations with regard to weldability.

The most straightforward method of obtaining yield strengths below 350 MPa is exhibited in carbon-manganese steel. These steels are similar to low-carbon mild material except for the addition of higher levels of carbon and manganese that serve to increase the strength to the desired level. The use of this method to strengthen steel is generally not practical for yield strengths much greater than 350 MPa due to a drop off in elongation and weldability.

Another approach to achieving high yield strengths (up to approximately 550 MPa and higher) is exhibited in High-Strength, Low-Alloy (HSLA) steels. These steels usually have a microstructure of fine-grained ferrite that has been strengthened with carbon and/or nitrogen precipitates of titanium, vanadium, or niobium/columbium. Manganese, phosphorus, or silicon may also be added to further increase the strength. These steels can be resistance welded successfully under a variety of conditions and generally have good forming characteristics. The HSLA grades of steel are generally more weldable at higher-strength values than the carbon-manganese steels. However, there may be a cost penalty associated with these improved characteristics.

The AHSS grades derive their material strength from several sources. The most common methods include solid solution strengthening by the controlled addition of carbon, silicon, manganese and/or phosphorus, a tightly controlled thermal cycle, grain refinement during the forming process, and precipitation strengthening from both carbides and nitrides that include niobium, vanadium, and/or titanium.

So, to answer the first part of your question: The Advanced High Strength Steels (AHSSs) are a unique class of high-performance, ferrous-based, low-alloy materials that are classified as IISI Group III or Group IV steels. These materials are becoming very popular within the automotive industry due to their improved strength-to-weight ratios when compared to HSLA material. The AHSSs are characterized by tensile strengths in excess of 500 MPa and their unique and complex microstructures. Specifically, the microstructures that could compose an AHSS include combinations of ferrite, bainite, martensite, and retained austenite. For comparison, conventional high-strength steel (the C-Mn steel described above) is predominantly a single-phase ferritic. The exact percentage of each microstructure in an AHSS varies by both the grade of material and within a given grade by manufacturer. The AHSSs are further classified to a specific mechanical property such as ultimate tensile strength with secondary classifications that include the yield strength and elongation. Unlike many other grades of sheet steel, the producers of AHSSs are not constrained by chemistry. As such, their chemical composition can vary from producer to producer.

The most common types of AHSSs are detailed below and in Fig. 1.

Dual-Phase Steel (DP). Dual-phase steel is typically composed of 5 to 20% martensite with the balance being ferrite. The tensile strength of DP steel ranges from 500 to 1200 MPa and is widely used in components that require high strength, good crashworthiness (automotive speak for toughness, which is the ability to absorb energy before breaking), and good formability.

Transformation Induced Plasticity Steel (TRIP). TRIP steel, has a microstructure of ferrite, bainite, and 5~15% retained austenite with strength ranging from 600 to 800 MPa. TRIP steel is specified where the application requires high elongation.

Complex Phase Steel (CP). CP steel has similar microstructure to TRIP steel except that CP steel has no retained austenite. As
a result, CP steel contains martensite and bainite, and by utilizing precipitation hardening can reach a tensile strength that ranges from 800 to 1000 MPa.

The next two materials are often grouped with AHSSs, but due to microstructural differences they should really be classified as ultrahigh-strength steels. However, as they appear on Fig. 1 and have become more popular within the industry they are discussed here.

Martensite steel (M). M steel is produced by fast quenching the material from the austenitic temperature to obtain a martensite microstructure. This process results in tensile strengths that can be in excess of 1300 MPa and makes M steel an excellent choice for applications that require very high strength. In the auto industry, M steel is used for safety components such as door intrusion beams.

Hot-Stamped or MnB steel. MnB steel or hot-stamping and die-quenched steel, contains mainly manganese and boron and has a higher carbon content, so it has excellent hardenability. The hot-stamping process consists of heating blanks to their austenization temperature, then press forming while the blanks are still red hot and soft. As a final step, the formed parts are quenched to hard phases like martensite within the die. Hot-stamped materials are capable of reaching tensile strengths in excess of 1500 MPa.

Now that we have a better feel for what an AHSS is, we should address the second part of your question and discuss any potential process considerations associated with resistively welding them.

AC or MFDC

The subtle nature of the differences between alternating current (AC) and midfrequency direct current (MFDC) and their possible effects on weld quality and process robustness really forces each AHSS application to be evaluated on its own merits. There have been multiple peer-reviewed papers published regarding the different welding characteristics of AC vs. MFDC on AHSS and the results are not always conclusive or consistent in determining which process is capable of producing better weld quality. Put another way, while a particular application or specific material may benefit from utilizing either AC or MFDC, the results to date do not permit anyone to make broad statements with regard to material weldability such as “all AHSSs weld better with MFDC.” Please reference the RWMA Q&A in the January 2009 Welding Journal for more details regarding this.

Weldability

The AHSS materials are all considered weldable by almost all of the resistive welding processes. Due to the processing latitude permitted in the manufacture of these materials, the weldability of each specific material should be verified for the given application and process. The successful spot welding of AHSS generally requires additional weld time and weld force (perhaps as much as 30–50% for both) when compared to HSLA steels. Variations in material weldability have been observed between materials from the same classification. A switch from one source of AHSS product to another can be a large and complex undertaking as each AHSS is in essence an engineered material, specific to the mill that produced it. Also, the AHSSs tend to have a lower tolerance with regard to the stack-up ratio being welded when compared to other high-strength steels. This impacts not only new product processing but also any potential material substitutions of existing product.

Inspection

The evaluation of welds produced on AHSS also has the potential to present its own challenges. For the majority of cases, what were deemed to be satisfactory welds in low-strength grades of steel will apply to the AHSS. However, as the gauge or strength of the substrate increases, or if the AHSS is welded to itself or another AHSS, the tendency increases for the destructive inspection of the weld to reveal new fracture modes. The details of these fracture modes (there are eight of them) are a topic for another column. Please reference the AWS D8.1M:2007, Specification for Automotive Weld Quality — Resistance Spot Welding of Steel, for more details on the fracture modes possible in resistance spot welding.

In summary, yes, the Advanced High Strength Steels are weldable utilizing many of the resistive processes providing good judgment is exercised to take into account their differences. But, as detailed previously, these new materials may require a different way of looking at welding from both a processing and inspection point of view. Another way to look at how the welding of AHSS requires a new mindset is to think back to when the automobile engine transitioned from carburetors to fuel injection. While on the outside you were still able to turn the key and go, a look under the hood revealed a different world with a new set of challenges and opportunities.

Acknowledgments

I would like to thank the RWMA (Resistance Welding Manufacturing Alliance) for allowing me to use portions of the upcoming RWMA publication, A Designers Guide to Resistance Welding, soon to be available through the RWMA. Also, I thank members of AK Steel Corp.’s research staff for their assistance in obtaining key technical information on AHSS (www.aksteel.com).

References


Donald F. Maatz Jr. is laboratory manager, RoMan Engineering Services. He is a member of the AWS Detroit Section Executive Committee, serves on the D8 and DSD Automotive Welding committees, is vice chairman of the Certified Resistance Welding Technician working group and of the RWMA Technical committee, and a graduate of The Ohio State University with a BS in Welding Engineering. This article would not have been possible were it not for the assistance from members of the RoMan team. Send your comments/questions to Don at dmaatz@romaneng.com, or to Don Maatz, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.
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Correcting Thin-Plate Distortion in Shipbuilding

Flame straightening and induction heating must be considered in the search for the most cost-effective method

BY N. A. McPHERSON

Distortion within the shipbuilding process is almost an expected feature, with a few exceptions. In warship design, there has been a progressive move to reduce plate thickness, mainly by using higher-strength steels. In other areas such as chemical carriers there is the potential to displace austenitic stainless steel in tanks with thinner-plate, higher-strength duplex stainless steels. Some accommodation units on cargo vessels are being progressively thinned down too, as well as non-structural bulkheads. The picture that is emerging is that in most sectors there are moves to actively reduce plate thickness or there is the potential to reduce plate thickness.

Dealing with Distortion

On the basis of this, it is realistic to assume that some form of rectification for thin-plate distortion will always be required. However, it is correct practice to tackle as much of the problem at source as possible, and not merely build in the cost of the rectification work. Figure 1 illustrates (Ref. 1) the application of that philosophy. Basically by tackling the known issues and putting the correct practices in place, major reductions in the measurable rework man-hours can be achieved. At that point, it is the responsibility of the process management to maintain that level. For further benefits, a more scientific approach generally has to be taken. This can take the form of further identifying areas of the process and assessing the relative potential contribution to distortion. This can be a hit and a miss process. A recent example (Ref. 2) has shown that the whole tack welding process contributes significantly to the total distortion. This was initially (Ref. 3) identified from some preliminary finite element modeling (FEM) and then validated (Ref. 4) and further developed (Ref. 2) using FEM. However, how much of that will actually contribute to reducing the level of distortion may be indeterminate. This will be the same for a number of other factors such as the use of higher-strength plate, altering welding consumable chemistry, thermal tensioning, and restraint. In addition to these particular investigative strands is the complete issue about the effect of plate residual stress. It is quite clear (Ref. 5) that residual stress effects impart variable levels of distortion into welded structures, and is therefore a random variable, which on its own will lead to the continuation of use of a heat-straightening process. However, it is quite clear that a major change is unlikely from the various issues discussed earlier. Therefore, progression below 5 man-hours/ton, shown in Fig. 1, will be potentially a slow process. As a result, there should also be a focus on developing the most cost-effective overall process to rectify the distorted areas.

Historical Perspective on Distortion

Historically, heat straightening has been used either as a pure heating process or a process of combined heating and water cooling. The heating and water-cooling process was effectively used to form plates, but much of this was based on years of individual experience. Whether any detailed study was ever carried out on the formed or straightened material properties is limited. However, the work of Pattee et al. (Ref. 6) did attempt to tackle a number of aspects related to heat straightening. Their initial conclusion was that higher alloy quench-and-temper steels could not be heat straightened. A number of issues arose from this work specifically related to the effect of thermal cycles on low-strength steels. In this instance very little effect was seen. However, none of the particular steels contained microalloying elements. If these had been present then the conclusions may well have required modification. The use of water combined with a wide span of heating control runs the risk of significantly affecting the steel properties either through a hardening effect or in the case of high-strength steel, through precipitation of deleterious phases in the steel matrix, which would adversely affect the toughness and hardness.

Growth of Induction Heating

Induction heating has been on the market for many years, and has wide-ranging applications in the metals processing industry. It has also been used in the past in the shipbuilding industry but was never fully adopted by many yards. However, since 1981 the move to induction heating has been progressive with at least 300 units sold. In these cases at least 50% improvement in rectification time has been reported against traditional heat straightening.

This renewed interest in the use of induction heating has largely been associated with the EFD system as demonstrated in a number of publications (Refs. 7,8). Based on a small-scale, carefully controlled, and monitored trial, it was established (Ref. 7) that it could radically reduce the heat straightening man-hours shown in Fig. 1, to that shown in Fig. 2. It was also established (Ref. 7) that the effect of the heating did not significantly affect the plate material properties. However, it can only be used to straighten areas that do not have a free edge, i.e., it can not straighten the areas shown in Fig. 3.

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One of the major advantages of the induction heating process is that there are no attachments to the plate surface and therefore no removal and cleanup of grinding. It is of interest to note that a number of these machines are in use within a yard that has invested heavily in hybrid laser welding.

Both induction heating and flame straightening are based on the physical principle that metals expand on heating and contract when cooled. As a result of this, there is a physical difference in the plate dimensions as shown in the dilatometric data in Fig. 4, which shows the potential for dimensional changes during the cooling process of the base plate material. If the expansion is restricted, then there is a buildup of compressive stresses, which can lead to plastic deformation.

**Heat Straightening**

The process of heat straightening covers a multitude of hybrid processes. However, the basics of it are heating — moving — shrinking. The key factor is that the heating process always leads to a contraction of the component. The comparison could be made with undesirable mechanical rectification where the component tends to be elongated due to the lack of heating/cooling.

Materials subject to heating are very varied. One of the most common steel grades used in shipbuilding is Lloyds Grade DH36 (S355). With this material there is little point in raising the temperature above 650°C, as there are issues related to potential changes to the material properties from precipitation in niobium-bearing steels. This tends to be the case for prolonged heating or cyclical heating.

One of the key drawbacks of heat straightening is the potential for significant variations in the practice. Evidence has been seen in the past where thin-plate (4-mm) bulkheads have been heated, and in addition to inducing plate buckling, the process caused the bulb bars to distort.

Various torches can be used, which may not necessarily be designed for the task, and the gas settings and compositions need to be optimized. It is essential in flame straightening that the material to
be heated is done precisely and in a very short time. This requires a high heat flux density, which can be obtained with the use of a high oxyacetylene ratio with a small flame cone distance. The process then centers on the torch required for flame straightening. Typically a single flame torch was used, but for thin plate this has been progressively superseded by a multitorch setup with numerous nozzles. An example of a twin nozzle torch is shown in Fig. 5. There are also a number of variables related to flame settings, and this is also a function of material type being heated. In addition, if aluminum is being straightened, it is essential to use a slight excess of acetylene, as too much oxygen leads to severe discoloration of the heated areas.

In addition, flame heating can use a number of variables in terms of the shape of the area heated. It has been suggested that using a large number of heating spots is a highly effective way of straightening
thin plate. This also requires a well-defined sequence to be followed.

The most common form of distortion is termed angular/out-of-plane distortion, which is shown in model form in Fig. 6. It can be tackled by heating from the bottom side of the panel on either side of the fillet weld, but the flame setting, the flame cone distance, and the travel speed have to be carefully controlled. For example, the distance between the flame cone and the workpiece should be in the range 3-5 mm. A cooling regime after flame straightening is generally seen as not being necessary.

In addition to the torch-only process, there is another process that uses studbed aluminum strongback plates to heat the distorted plate up against. This process is normally very controlled but introduces a significant amount of work by stud welding, removing the studs, and grinding back the studded areas. In addition, the strongbacks have to be manufactured, but they are infinitely reusable. An example of this is shown in Fig. 7. Experience has shown that this is a relatively well-controlled process.

Reducing the Variables

Heat straightening is a relatively cheap process, although progressively more sophisticated heating torches are being developed, and no doubt there may be a future need for them to become more sophisticated, as could the control systems. A further step in reducing the variability of heat straightening has been the development of a mathematical model (Ref. 9) by IMG to in turn develop an automated straightening process. This is based on a spot heating pattern. The surface topography of the plate is determined and this in turn determines the required heating profile. This could be a combination of heating spots, circles, ovals, etc. The process, as developed, can control the maximum temperature the material reaches. It is, however, unclear how far this technology has been taken onto the straightening of panels. The current situation is that IMG is now apparently concentrating its efforts on automating the induction heating system under InduRiS.

Putting Induction Heating to Use

Induction heating as a process has a long history, but in recent years it has been significantly developed as a viable tool for distortion rectification to plate thicknesses as low as 4 mm, in the shipbuilding sector. It has also been used down to 3 mm thick for a ground transport application. Initially it was considered that 4-mm-thick plate could not be effectively straightened, but it has been shown (Ref. 7) that this in fact can be achieved.

This equipment has been used in a number of yards in the UK and Europe, and has actually found significant favor in a yard that has invested heavily in laser welding.

The equipment relies on heating a small area equivalent to the size of the induction coil in a well-controlled manner, and this can be seen in Fig. 8. The system outputs energy at a rate that heats the steel rapidly to the Curie Point (~780°C). At that temperature the change in the magnetic properties, related to the ferrite-to-austenite phase transformation, is detected and the system automatically regulates the power output ensuring no increase in temperature. Then the heating depth is increased, which assists the rapid penetration through the complete thickness of the deck at a rate of 1 s/mm. Although the temperature reached is above the 650°C quoted earlier, the time spent above that temperature is relatively short and will not significantly affect the structure or the kinetics of precipitation. A similar philosophy exists in flame heat straightening, i.e., to heat small areas and not large areas.

It is feasible to operate to a well-defined heating pattern with flame straightening, but there is still a significant tendency to rely on experience. The induction heating system has to be used to a well-defined pattern, and as a result relies significantly less on operator experience. Examples of what may be used are shown in Fig. 9. The starting point is directly in line with the stiffener.

Some work has been reported comparing induction heating with flame straightening using strongbacks. This came down very much in favor of induction heating. It did not, however, cover the total cost aspects such as capital equipment costs, gas usage, and energy costs. A similar comparison between induction heating and flame straightening without strongbacks is not currently available.

What the processes can do is take a step change in the rework reduction curve shown in Fig. 1 to develop a situation shown in Fig. 2. While the rework level is the same, a more effective rectification process will reduce the rework man-hours.

At the stage shown in the development of distortion reduction in Fig. 1, it is widely accepted that further improvements will be inversely proportional to the time taken to develop the benefit. Further improvements will be incremental, and it is unlikely that any major ‘big hitters’ will surface.

Process Comparison

Irrespective of what process is now used, greater cognizance needs to be taken of the steel type being straightened and even what elements are present in some steels, especially in the medium- to high-strength steels groups. Table 1 is a perceived comparison of the strengths and weaknesses of the two processes.

This list is clearly not exhaustive and does not attribute weightings to specific items. On a simplistic basis, this comparison shows that there could be an approximate 18% overall benefit in the application of induction heating. However, a critical part of the decision-making process is related to the capital expenditure criteria within individual organizations. As an example, the study carried out by Coyle et al. (Ref. 7) quite clearly showed significant benefits of induction heat straightening over the stud welded strongback process in place in that shipyard. However, if compared against a well-trained heating torch approach, then benefits, if any, would be less significant. The main issue is whether a yard invests in a capital expenditure that has a higher degree of control than in a low equipment cost process route that has the potential to be more variable. Many classification societies would probably prefer to see a process in place that has the lowest potential for variation in performance.

Although system automation is an area

| Table 1 — Comparison of Perceived Heat Straightening Process Attributes |
|--------------------|-----------------|-----------------|
|                    | Induction Heating | Flame Straightening |
| Capital cost       | + + +            | + +             |
| Consumable/energy cost | + + +        | + +             |
| Portability        | + +             | + + +           |
| Training           | + + +           | +               |
| Repeatability      | + + +           | +               |
| Rate of work       | + + +           | + +             |
| Flexibility        | + +             | + + +           |
| Health and safety  | + + +           | + +             |
| Environmental      | + +             | +               |
| Manual handling    | + +             | +               |
| Capability to automate | + + +    | +               |

Note: + is adverse; + + is midway; + + + is favorable.
only briefly discussed, it has to be stressed that the control systems within the induction heating systems makes automation more viable than with automated flame straightening. The decision may also revolve around actual yard build order mix, plate thickness range, and distortion rectification requirements.

Within Europe and North America there is a significant focus on safety and also environmental aspects of processes. In this specific case, the induction heating process has significant benefits over flame straightening, with almost no fumes and no combustion products from the hydrocarbon heating gases.

Potentially other processes are available. Brust and Kim (Ref. 10) have summarized the effects of mechanical straightening, postweld heat treatment, laser shock processing, and hammer peening. Some years ago Masubuchi (Ref. 11) also summarized a number of flame heating methods that could be used for removing distortion. These were line heating, pine needle heating, heating in cross directions, spot heating, triangular heating, and red hot heating. For thin-plate distortion, Masubuchi’s favored approach was spot heating. Other techniques that he highlighted were vibratory stress relieving techniques and the use of an electromagnetic hammer. A number of these techniques (Refs. 10, 11) are clearly impractical for general shipyard application, e.g., postweld heat treatment. However, others such as spot heating are standing the test of time.

Summary

The use of techniques to straighten thin welded sections will continue. The main thrust is to identify the most cost-effective rectification solution. That solution may not be the same for every fabricator, as the selection process will be subject to a number of factors within each organization. However, it is reasonable to consider two techniques: the use of flame straightening in some areas and induction heating in other areas. Both are potentially highly beneficial.

Acknowledgments

The input of Mark Wells of EFD Induction A.S. is most gratefully acknowledged.

References


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Hurricane Ike slammed into the Texas Coast Sept. 13, 2008, as a Category 2 storm. Damages were placed at $32 billion making it the third-costliest after Hurricanes Andrew in 1992 and Katrina in 2005. While Ike’s winds were not as strong as some previous storms, its massive size exposed the offshore facilities in its path to a prolonged period of battering from the winds and waves.

Surveys performed on offshore shelf platforms in the path of the storm showed major damage to some structures that had survived for 30 years. Figure 1 shows a K-brace platform node, where the vertical diagonal brace on the left pulled loose and pounded the joint, blunting the coped end of the brace. Overall, the joint withstood this pounding and remained relatively intact considering the magnitude of the forces and duration of the storm.

Repairing underwater damage of this scale presents unique structural engineering challenges to the client and the underwater repair contractor regardless of the selected repair method.

Wet welding is often a first choice for underwater repairs, as it presents the best economics at shallow depths. Its use can be limited by the joint configuration, high loads, fatigue-prone areas, and carbon equivalents (CE) that would make the weld repair subject to failure. The best way to ensure a quality wet weld repair is to understand its limitations. It is often best to avoid wet welding when the economics that make it attractive are no longer in place due to any of the following limitations.

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Hurricane-force winds and pounding wave action have wreaked heavy damage to offshore platforms forcing a review of underwater repair strategies

BY W. JACK COUCH

Completing a given size fillet weld takes longer using the downhill shielded metal arc welding (SMAW) process in wet welding when compared with dry habitat or topside welding. At shallower depths, this limitation can often be minimized by using two diver/welders working simultaneously on the same joint to complete the weld in a reasonable time frame — Fig. 2.

At deeper depths the weld deposition rate drops further due to the reduced size of the SMAW gas shield, and the available bottom time for surface diving compounds the problem of effectively completing the weld in a reasonable time frame.

Wet welding is highly adaptable for unexpected problems encountered during actual offshore repairs. Repair pieces can easily be modified offshore or new pieces can be fabricated and shipped while other work is progressing.

The nondestructive examination of wet welding is limited to magnetic particle testing, as the small weld porosity and the normal fillet weld tend to make volumetric testing methods, such as ultrasonic testing, of limited value.

Dry chamber or habitat welding can be used in areas where wet welding would not provide an adequate repair. Dry habitat welding offers the ability to perform complete-joint-penetration welds with strengths equal to a surface-made weld. Dry habitat welded joint configurations create little to no increase in the surface area of the repair. This can be an asset at shallow depths that experience hydrodynamic loading from wave action.

Most platforms also have thicker wall joint cans at the node sections and hyperbaric dry welding allows a reconnect of the load path back into the same point on the jacket leg.

Volumetric nondestructive examination with ultrasonic testing, and even radiography, are available for use in the dry habitat atmosphere with only minor modifications to adapt for the underwater conditions.
Fig. 3 — The habitat must be designed to prevent the rapid loss of heat from the weld area, and the fume-extraction equipment or habitat venting process must be controlled to avoid blowing directly on the weld.

Fig. 4 — Unless the welding is on thick materials, the welding time is often just a few hours of the total dry habitat repair time.

Several welding methods are available for use inside a welding habitat with the SMAW process widely used. Gas metal arc welding and some flux core semiautomatic welding can also be performed, but they are not used as often as SMAW.

The quality of welds made in a properly sized habitat with a good set of preheat procedures is difficult to differentiate from an equivalent weld made on the surface. However, the habitat design must prevent the rapid loss of heat from the weld area, and the fume-extraction equipment or habitat venting process has to be controlled to avoid blowing directly on the weld operations, again reflecting the need for proper habitat design — Fig. 3.

The design and fit of underwater habitats have improved with the use of 3-D software, making it much easier and less costly to design a habitat that will fit in several critical repair locations. By changing the brace seal doors, habitats can be reused or recycled, helping to reduce the
design and fabrication costs that are the major objections to using habitats. Dry habitat welding also adapts well to unexpected problems discovered during the repair process since the fabrication tends to be relatively simple compared to using clamps. Changes can be made to the repair plan easily as long as the new problem is contained within the habitat.

The uphill SMAW process is efficient, and weld times can be further reduced if two diver/welders work simultaneously in the habitat on either side of the weld. Unless the welding is on thick materials, the welding time is often just a few hours of the total dry habitat welded repair — Fig. 4.

When welding is inappropriate, the best option is to use long bolt friction- or stress-grouted clamps. The engineering costs involved with clamp repairs can translate to higher costs than a welded repair, and the onshore fabrication of the clamps is time-consuming and expensive. In addition, the bulk of the clamp subjects the repaired section to increased exposure to wave action.

When properly engineered, clamp-type repairs can be installed at the offshore location faster than most welded repairs, but clamps are not easily adapted to any unexpected changes that may appear during the repair. Other factors include the complexity of the fabricated clamps and the difficulty of placing clamps on large-diameter legs with complex joint cans, requiring offsetting of repair clamps to avoid other braces.

Stressed-grouted clamps need a grout spread to complete the repair, and the large bulk grout tanks can require a larger repair vessel than a welded repair.

Clamping, however, works well at deeper depths since the quality of the clamp repair is not affected by depth. Testing and inspection of the final clamp repair includes checking the tightness of the bolts, a visual inspection, a check for movement in the clamp-to-brace connection, and testing the strength of the cured grout in stressed-grouted clamps — Fig. 5.

The most effective offshore repair may be a combination of welded and clamped repairs, using the dry welded repairs at the critical brace to leg connections, and clamped and wet welded scallop sleeve repairs. Figure 6 shows a good example of a combination repair technique with the new horizontal brace dry habitat welded to the main jacket leg connection, a long bolt friction clamp on the new horizontal brace, and a scallop sleeve wet welded to connect the horizontal clamp to the conductor bracing.

It takes a well-experienced underwater structural engineer to study each assignment to recommend the most effective repair techniques that are consistent with the client’s cost constraints.
How Can Computational Weld Mechanics Help Industry?

By Sudarsanam Suresh Babu, Garrett Sonnenberg, Christopher Schwenk, John Goldak, Harald Porzner, Shuchi P. Khurana, Wei Zhang, and John L. Gayler

Prediction of distortion and residual stresses are just two examples of how computational models may be used in welding right away.

With an increasing focus on energy efficiency, sustainability, and cost, there is also an increased focus on advanced materials usage for a wide range of applications (Ref. 1). For example, the automotive and energy exploration industries are implementing new materials that are stronger to meet higher operating conditions (Ref. 2). In both applications, the use of new materials is often done with a limited knowledge of a materials' welding characteristics. Since weldability of these next-generation steels is affected by local changes in material behaviors due to a wide range of welding processes, the assumption of bulk properties for the joints may not be valid. This can lead to three potential challenges. First, if too aggressive, the assumption of bulk properties for joints may lead to an underdesigned part resulting in premature failure under loading conditions. Second, if too conservative, the design engineer may underestimate the joint strength and require thicker components, which defeats the purpose of leveraging advanced materials. Third, the design engineer may require certain mechanical properties from welding leading to expensive trial-and-error optimizations. For example, in shipbuilding, fabrication of an 8000-ton ship has a conservative estimate of 16,000 labor hours allocated for flame straightening of weld-induced distortion, which excludes alternative mechanical straightening methods and increased fit-up costs (Ref. 3). These challenges are not new; they have existed since the introduction of welding in a production environment. This leads to a fundamental question: Why can’t we use some mathematical and computational tools to address these challenges?

Utility of Computational Weld Mechanics Tools

To make a case for developing computational weld mechanics (CWM) standards, the predictive utility of CWM tools is briefly presented in the following examples.
Minimizing Welding Distortion in a Heavy-Section Joint

Goal: To deliver a product that meets flatness specifications while minimizing fabrication costs. Due to their geometry, these weld joints require a high amount of labor to weld, rework, and flame straighten. This is especially acute when mechanical pressing is not feasible.

The original procedure called for multiple gas metal arc welding (GMAW) passes in the root with follow-on single-wire submerged arc welding (SAW) until approximately 75% of the first side was completed. The structure was then flipped and backgouged to sound metal, with multiple layers of GMAW placed in the root.

This was followed by single-wire SAW to close out the second side. The structure was flipped back and double-wire SAW used to close out the first side. Initial attempts resulted in exceeding the out-of-flatness tolerance, requiring the joint to be thermally cut apart and ground down to sound metal and rewelded. Computational weld mechanics was used to solve this fabrication issue.

Results: Multipass welding simulation was used to develop a baseline and conditions to compare alternative geometry and welding. Two alternative designs changed the joint geometry while a third altered both the joint geometry and the welding process — Fig. 1. Distortions were measured at a point 101.6 mm from the weld centerline. The results are shown in Fig. 2 and Table 1. Simulations of Alternative Joints 1 and 2 predicted less distortion and saved 84 and 96% of the backside welding, respectively. However, during the simulation, Alternative Joint 2 generated more in-process distortion, indicating higher process stresses.

Alternative Joint 3 not only altered the joint geometry but also the process. It called for completely welding one side of the joint with double-wire SAW, then flipping the structure and, using the same process, completing the weld joint. Although this geometry required more backside welding, analysis predicted less distortion with a mechanical process that reduces labor by depositing higher volumes of metal per pass and requiring less fitup. This joint design has now been implemented into production. It is important to note that, in this work, experimental welds were produced after the simulation without model calibration, showing a truly predictive application of CWM. This example clearly shows the reduction in experimental trial-and-error welding procedure development.

Rapid Prediction of Welding Distortion in Large-Scale Assemblies

Goal: Although the previous example clearly showed the benefit of CWM, the setup and running of simulations for large-scale welding with multiple attachments and optimization of the same to minimize residual stress and distortion is often complex. Goldak (Ref. 4) addressed this problem. The goal in this example was to minimize the time taken to apply the CWM tools for large-scale structures shown in Fig. 3. As shown in Fig. 3, the geometry of the welded structure consists of a cylindrical pipe 2680 mm long, 228 mm in diameter with a 6-mm wall thickness. Six quadrilateral plates with a 12-mm wall thickness are wrapped around the cylindrical pipe. In each of the six plates, 12 circular holes are welded to the pipe with fillet welds. Circular disks are welded to close the ends of the pipe. The total number of welds is 74. The material is low-alloy steel.

Results: The first step in the CWM analysis is to import into the weld analysis program VrWeld®, the CAD-created

Table 1 — Results Summary of Predicted Weld Distortion from the Analyses Models

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Maximum Distortion (mm)</th>
<th>Max. Production @ Corners (mm)</th>
<th>Distortion @ the Corners (mm)</th>
<th>Backside Welding Reduction (%)</th>
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<td>Baseline</td>
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<td>0.458</td>
<td>0–0.035</td>
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</tbody>
</table>
Stereo-lithographic files that define the geometry of each part with a user-assigned material type for each part. The next step is to create a set of candidate weld paths automatically by computing the adjacency of all parts and checking where the geometry would permit a weld to join a pair of parts. The candidate weld paths are shown in Fig. 4.

In the second step, the software classifies the candidate weld paths by parameters such as the following: 1) weld path length; 2) whether the weld path is a closed or open loop; 3) whether the weld path is a circle. In this example, the designer chooses welds that are circles and have a weld path length corresponding to the circumference of the small circles. The appropriate weld procedure is assigned to all 72 weld paths. Next, the two larger circular welds on the ends of the pipe are chosen and the appropriate weld procedure assigned. The welds not chosen are deleted. The weld procedures define welding speed, current, voltage, arc efficiency, and double-ellipsoid semi-axes lengths. The welds can be ordered and assigned a start time automatically based on the weld sequence, welding speed, and a delay time between the end time of one weld and the start time of the next weld.

In the third step, the parts and weld joints are meshed, largely automatically — Fig. 3. In the fourth step, the designer assigns boundary conditions to constrain the rigid body modes for stress analysis and applied tack welds. Then the user sets the fields to be processed and checks "run." After the analysis is complete, the user visualizes the results such as displacement, residual stress, microstructure, and hardness. The significance of this work is the time it takes to set up this analysis, 15 min, with only a few days of training.

**Your Input Is Needed**

**Current AWS Activities to Develop CWM Standards.** The American Welding Society has established a technical committee (A9) with members representing academia, industry, nonprofit consulting organizations, and government national laboratories in order to develop a standard for CWM. To limit the task ahead to a reasonable scope, an initial survey of the committee members was conducted and resulted in a decision to focus on developing a recommended practice for CWM of fusion welding of metallic materials to predict residual stress and distortion. The necessary background information is being collected for incorporation into this AWS standard. A draft version of the standard is expected to be developed within two years. The committee has posted an open survey for the general public and welcomes any additional input. You can access the survey at www.aws.org/IY2X.

**Reduction of Welding-Induced Distortion in an Electron Beam Welded Gear Wheel**

**Goal:** An automotive gear wheel (Fig. 5) is welded with an electron beam allowing for high flexibility in the weld plan configuration. The current weld plan takes advantage of this fact and uses three simultaneous heat sources generated by a single electron beam, which is able to jump to three or even six positions nearly simultaneously. Despite the fact that this configuration already enhances the deformation behavior favorably, it was not sufficient as the pitch of the gear wheel was altered too much resulting in high wear and cracks. A manual trial-and-error optimization using numerous welding experiments generated no significant advantages. In order to solve this problem effectively, a numerical welding simulation was done (Ref. 5).

**Results:** First, a validated temperature field was simulated to begin the welding simulation. Thermal simulation results were relative to the measured data. Hence, the numerical model of the temperature field is suited for subsequent calculation of the welding-induced distortions. Baseline simulations (Fig. 6) showed that the circularity of the weld changes as the weld progresses.

Before welding (t = 0.0 s), the geometry of the synchronizing disc is an ideal circle. With the start of the welding procedure, the heat input into the workpiece...
leads to a high local temperature rise resulting in thermal expansion of the material. This creates a bulge in the circumference of the synchronizing disc that moves together with the advancing heat sources (t = 1.0 s to t = 2.0 s). The above deformation remains during the subsequent part cooling to room temperature (t = 5.0 s to t = 5000 s). Further investigation of the results indicated that the geometrical grooves create a heat accumulation at the end of the weld joints because of the smaller volume fraction in these regions and the already existing heat of the welding start point from the adjacent section. This further intensifies the radial distortion created by the electron beam heat input. Using this knowledge, modified welding direction and procedures were developed. The target was a more uniformly distributed temperature field in the workpiece which, in this special case, did not correspond with a more uniformly distributed heat input because the geometrical features had a significant influence. The direct optimization approach using CWM showed that a welding configuration with six simultaneous heat sources moving in different directions generated by the electron beam had the most positive effect on the resulting distortions. Pitch variations in the gear-tooth were reduced (Fig. 7) by 35% with these modified welding procedures.

**Technology Transfer of CWM to Welding Engineers**

**Goal:** The previous examples clearly show that CWM can be used as a tool to perform virtual trial-and-error welding experiments. However, this work still requires a design engineer who is well versed in computational methodologies. There is a growing need to transfer this technology to welding engineers who have a limited background in computational methodologies. These tools can be used for routine weld geometries to evaluate some of the “what if” scenarios. Recently, Zhang et al. (Ref. 6) developed E-Weld Predictor®, a CWM tool that leverages weld modeling, supercomputer, and Internet technologies to transfer the CWM tools for specific applications such as plate and pipe welding. This is demonstrated with a material substitution problem. While welding a 2.25Cr1Mo steel pipeline with ER70S6 filler metal, a hard zone was observed in the heat-affected zone. The case study focus was to substitute traditional X-65 steels in lieu of the 2.25Cr1Mo steels using the same process and welding wire conditions without adverse residual stress and distortion effects.

**Results:** The individual steps in running the simulations and input parameters are shown in Fig. 8. The results obtained based on these inputs are summarized in Fig. 9. Thermal calculations indicated that there are no significant differences in the HAZ width, residual stress, or distortions by substitution of the 2.25Cr1Mo with the X-65 steel — Fig. 9A, F-H. The most important difference was the formation of martensite in the HAZ of the 2.25Cr1Mo steels compared to bainitic microstructure in the X-65 steels. The above microstructural distribution is also reflected in the reduction of peak hardness in the heat-affected zones of the
X-65 steels. With this tool, the range of other process parameter and material combinations can be evaluated and some key conditions are being considered for detailed experimental evaluations.

Although the examples shown here are focused on the fusion welding processes, there are numerous examples of applying CWM to other joining processes such as resistance spot welding, inertia welding, etc., published in the literature. Computational weld mechanics tools can be used to reduce the number of trial-and-error optimizations. Based on the authors' experience, the reduction in number of experiments is expected to be 50%. This reduction will result in cost savings for the potential application. Currently, the above tool is not comprehensive for a wide range of geometries (fillet welds), boundary conditions (restraints), processes (resistance, laser, friction stir welding, etc.), alloy (aluminum, titanium, etc.) systems, and performance (toughness, creep, fatigue, etc.). However, the above framework can be modified for these needs with the development of sub models for these processes, materials, and performances by interfacing with researchers in this area.

Challenges to Deploying CWM to Welding Industries

Even with the success stories mentioned here, the introduction of CWM has been limited in the welding industry. In contrast, computational fluid dynamics and computational solid mechanics models have been used routinely in industry to great advantage for more than three decades. Perhaps the most dramatic example of how computational models can impact an industry are the computational models that make it possible to design electronic circuits that are the heart of modern computer and cell phone technology. This use of computational models suggests that industry has confidence and trust in their accuracy and expects to reduce costs and delivery times and improve quality. Currently, CWM models are not yet used routinely in the welding industry. This is related to both business and technical reasons. Business reasons are related to managers’ perception that CWM usage does not lead to costs reductions and improved delivery times and quality for welded construction. Although much of the published literature includes demonstrated case studies that counteract this perception, the widespread adoption of these tools is also plagued by technical challenges. This is to a large extent due to a lack of standard verification and validation tests to build the technical case for the use of CWM tools.

The process for developing trust and confidence in a computational model is called Verification and Validation. Verification tests that the computational model solves the mathematical equations that are the essence of the model with sufficient accuracy, robustness, and reliability. Validation tests that the computational model predicts the reality relevant to the decision maker with sufficient accuracy, robustness, and reliability. In welding, the reality relevant to a decision maker might be distortion, residual stress, microstructure, and the risk of in-service failure. A computational model that has been verified and validated for a given application area can be used as a predictive tool before any experiments are performed. Computational models that must be fit to experimental data before they can be used are called calibrated. These calibrated models cannot predict the reality relevant to a decision maker before the required experimental data are provided. This is the reason that computational models that are verified and validated are much more valuable and more useful than calibrated computational models.

Compared to the linear elastic analysis of structures such as bridges, the simplest welding examples are more complex, involve nonlinear-coupled equations, a larger range of length scales and time scales, and are more sensitive to microstructure evolution. It is for these reasons that CWM emerged about two decades later than computational solid mechanics.
At this time, CWM is rapidly rising from an emerging technology to one approaching maturity. ASME has developed standards for verification and validation for computational fluid mechanics and for computational solid mechanics (Ref. 7). AWS is currently working on developing a verification and validation standard for CWM. The objective of this paper is to increase awareness of the current state of CWM and to encourage a dialogue with the welding community such that these tools can be used routinely in industry in the near future.

Conclusion

Computational weld mechanics can become an active field of scientific research that not only could leapfrog the welding science and technology but also bring much needed new talent into the welding community.

References

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For info go to www.aws.org/ad-index
Underwater laser beam welding is used here to apply an Alloy 690 inlay to the inside diameter of a pipe.

Laser Beam Welding Process Automates Underwater Repairs

The benefits of this approach include mechanical and material properties remaining unchanged along with effective tempering of the heat-affected zone

BY RYAN BUCUREL AND GEORGE HLIFKA

In the past, the five basic methods of underwater welding all utilized an arc welding process and a diver. These were also typically performed manually or using mechanized welding equipment (see sidebar). Today however, WEC Welding and Machining, LLC, a subsidiary of Westinghouse Electric Co., is adding laser beam welding to its toolbox as a viable underwater repair option for use in the nuclear power industry.

How Underwater Laser Beam Welding Works

The process entails merging two laser technologies together — active optical fibers and semiconductor diodes. The extremely bright semiconductor emitter diodes are used as the light source to pump focused light through fibers, permitting an extremely bright light to be emitted from a very small fiber core. The laser beam is contained within the optical fibers that are shielded by a flexible armored metal conduit.

Understanding the Technique

Underwater laser beam welding (ULBW) utilizes a diode fiber laser beam, and the molten weld pool is shielded with a primary and secondary shielding gas delivered through a laser beam weld head. The primary shielding gas displaces the water, providing a dry environment to weld in while simultaneously providing a shielding medium for welding. The secondary shielding gas supports other functions unique to the laser welding system, preventing the ingress of water during welding into those components. A shield cover is used to seal the area, creating the dry chamber when pressurized for welding — Fig. 1.

ULBW Compared to GTAW

The filler metal used is the same as that for gas tungsten arc welding (GTAW), and is selected to ensure suitability for the application and base material being joined. It is introduced into the pool created by
the laser beam in a manner very similar to that seen during welding with a GMAW machine; however, ULBW is a completely automatic welding process. In this respect, ULBW differs from GTAW performed with a machine, where the operator makes adjustments during welding.

**Automatic Process Features**

Because ULBW is fully automatic, initial setup is critical to obtaining the desired weld quality required. The automatic process reduces reliance on welding operator skill and enables use of precise process controls to create highly consistent welds. Once equipment setup is complete and program controls are set, the welding operator initiates welding by pushing a button. From that point forward, the operator does not perform any adjustments during welding.

**Reliable Weld Characteristics**

The laser beam’s precise heat input and dilution controls result in consistent weld quality — Fig. 2. This image shows the as-welded surface appearance of a three-layer Alloy 52MS deposit on low-alloy steel substrate. Weld chemistry testing shows high deposit purity as a result of the low heat input generated during welding.

**Various Application Uses**

The optical fiber delivery of the laser light as its heat source during ULBW minimizes the welding system complexity and enables weld heads to be developed for tight and remote applications. Being an automatic process (not requiring any adjustment during welding) also permits it to be used in locations that may not be desirable for humans to work in for extended periods of time, such as in high-radiation areas found in nuclear power plants.

**Common Work Categories**

Underwater laser beam welding is intended primarily for repair/maintenance applications similar to those for which the other underwater processes have been developed. These applications may include repair of offshore oil platform supports and other undersea applications where conventional welding methods have demonstrated shortcomings. The process is also well suited to welding in ‘splash’ locations (such as welding on ship hulls near the waterline), where water movement creates safety hazards for welders using conventional arc methods.

WEC Welding and Machining is presently developing procedures to perform Alloy 600 mitigation in reactor vessel nozzle to safe-end welds that are susceptible to primary water stress corrosion cracking (PWSCC).

**Exploring Temperbead Welding**

The American Society of Mechanical Engineers (ASME) has formed an ULBW Task Group on temperbead welding. This task group has submitted a draft code case addressing requirements for ambient temperature temperbead welding of low-alloy steels using ULBW in an underwater environment. Ambient temperature temperbead welding eliminates the need for elevated temperature preheat and postweld heat treatment, and also eliminates requirements for elevated temperature postweld hydrogen bake-out.

Hardness and Charpy impact testing have shown that tempering can be successfully achieved using the ULBW process. Impact tests of the heat-affected zone (HAZ) were taken with the V-notch centered on the ULBW HAZ — Fig. 3. The results, as seen in Table 1, exceed those taken from the original base metal.

**Different Types of Weld Metal Testing**

To date, mechanical testing has included tensile testing and side-bend testing to evaluate the soundness and strength of ULBW deposits. The side-bend specimens were removed from a plate overlaid

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**Table 1 — Impact Testing Results**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Test Temp (°F)</th>
<th>Impact Energy (ft-lb)</th>
<th>Ductile Shear (% area)</th>
<th>Lateral Expansion (mils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAZ Sample 1</td>
<td>0</td>
<td>159.5</td>
<td>85</td>
<td>80</td>
</tr>
<tr>
<td>HAZ Sample 2</td>
<td>0</td>
<td>155.5</td>
<td>85</td>
<td>86</td>
</tr>
<tr>
<td>HAZ Sample 3</td>
<td>0</td>
<td>157.9</td>
<td>85</td>
<td>79</td>
</tr>
<tr>
<td>Base Sample</td>
<td>0</td>
<td>55.5</td>
<td>35</td>
<td>37</td>
</tr>
</tbody>
</table>
with three layers of multipass underwater laser beam welds. Side bends were performed using both plunger-type test fixture and wraparound style test jigs. Samples tested using both types of test fixtures were visually examined and found to contain no indications — Fig. 4. Subsequent liquid penetrant testing of bend faces revealed no indications.

Looking at Electrical Discharge Machining

All-weld-metal tensile specimens were produced by depositing several layers of multiple pass welds on a low-alloy steel plate. Using wire electrical discharge machining (EDM), four all-weld-metal tensile specimens were removed from the weld deposit — Fig. 5. All four samples exceeded the minimum required tensile strength for the material, as exhibited in Table 2. Tensile test results were comparable to those expected for comparable deposits prepared with conventional GTAW.

Details on Diffusible Hydrogen Testing

Diffusible hydrogen testing was performed to evaluate any potential effects on hydrogen content due to welding underwater with the ULBW process. Results showed that the amounts of diffusible hydrogen present were less than those resulting from dry welding with an H4 designation shielded metal arc welding (SMAW) electrode. In fact, residual hydrogen content was shown to be comparable to that contained in similar GTAW deposits welded in air.

The ULBW samples averaged approximately 0.5 mL/100 g, meeting the International Institute of Welding (IIW) criteria for “Extra Low Hydrogen” (<5 mL/100 g). These deposits’ susceptibility to hydrogen entrainment was demonstrated to be roughly an order of magnitude below the “Extra Low Hydrogen” IIW limit. Based on these test data, ULBW deposits are likely to demonstrate low susceptibility to delayed hydrogen-induced cracking when compared to conventional arc welded underwater deposits.

Utilizing Digital Ferrite Scope and Microexamination

Delta ferrite determinations were performed to determine the susceptibility of cracking in stainless steel welds. Multilayer stainless steel welds were tested using a digital ferrite scope and microexamination for ferrite content — Fig. 6. Dilution effects of the base metal were overcome by the third layer, and third-layer ferrite measurements were consistent with the ferrite number specified by the filler metal certified material test report (CMTR).

Conclusions

From the testing performed on underwater laser beam welding, the following conclusions were made:

1. Mechanical properties, tested using side-bend and all-weld-metal tensile tests, were unaffected by welding underwater.
2. Material properties, tested using diffusible hydrogen determination and delta ferrite testing, were not affected by welding in the underwater environment.

3. Hardness and Charpy impact testing shows that effective tempering of the HAZ can be achieved by using the ULBW process.
4. Laser beam welding is a viable process for underwater repair.

Underwater Welding’s Five Basic Methods

Underwater welding is primarily used as a piping repair/maintenance process in the offshore oil and gas industries and for localized repairs on ships and barges.

The American Welding Society’s D3.6, Specification for Underwater Welding, describes the following five basic methods of underwater welding currently in use:

- Welding in a pressure vessel in which the pressure is reduced to approximately one atmosphere, independent of depth (dry welding at one atmosphere).
- Welding at ambient pressure in a large chamber from which water has been displaced in an atmosphere such that the welder/diver does not work underwater (dry welding).
- Welding at ambient pressure in a simple open-bottomed dry chamber that accommodates, as a minimum, the head and shoulders of the welder/diver in full diving equipment (dry welding in a habitat).
- Welding at ambient pressure in a small, transparent, gas-filled enclosure with the welder/diver outside in the water (dry spot welding).
- Welding at ambient pressure with the welder/diver in the water without any mechanical barrier between the water and welding arc (wet welding).
Friends and Colleagues:

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

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

Sincerely,

Nancy C. Cole
Chair, AWS Fellows Selection Committee
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 candidate's outstanding contributions to the advancement of welding science and technology. In order for the Fellows Selection Committee to fairly assess the candidate's qualifications, the nomination package must list and clearly describe the candidate's specific technical accomplishments, how they contributed to the advancement of welding technology, and that these contributions were sustained. Essential in demonstrating the candidate's impact are the following (in approximate order of importance).

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

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

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

Return completed Fellow nomination package to:

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

Telephone: 800-443-9333, extension 293

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

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: ____________________________

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, 2010
Get ready to emerge from the recession at the forefront of the welding industry.

2010 co-located Annual Meeting

Palm Beach Gardens, Florida
March 11-13, 2010

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

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

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

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

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

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

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

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

For more information or to register contact:
Susan Hopkins at susan@aws.org or 800-443-9353, ext. 295
COMING EVENTS

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


AWS Detroit Sheet Metal Welding Conf. XIV. May 11–14, VisTaTech Center, Livonia (Detroit), Mich. Contact American Welding Society Detroit Section at smwc@awsdetroit.org, or visit www.awsdetroit.org.


♦FABTECH International & AWS Welding Show including METALFORM. Nov. 2–4, Georgia World Congress Center, Atlanta, Ga. This show is the largest event in North America dedicated to showcasing the full spectrum of metal forming, fabricating, tube and pipe, welding equipment, and technology. Contact American Welding Society, (800/365) 443-9353, ext. 455; or visit www.aws.org.


♦JOM-16, 16th Intl’l Conf. on the Joining of Materials. May 15–19, 2011. Contact JOM Institute, Gilleleje, Denmark. Phone: +45 48 35 54 58; jom_aws@post10.tele.dk.


Educational Opportunities


Machinery Vibration Analysis. Feb. 23–26, Willowbrook, Ill. Emphasizes the effects of vibration on mechanical equipment, the instrumentation used to measure vibration, techniques used for vibration analysis and control, and vibration correction. Contact The Vibration Institute, www.vibinst.org; vibinst@att.net; (630) 654-2254.

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


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

Brazing School. May 11–13, Wall Colmonoy Aerobraze Sulphur, La. Contact: Real Educational Services, Inc., (800) 489-2890, info@realsales distribution.com.

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

CWI/CWE Prep Course and Exam and NDT Inspector Training. Courses. An AWS Accredited Testing Facility. Courses held year-round in Allentown, Pa., and at customers’ facilities. Contact: Welder Training & Testing Institute, (800) 223-9884, e-mail Chairman Florian Kongoli fkongoli@flogen.com.

CWI Preparatory and Visual Weld Inspection Courses. Classes presented in Pascagoula, Miss., Houston, Tex., and Houma and Sulphur, La. Contact: Real Educational Services, Inc., (800) 489-2890, info@realedomucational.com.
Consumables: Care and Optimization. Free online e-courses presenting the basics of plasma consumables, designed for plasma operators, distributor sales and service personnel, etc. Visit www.hyperthermcuttinginstitute.com.

Environmental Online Webinars. Free, online, real-time seminars conducted by industry experts. For topics and schedule, visit www.augustmack.com/Web%20Seminars.htm.

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


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


Laser Safety Training Courses. Courses based on ANSI Z136.1, Safe Use of Lasers, presented in Orlando, Fla., or at customer’s site. Contact Laser Institute of America, (800) 345-3737, or visit www.laserinstitute.org.


Preparation for AWS Certified Welding Inspector/Educator Exam and Exam. Two-week-long courses beginning Jan. 11, Feb. 22, April 12, May 17, June 21, Aug. 9, Sept. 20, Nov. 1, and Nov. 29. Contact Hobart Institute of Welding Technology, Troy, Ohio; (800) 332-9448; hiwt@welding.org; www.welding.org.

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


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GTAW / PAW Gas Trailering Shields

PWT is introducing its latest gas shielding product, the small curved trailing shield for welding pipe and tube. Like its patented Ultimate Shield® auxiliary/trailing shield cousins, the curved trailing shield is designed to interface with industry common manual or machine gas tungsten arc welding torches. The new curved trailing shield can be supplied in skirt sizes of one inch increments, and kits are available with all four skirts for users welding several different diameters.

Features & Benefits of PWT's Gas Shielding Systems:

- Protects the weld end surrounding area from atmospheric contamination and discoloration like no other shield.
- The devices incorporate PWT's patented technology for modifying the inert gas pressure and flow from the single source entering the welding torch into efficient multiple shielding paths.
- Cost savings obtained from higher travel speeds, less post weld processing due to cleaner welds and more even weld deposition, less weld defects, and less post distortion due to lower heat required to melt through oxides.
- No secondary source of inert gas is required for many of our products, resulting in gas savings.
- Plasma torch auxiliary/trailing shields also available.
- Go to Web Site for further information and to download price lists.

For info go to www.aws.org/ad-index
### AWS Certification Schedule

**Certification Seminars, Code Clinics and Examinations**

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

#### Certified Welding Inspector (CWI)

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami, FL</td>
<td>EXAM ONLY</td>
<td>Feb. 25</td>
</tr>
<tr>
<td>Birmingham, AL</td>
<td>Feb. 21-26</td>
<td>Feb. 27</td>
</tr>
<tr>
<td>Long Beach, CA</td>
<td>Feb. 21-26</td>
<td>Feb. 27</td>
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<tr>
<td>Milwaukee, WI</td>
<td>Feb. 28-Mar. 5</td>
<td>Mar. 6</td>
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<tr>
<td>Atlanta, GA</td>
<td>Feb. 28-Mar. 5</td>
<td>Mar. 6</td>
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<tr>
<td>San Diego, CA</td>
<td>Feb. 28-Mar. 5</td>
<td>Mar. 6</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Mar. 7-12</td>
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<tr>
<td>Norfolk, VA</td>
<td>Mar. 7-12</td>
<td>Mar. 13</td>
</tr>
<tr>
<td>Perrysburg, OH</td>
<td>EXAM ONLY</td>
<td>Mar. 13</td>
</tr>
<tr>
<td>Indianapolis, IN</td>
<td>Mar. 14-19</td>
<td>Mar. 20</td>
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<tr>
<td>Portland, OR</td>
<td>Mar. 14-19</td>
<td>Mar. 20</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>EXAM ONLY</td>
<td>Mar. 18</td>
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<tr>
<td>Rochester, NY</td>
<td>EXAM ONLY</td>
<td>Mar. 20</td>
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<tr>
<td>Corpus Christi, TX</td>
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<td>Boston, MA</td>
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<tr>
<td>Phoenix, AZ</td>
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<td>Anchorage, AK</td>
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<td>Chicago, IL</td>
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<td>York, PA</td>
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<tr>
<td>Miami, FL</td>
<td>Mar. 28-Apr. 2</td>
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<tr>
<td>Dallas, TX</td>
<td>Apr. 11-16</td>
<td>Apr. 17</td>
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<tr>
<td>Beaumont, TX</td>
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<td>Springfield, MO</td>
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<td>Mobile, AL</td>
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<td>St. Louis, MO</td>
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<td>Portland, ME</td>
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<td>Las Vegas, NV</td>
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<td>Waco, TX</td>
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<tr>
<td>Baton Rouge, LA</td>
<td>May 2-7</td>
<td>May 8</td>
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<tr>
<td>San Francisco, CA</td>
<td>May 2-7</td>
<td>May 8</td>
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<tr>
<td>Nashville, TN</td>
<td>May 9-14</td>
<td>May 15</td>
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<tr>
<td>Jacksonville, FL</td>
<td>May 9-14</td>
<td>May 15</td>
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<td>Baltimore, MD</td>
<td>May 14-15</td>
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<td>Corpus Christi, TX</td>
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<td>May 15</td>
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<tr>
<td>Detroit, MI</td>
<td>May 16-21</td>
<td>May 22</td>
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<tr>
<td>Miami, FL</td>
<td>May 16-21</td>
<td>May 22</td>
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<tr>
<td>Albuquerque, NM</td>
<td>May 16-21</td>
<td>May 22</td>
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<td>Long Beach, CA</td>
<td>EXAM ONLY</td>
<td>May 29</td>
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<tr>
<td>Spokane, WA</td>
<td>Jun. 6-11</td>
<td>Jun. 12</td>
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<tr>
<td>Oklahoma City, OK</td>
<td>Jun. 6-11</td>
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<td>Birmingham, AL</td>
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<td>Miami</td>
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<td>Jun. 17</td>
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<td>Hartford, CT</td>
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<td>Jun. 19</td>
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<td>Pittsburgh, PA</td>
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<tr>
<td>Corpus Christi, TX</td>
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<td>Jun. 10</td>
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<tr>
<td>Miami</td>
<td>EXAM ONLY</td>
<td>Jul. 15</td>
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<tr>
<td>New Orleans, LA</td>
<td>Jul. 11-16</td>
<td>Jul. 17</td>
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<td>Phoenix, AZ</td>
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<td>Orlando, FL</td>
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<td>Milwaukee, WI</td>
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<tr>
<td>Los Angeles, CA</td>
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<td>Sacramento, CA</td>
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<td>Kansas City, MO</td>
<td>Jul. 25-30</td>
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<td>Cleveland, OH</td>
<td>Jul. 25-30</td>
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<tr>
<td>Louisville, KY</td>
<td>Jul. 25-30</td>
<td>Jul. 31</td>
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<tr>
<td>Denver, CO</td>
<td>Aug. 1-6</td>
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<td>Philadelphia, PA</td>
<td>Aug. 1-6</td>
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<td>Chicago, IL</td>
<td>Aug. 8-12</td>
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<td>Aug. 8-12</td>
<td>Aug. 14</td>
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#### 9-Year Recertification Seminar for CWI/SCWI

<table>
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<th>Exam Date</th>
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<tr>
<td>Denver, CO</td>
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<td>Dallas, TX</td>
<td>Mar. 15-20</td>
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<td>Miami, FL</td>
<td>Apr. 12-17</td>
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<td>Sacramento, CA</td>
<td>May 3-8</td>
<td>NO EXAM</td>
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<td>Pittsburgh, PA</td>
<td>Jun. 7-12</td>
<td>NO EXAM</td>
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<tr>
<td>San Diego, CA</td>
<td>Jul. 12-17</td>
<td>NO EXAM</td>
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<tr>
<td>Orlando, FL</td>
<td>Aug. 23-28</td>
<td>NO EXAM</td>
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<tr>
<td>Denver, CO</td>
<td>Sept. 20-25</td>
<td>NO EXAM</td>
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<tr>
<td>Dallas, TX</td>
<td>Oct. 4-9</td>
<td>NO EXAM</td>
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<tr>
<td>Miami, FL</td>
<td>Nov. 29-Dec. 4</td>
<td>NO EXAM</td>
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#### Certified Welding Supervisors (CWS)

<table>
<thead>
<tr>
<th>Location</th>
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<tbody>
<tr>
<td>New Orleans, LA</td>
<td>Apr. 19-23</td>
<td>Apr. 24</td>
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<tr>
<td>Minneapolis, MN</td>
<td>Jul. 19-23</td>
<td>Jul. 24</td>
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<tr>
<td>Miami, FL</td>
<td>Sept. 13-17</td>
<td>Sept. 18</td>
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<tr>
<td>Norfolk, VA</td>
<td>Oct. 4-8</td>
<td>Oct. 9</td>
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#### Certified Radiographic Interpreter (CRI)

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
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<tr>
<td>Miami, FL</td>
<td>Mar. 8-12</td>
<td>Mar. 13</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Apr. 19-23</td>
<td>Apr. 24</td>
</tr>
<tr>
<td>Allentown, PA</td>
<td>May 17-21</td>
<td>May 22</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Jun. 21-25</td>
<td>Jun. 26</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Jul. 26-30</td>
<td>Jul. 31</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Oct. 18-22</td>
<td>Oct. 23</td>
</tr>
</tbody>
</table>

#### Certified Radiographic Interpreter (CRI)

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

#### Certified Welding Sales Representative (CWSR)

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami, FL</td>
<td>Mar. 8-12</td>
<td>Mar. 13</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Apr. 19-23</td>
<td>Apr. 24</td>
</tr>
<tr>
<td>Allentown, PA</td>
<td>May 17-21</td>
<td>May 22</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Jun. 21-25</td>
<td>Jun. 26</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Jul. 26-30</td>
<td>Jul. 31</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Oct. 18-22</td>
<td>Oct. 23</td>
</tr>
</tbody>
</table>

#### Certified Welding Sales Representative (CWSR)

CWSR exams will also be given at CWI exam sites.

#### Certified Welding Educator (CWE)

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

#### Senior Certified Welding Inspector (SCWI)

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

#### Certified Robotic Arc Welding (CRAW)

<table>
<thead>
<tr>
<th>Location</th>
<th>Week of</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB, Inc., Auburn Hills, MI</td>
<td>Mar. 1</td>
<td>(248) 391-8421</td>
</tr>
<tr>
<td>Lincoln Electric, Cleveland, OH</td>
<td>Mar. 1</td>
<td>(216) 383-8542</td>
</tr>
<tr>
<td>Wolf Robotics, Ft. Collins, CO</td>
<td>Mar. 8</td>
<td>(970) 225-7736</td>
</tr>
<tr>
<td>ABB, Inc., Auburn Hills, MI</td>
<td>Apr. 5</td>
<td>(248) 391-8421</td>
</tr>
<tr>
<td>Wolf Robotics, Ft. Collins, CO</td>
<td>Apr. 19</td>
<td>(970) 225-7736</td>
</tr>
<tr>
<td>Lincoln Electric, Cleveland, OH</td>
<td>Oct. 25</td>
<td>(216) 383-8542</td>
</tr>
</tbody>
</table>

#### International CWI Courses and Exams

Please visit [http://www.aws.org/certification/inter_contact.html](http://www.aws.org/certification/inter_contact.html) for more information.
The American Welding Society elected its incoming slate of national officers Nov. 16 during the FABTECH International & AWS Welding Show held in Chicago, Ill. The officers take their posts on Jan. 1, 2010.

John C. Bruskotter was elected president. Currently, he heads Bruskotter Consulting Services where he works for an independent oil and gas operator. He is a past chair of the New Orleans Section and a past District 9 director.

John L. Mendoza was elected to his third term as an AWS vice president. Mendoza, a past District 18 director, is a Certified Welding Inspector, Certified Welding Educator, and a journeyman welder qualified to ASME Section IX in SMA and GTA welding. With 34 years of experience at CPS Energy, he is currently with Lone Star Welding in San Antonio, Tex.

William A. Rice Jr., was elected to his second term as an AWS vice president. Rice serves as a part-time CEO for OKI Bering Supply, and is a member of the boards of trustees for several health and financial organizations in West Virginia. Rice worked for Airgas from 1993 to 2001, where he served as its president and COO. From 1971 to 1992, he was president of Virginia Welding Supply Co. and president of several other welding-related companies.

Nancy C. Cole has been elected to her first term as a vice president. She is an AWS Fellow, a Life Member, and a registered Professional Engineer in the state of Tennessee. She has been a member of the Northeast Tennessee, Chattanooga, and Northeast Florida Sections. She served as chair of the AWS Technical Activities, Fellows, and C3 Brazing and Soldering Committees. Cole has worked at ABB Combustion Engineering and, before forming her own company, she was program manager and contract manager at Oak Ridge National Laboratories.

Robert G. Pali has been elected treasurer. He is vice president, secretary, and COO of J. P. Nissen Co. Pali is currently vice chair of the AWS Finance Committee and a member of the AWS Publications, Expositions, and Marketing Committee. He has served on the Welding Equipment Manufacturers Committee (WEMCO) executive board, National Nominating Committee, and numerous subcommittees and presidential task forces. From 1965 to 1978, Pali worked for Bethlehem Steel Corp. in analytical chemistry and plant operations research. In 2006, Pali...
received the National Meritorious Award for his many contributions to the Society.

Director-at-Large
Dean R. Wilson

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

Director-at-Large
Thomas J. Liernert

Thomas J. Liernert, an AWS Certified Welding Inspector, is a technical staff member, Materials Science Technology Division, at Los Alamos National Laboratory. He received his PhD in materials science and engineering from The Ohio State University in 1998. Currently, he is a Principal Reviewer and member of the AWS Technical Papers Committee, and chairs the AWS Handbook chapters on Friction Stir Welding and Stainless and Heat-Resisting Steels, and chairs the C6 Committee on Friction Welding and the AWS Higher Education Committee. Liernert is also vice chair of the Education Committees, and a member of the Technical Activities Committee. He has published widely and received the McKay-Helm Award and the Charles H. Jennings Memorial Award. He is a member of Tau Beta Pi Engineering Honor Society and Alpha Sigma Mu Metallurgy/Materials Science Honor Society.

District 1 Director
Thomas A. Ferri

Thomas A. Ferri, a CWI and an AWS member for 30 years, has been elected to his first term as District 1 director. He is district manager New England for Thermadyne Industries. Ferri served four terms as Boston Section chair, certification chair from 2001 to 2008, and most recently as education chair. He serves as a welding consultant to many companies in Massachusetts, and is a member of the advisory committees at five vocational technical schools.

District 4 Director
Roy C. Lanier

Roy C. Lanier has been reelected District 4 director. An AWS member for more than 30 years, he has served as chairman of the Northeastern Carolina Section. Lanier has taught in the community college system for the past 33 years, performing as an instructor and chairman of the Welding Technology Department. At Pitt Community College, he held offices on various committees including its Scholarship Committee, and is a Certified Welding Educator. In 1989, Lanier received the Howard Adkins Award of Excellence for teaching. He recently retired from the North Carolina National Guard with 30 years of service. Today, Lanier teaches welding and serves as department chairman of the Welding Division.

District 7 Director
Donald C. Howard

Don C. Howard has been reelected District 7 director. He is a technical staff member at Concurrent Technologies Corp. in Johnstown, Pa., where he has worked in the Advanced Materials department since 1990. He specializes in welding high-strength low-alloy steels for use in shipbuilding. Prior to joining the company, he worked as a welder in a truck body manufacturing plant. He received his welding engineering technology degree from Westmoreland County Community College, where he serves as an adjunct faculty member, teaching courses in its welding program.

District 10 Director
Richard A. Harris

Richard Harris has been reelected District 10 director. Harris is a contributing editor for Penton Publishing Co. in Noveltyle, Ohio.

District 13 Director
W. Richard Polanin

W. Richard Polanin has been reelected District 13 director. He received a PhD from the University of Illinois. He is professor and program chair for the Manufacturing Engineering Technology and Welding Technology programs at Illinois Central College. An AWS member for 30 years, he has twice served as chair of the Peoria Section. Polanin is a member of the D16 Robotic and Automated Welding Committee. He is an AWS Certified Welding Inspector and Certified Welding Educator, and is a SME Certified Manufacturing Engineer. He has received the District Educator Award and the District CWI Award. Polanin has published numerous papers and textbooks. Polanin is also a consultant in manufacturing and welding for the construction equipment and chemical industries in central Illinois.

District 16 Director
David J. Landon

David J. Landon has been reelected District 16 director. An AWS member since 1983, he is manager of welding engineering at Vermeer Mfg. Co., Pella, Iowa. He has served two terms as chairman of the Iowa Section, and chaired the Welding Industry Network, and the Technical Activities Committee. He is a member of the D14 Committee on Machinery and Equipment, International Standards Activity Committee, and Awards Committee. Landon is a Senior Certified Welding Inspector and a recipient of the District Dalton E. Hamilton Memorial CWI of the Year Award, and the District Meritorious Award. He holds a welding en-
gineering technology degree from Le-Tourneau University.

District 19 Director
Neil S. Shannon
Neil S. Shannon, an AWS Life Member, has been reelected District 19 director. He has been active in District and Portland Section activities for 30 years. He is a project manager and senior special inspector for Carlson Testing of Portland, Ore. He is a Senior Certified Welding Inspector and Int’l Code Council special inspector, and provides special inspection services for complex building construction in Portland. He trained as a welding technician at the College of San Mateo, Calif., and later earned his engineering degree at California Polytechnic State University. He has experience in marine construction, material-handling equipment, railroad equipment, and robotics in welding applications.

District 22 Director
Dale A. Flood
Dale A. Flood has been reelected District 22 director. He is a project manager at Tri-Tool Inc., Rancho Cordova, Calif. He holds several patents for his welding-automation work. Flood has served the Sacramento Valley Section in numerous capacities. Currently, he is a member of the executive committee where his involvement continues as a CWI supervising examiner. He is an active member of the D10 Committee on Piping and Tubing, and the D10U Subcommittee on Orbital Pipe Welding. He started his career as a welder with the Plumbers & Steamfitters Local Union 157. Later, he worked as a weld superintendent for CBI Services at several nuclear facilities where he was involved with machine and automated welding of critical application piping.

Addison, Fleury, and Scarince Honored as Gold Members

Harry Addison graduated from the University of Pittsburgh with a chemical engineering degree in 1951. He served as a welding engineer at the Philadelphia Naval Base and later as head of the Metal Joining Group at Frankford Arsenal. He received three patents and published several papers in the Welding Journal Research Supplement. From 1977 to 1981 and 1984 to 1991, he taught a metals-joining course at Cheyney State University. From 1981 to 1984, he worked for Stone and Webster Engineering Corp, on fossil- and nuclear-fuel power plants where he became a Certified Welding Inspector. He served on the Philadelphia Section executive board from 1980 to 1991, was elected chairman in 1989, and twice received the District Educator Award.

Alfred F. Fleury, an AWS Counselor and Distinguished Member, served as District 2 director for two terms, and is a past chair of the New Jersey Section where he has served many years as treasurer and cochair of the Welders Picnic annual fund-raiser. He received the District Meritorious Award in 1977 and 1985, and the Section award in 2009. He began his career in 1947 working in various positions at Metal & Thermit Corp., M&T Chemicals, Murex Welding Products, Airco Welding Products, and Big Three Industries. For 25 years he was general manager of Tempil Div., Air Liquide America, Inc. He retired in 1997 to start a consulting business. He served on many AWS committees including National Nominating, Membership, Education, and Product Development, and currently chairs the Counselor Selection Committee.

William F. Scarince Jr. received his welding technology degree from Le-Tourneau University in 1962, then served three years in the U.S. Army Ballistic Research Lab. In 1966, he joined Worthington Corp., Steam Turbine Div., where he served until 1972 as a welding engineer and shop manager. He served as manager of the plant welding engineering department for a year at ACF Industries Rail Car Div., then rejoined Worthington Corp. in its Turbodyne Div. There he worked until 1983 as manager of shop operations and manager of product diversification. In 1983 he founded WF Scarince, Inc., a job shop specializing in high-quality weldments for the military, power-generation, robotics, machine tool, and oil-exploration industries with a workforce of 40 employees. A past chair of the Northwest Section, he also served on the boards of directors of St. Cloud area Chamber of Commerce, Economic Development Partnership, School to Work Partners, and Central Minnesota Initiative Foundation, among many others.
New D14J Armament Systems Welding Subcommittee Seeks Members

The D14J Subcommittee on Armament Systems Welding was formed Nov. 17, during the AWS Welding Show, to prepare welding standards for armament systems. The D14 Committee on Heavy Machinery and Equipment founded D14J with 37 people attending the kick-off meeting. Represented were members of the military, defense contractors, research institutes, heavy manufacturing, robotics, consulting and inspection firms, and others. It is the intent that D14J's standards will supersede U.S. TACOM’s ground combat vehicle Welding Codes 12479550 and 12472301 for steel and aluminum. Contact Matt Rubin, mrubin@aws.org, (800/305) 443-9353, ext. 215, to contribute to this important work.

Share Your Expertise with the World — Join an AWS Technical Committee

Magnesium Alloy Filler Metals
Volunteers are invited to participate on the ASL Subcommittee on Magnesium Alloy Filler Metals. This subcommittee is responsible for updating AWS A5.19-92 (R2006), Specification for Magnesium Alloy Welding Electrodes and Rods. For complete information, contact Subcommittee Secretary Rakesh Gupta at gupta@aws.org, or call (800/305) 443-9353, ext. 301. You may also visit www.aws.org/1UQ4 to submit your member application online.

Thermal Spraying
Volunteers are invited to participate on the C2 Committee on Thermal Spraying. Its documents include C2.16, Guide for Thermal-Spray Operator Qualification; C2.18, Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites; C2.19, Machine Element Repair; C2.20, Thermal Sprayed Coating for Reinforced Concrete; C2.21, Specification for Thermal Spray Equipment Acceptance Inspection; C2.23, Specification for the Application of Thermal Spray Coatings (Metalizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel; C2.25, Specification for Thermal Spray Feedstock — Solid and Composite Wire and Ceramic Rods. Contact Reino Starks, rstarks@aws.org, (800/305) 443-9353, ext. 304, for information, or visit www.aws.org/1UQ4 to submit your application online.

Welding Sales Representatives
AWS established a new certification program for welding sales representatives in 2009. Volunteers are invited to be part of the technical subcommittee responsible for setting the qualification requirements, AWS B5.14, Specification for the Qualification of Welding Sales Representatives, that this program is based on. For complete information about this committee's work, contact John Gayler, gayler@aws.org, (800/305) 443-9353, ext. 472; or submit a technical committee application online at www.aws.org/1UQ4.

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

Technical Committee Meetings

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

Copies of Welding Journal articles may be purchased from Ruben Lara, (800/305) 443-9353, ext. 288; rlara@aws.org. Custom reprints of Welding Journal articles, in quantities of 100 or more, may be purchased from FosteReprints, Claudia Stachowiak, (866) 879-9144, ext. 121; claudia@fostereprints.com.

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.
D10 Heat Treating Subcommittee Meets at FABTECH Int’l & AWS Welding Show

The D10 Subcommittee on Local Heat Treating of Pipework recently met in Chicago, Ill., during the FABTECH International & AWS Welding Show. The Subcommittee is responsible for D10.10/D10.10M, Recommended Practices for Local Heating of Welds in Piping and Tubing, which recently has been recognized in ASME B31.1. The Subcommittee is commencing a review of the document and is actively seeking new members with expertise from the utilities, owners, and designers areas. If you would like to contribute to the development of this standard, please contact Brian McGrath, subcommittee secretary, bmcgrath@aws.org, or call (305) 443-9353, ext. 311.

Members and guests of the D10 Subcommittee on Local Heat Treating of Pipework are (from left) Chair Daniel Ciarcia, Secretary Brian McGrath, Miles Brown, Bill Kashin, John Hill, Bill Newel, Walter Sperko, and Gary Lewis.

New AWS Supporters

Sustaining Company
Flexco Engineered Systems Group
401 Remington Blvd., Ste. A
Bolingbrook, IL 60440
Representative: John Cieplak
www.flexcoengineeredsystems.com
For more than 25 years, Flexco has been solving bulk material transfer point challenges with its powerful controlled-flow technology. The company’s Controlled Flow Materials Transfer Systems™ (CFMTS®) not only improve throughput, but reduce excessive dust, spillage, plugging, downtime, belt wear, and combustion hazards.

Supporting Company
GroQuip
37056 Cornerview Rd.
Geismar, LA 70734

Affiliate Companies
Aitkin Iron Works
301 Bunker Hill Dr.
Aitkin, MN 56431

Fortson Welding and Repair
2008 Piney Grove Church Rd.
Kenly, NC 27542

High Purity Technologies
101 Ashmore Dr.
Leola, PA 17540

Kubota Metal Corp.
Fahramet Div., 25 Commerce Rd.
Orillia, ON L3V 6L6, Canada

L & M Industrial Fabrication
31975 Rolland Dr.
Tangent, OR 97389

Lamar’s Fabrication
210 Ashley Cir.
North Augusta, SC 29841

Maxum Industries LLC
1307 Tool Dr.
New Iberia, LA 70560

Micro Air
2009 S. West St.
Wichita, KS 67213

Midland Steel Co.
202 Boeh Ln., PO Box 527
Wathena, KS 66090

Quality Fabrication & Supply
699 Aero Ln.
Sanford, FL 32771

Seprotec
VLN 1533, PO Box 25685
Miami, FL 33102

Soldadura y Equipos Automaticos SA
Leopoldo Gonzalez Saenz 3327-A
Colonia La Campana
Monterrey, NL 64760, Mexico

Stonebridge Steel Erection
165 Ryan St.
South Plainfield, NJ 07080

Tabet Mfg. Co., Inc.
1336 Balleritine Blvd.
Norfolk, VA 23504

USA Shade
8319 Chancellor Row
Dallas, TX 75247

Welding Distributors
Al-Hamad Construction & Dev. Co., W.L.L., PO Box 1125, Manama, Bahrain

Meridian Exports
26 Arihant Industrial Estate
Gnd. Fl., 94 C&D, Krantinagar
Opp. Shetty Chemicals
Off. Saki Vihar Rd.
Sakinaka, Mumbai 400 072, India

Educational Institutions
Emirates Technical & Safety Development Centre
Mussafah Cornish Ind. Area
PO Box 35450, Abu Dhabi, UAE

Kellogg Community College
Regional Mfg. Technology Center
405 Hill Brady Rd.
Battle Creek, MI 49037

LaGrone Advanced Technology Complex
1504 Long Rd.
Denton, TX 76207

Pearl River Community College
101 Hwy. 11 N.
Poplarville, MS 39470

Membership Counts

<table>
<thead>
<tr>
<th>Grade</th>
<th>As of 12/01/09</th>
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<tr>
<td>Member</td>
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<td>Sustaining</td>
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<td>Supporting</td>
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<td>Welding distributor</td>
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<td>Total corporate members</td>
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<tr>
<td>Student + transitional members</td>
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<td>Total members</td>
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WELDING JOURNAL 61
Listed below are those who participated in the 2009-2010 campaign. See page 69 in this Welding Journal or visit www.aws.org/mgm for rules and prize list. These standings are as of November 20, 2009. Call the AWS Membership Dept. (800/305) 443-9353, ext. 480, for information on your proposer status.

<table>
<thead>
<tr>
<th>President's Honor Roll</th>
<th>Sponsored 2 new members.</th>
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<tbody>
<tr>
<td>J. Barber, Connecticut</td>
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<tr>
<td>G. Burrion, South Florida</td>
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<tr>
<td>G. Callender, San Fernando Valley</td>
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<tr>
<td>K. Carter, Tri-River</td>
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</tr>
<tr>
<td>J. Compton, San Fernando Valley</td>
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<tr>
<td>R. Davis, Utah</td>
<td>2</td>
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<tr>
<td>G. Euliano, Northwestern Pa.</td>
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<tr>
<td>M. Haynes, Niagara Frontier</td>
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<tr>
<td>K. Hurst, Kansas City</td>
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<tr>
<td>D. Mandina, New Orleans</td>
<td>2</td>
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<tr>
<td>V. Matthews, Cleveland</td>
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<tr>
<td>J. Medina, International</td>
<td>2</td>
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<tr>
<td>P. Newhouse, British Columbia</td>
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<tr>
<td>T. Rowe, Tulsa</td>
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<tr>
<td>M. Rudden, Colorado</td>
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<tr>
<th>President’s Club</th>
<th>Sponsored 3-8 new members.</th>
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<tr>
<td>D. Berger, New Orleans</td>
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<tr>
<td>J. Ciaramitaro, North Central Florida</td>
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<tr>
<td>L. Taylor, Pascagoula</td>
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<tr>
<td>S. Keskar, India Int'l</td>
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<tr>
<td>E. Ravelo, International</td>
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<tr>
<td>J. Hope, Puget Sound</td>
<td>3</td>
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<td>T. Morris, Tulsa</td>
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<tr>
<th>3+ Student Member Sponsors</th>
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<tbody>
<tr>
<td>C. Rogers, San Antonio</td>
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<tr>
<td>D. Berger, New Orleans</td>
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<tr>
<td>J. Morash, Boston</td>
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<tr>
<td>M. Anderson, Indiana</td>
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<tr>
<td>H. Hughes, Mahoning Valley</td>
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<tr>
<td>D. Saunders, Lakeshore</td>
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<tr>
<td>J. Carney, Western Michigan</td>
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<tr>
<td>S. Siviski, Maine</td>
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<tr>
<td>A. Baughman, Stark Central</td>
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<td>S. Burdge, Stark Central</td>
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<tr>
<td>R. Evans, Siouxland</td>
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<tr>
<td>E. Norman, Ozark</td>
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<tr>
<td>G. Marx, Tri-River</td>
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<tr>
<td>C. Donnell, Northwest Ohio</td>
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<td>J. Durbin, Tri-River</td>
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<td>V. Facchiano, Lehigh Valley</td>
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<td>D. Aragon, Puget Sound</td>
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<td>M. Arand, Louisville</td>
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<tr>
<td>A. Duron, New Orleans</td>
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<tr>
<td>K. Rawlings, Columbia</td>
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<tr>
<td>G. Seese, Johnstown-Altoona</td>
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<td>J. Daugherty, Louisville</td>
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<tr>
<th>President’s Roundtable</th>
<th>Sponsored 9-19 new members.</th>
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<tr>
<td>R. Ellenbecker, Fox Valley</td>
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<tr>
<td>A. Sumal, British Columbia</td>
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<tr>
<td>H. Thompson, New Orleans</td>
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<table>
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<tr>
<th>President’s Guild</th>
<th>Sponsored 20+ new members.</th>
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<tbody>
<tr>
<td>V. Craven, Pascagoula</td>
<td>54</td>
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<table>
<thead>
<tr>
<th>President’s Circle</th>
<th>Sponsored 20+ new members.</th>
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<tr>
<td>T. Weaver, Johnstown-Altoona</td>
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<tr>
<td>W. Shreve, Fox Valley</td>
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<td>L. Taylor, Pascagoula</td>
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<tr>
<td>D. Berger, New Orleans</td>
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<tr>
<td>A. Duron, New Orleans</td>
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<tr>
<td>V. Facchiano, Lehigh Valley</td>
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<tr>
<td>J. Durbin, Tri-River</td>
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<tr>
<td>V. Matthews, Cleveland</td>
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<td>J. Medina, International</td>
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<td>P. Newhouse, British Columbia</td>
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<td>T. Rowe, Tulsa</td>
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<tr>
<td>M. Rudden, Colorado</td>
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</tbody>
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<thead>
<tr>
<th>Candidates Sought for the Prof. Masubuchi Award</th>
</tr>
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<tbody>
<tr>
<td>November 2, 2010, is the deadline for submitting nominations for the 2011 Prof. Koichi Masubuchi Award, sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology. 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 <a href="mailto:jnd1@lehigh.edu">jnd1@lehigh.edu</a>.</td>
</tr>
</tbody>
</table>

A. Stute, Madison-Beloit | 15 |
A. Sumal, British Columbia | 54 |
J. Ciaramitaro, North Central Florida | 14 |
R. Munns, Utah | 14 |
D. Vranich, North Florida | 14 |
R. Vann, South Carolina | 14 |
J. Boyer, Lancaster | 12 |
T. Gerber, Allegheny | 12 |
D. Kowalski, Pittsburgh | 12 |
S. Mattson, North Florida | 12 |
B. Benyon, Johnstown-Altoona | 11 |
J. Stallsmith, South Carolina | 11 |
T. Garcia, New Orleans | 10 |
S. Kuntz, Pittsburgh | 10 |
R. Rummel, Central Texas | 10 |
C. Schiner, Wyoming | 10 |
P. Watland, Niagara Frontier | 10 |
D. Zabel, Southeast Nebraska | 10 |
W. Galvery, Long Bch./Or. Cty. | 9 |
W. Harris, Pascagoula | 9 |
S. Kuntz, Pittsburgh | 10 |
V. Harthun, Northern Plains | 8 |
W. Garrett, Olympic | 7 |
A. Mattox, Lexington | 7 |
J. Fitzpatrick, Arizona | 6 |
M. Hayes, Puget Sound | 6 |
A. Badeaux, Washington, D.C. | 5 |
S. Liu, Colorado | 5 |
S. Hansen, Southeast Nebraska | 4 |
S. Henson, Spokane | 4 |
A. Kitchen, Olympic | 4 |
J. Lynn, Idaho/Montana | 4 |
S. Mackenzie, Northern Michigan | 4 |
N. Carlson, Idaho/Montana | 3 |
C. Gilbertson, Northern Plains | 3 |
E. Hinojosa, L.A./Inland Empire | 3 |
G. Kimbrell, St. Louis | 5 |
D. Newman, Ozark | 3 |
S. Robeson, Cumberland Valley | 3 |
J. Smith, Greater Huntsville | 3 |
District 1
Thomas Ferri, director
(508) 527-1884
tferri@thermadyne.com

BOSTON
November 2
Activity: The Section members participated in a vendors’ demonstration program. Matthew Eaton, Magnatech Corp., demonstrated mechanized orbital GTAW on stainless steel pipe. Incoming District 1 Director Tom Ferri, Thermadyne, demonstrated the Arcair exothermic Slice® Pak and coached attendees in a hands-on session. The District Educator of the Year Award was presented to John Fusco, from Shawsheen Valley Technical High School.

CONNECTICUT
November 4
Activity: The Section and Howell Cheney Technical High School hosted a vendors’ night at the school in Manchester, Conn. Attendees had the opportunity to try equipment from Miller, Smith, Jancy, Thermal Arc, and Arcair. Overseeing the activities were ITW representative Dean Donavan, Nicholas Parrotte of Jancy Engineering, and Tom Ferri of Thermadyne. Organizing the event were Bob Cullen, department head; and welding instructor Kathy McGirr.

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

NEW JERSEY
October 20
Speaker: Wyatt Mann, sales engineer
Affiliation: The Lincoln Electric Co.
Topic: The importance of fume extraction in the school and workplace
Activity: The program was held at Pantagis Renaissance, Snuffy’s Clambar in Scotch Plains, N.J.
Shown at the Lancaster Section program are (from left) John Ganoe, presenter Dave Watson, Justin Heistand, Julia Allison, instructor John Boyer, Treasurer Russ Ross, and Todd Sload.

Tour guides (from left) Bruce Sine, Jim Gillespie, Bruce Etter, and Rick Bockey are shown during the Reading, Lancaster, and York-Central Pa. Sections’ visit to Greiner Industries.

Shown during their Manitowoc Cranes tour are Pennsylvania College of Technology Student Chapter members (from left) Justin Stramitis, Bill Badger, Lee Asbeck, Nate Myers, Mike Hyers, Zach MacMullen, Stephanie Irvine, Nick Anderson, Eric Speer, Logan Kucerak, and Robert Lamb.

Speaker Kelly Morrow (right) is shown with Robert Brewington, Florida West Coast Section chairman.

Michael Bannister (right) is shown with Steve Mattson, District 5 director, at the North Central Florida Section event.

Claudia Bottenfield received the Silver Membership Award from Mike Sebergandio, Lancaster Section chairman.

NEW YORK
November 9
Speaker: Joe Kane
Affiliation: Cobe Welding
Topic: Welding inspection problems encountered in fabrication shops
Activity: The program was held at Buckley’s Restaurant in Brooklyn, N.Y.

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

LANCASTER
October 20
Activity: The Section members met at Lancaster County Career and Technology Center in Mount Joy, Pa., for an introduction and demonstration of the SimWelder virtual welding training system. Dave Watson from Lincoln Electric and John Boyer, a welding instructor at the center, made the presentations.

Pennsylvania College of Technology Student Chapter
October 22
Activity: The Pennsylvania College of Technology Student Chapter members toured the Manitowoc Cranes manufacturing facility in Shady Grove, Pa., to study the crane-building process. The presenters included Mike Allen, Jacob Sensinger, and Sammy Munaswamy.

Reading, Lancaster, York-Central PA.
November 5
Activity: Twenty-eight Section members from the Lancaster, York-Central Pennsylvania, and Reading Sections toured Greiner Industries in Mt. Joy, Pa. Frank Greiner, owner of the factory, and Claudia Bottenfield received the Silver Membership Award for 25 years of service to the Society. The tour guides included Bruce Sine, Jim Gillespie, Bruce Etter, Rick Bockey, and Gary LeFever.

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

District 5
Steve Mattson, director
(904) 260-6040

Florida West Coast
November 11
Speaker: Kelly D. Morrow, district manager
Topic: Weld control cable innovations and improvements
Activity: The program was held at Frontier Steakhouse in Tampa, Fla.

North Central Florida
October 13
Speaker: Steve Weaver, district manager
Affiliation: Thermadyne
Topic: Pulse-on-pulse welding process
Activity: District 5 Director Steve Mattson presented Curtis Warren the District Educator Award, and Michael Bannister the Private Sector Instructor District Award. Section Chair Mark Geiger presented Leroy “Bill” Myers, an AWS past president, with his Gold Membership Award for 50 years of service to the Society. More than 60 people attended the event, including students from Mid-Florida Tech in Orlando, Fla., where the meeting was held.

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

Columbus
October 21
Speaker: Matt Robinson, welding engineer
Affiliation: Caterpillar, Peoria, Ill.
Topic: Development of the D7E electric drive tractor
Activity: This was a joint meeting of the Columbus area chapters of AWS, SWE, ASME, ASM Intl, IIE, AIAA, ISA, and NACE. Each society takes a turn hosting a meeting throughout the year. The Ohio University Student Chapter, led by Chair-

Dayton
October 13
Activity: The Section members met for a tour of Motoman, Inc., West, in Carrollton, Ohio. Chris Anderson, thermal technology leader, described and demonstrated the company’s latest 7-axis robots for arc and spot welding applications.

November 10
Activity: The Dayton Section members met at the Miami County Fairgrounds in
Triangle Tech Student Chapter members pose for a group shot at their welding expo.

Dayton Section members and students are shown at the November program.

Dayton Section Vice Chair Ben Finney (far right) is shown with presenters Gary Ward (left) and Steve Roth in November.

Triangle Tech Student Chapter welders strut their skills at the October welding expo.

Troy, Ohio, for a presentation by Southern Ohio Forge and Anvil Assn. Steve Roth and Gary Ward discussed forging and forge welding then demonstrated the processes. The program included a hands-on exercise for those willing to try. Also attending were a number of students from Wright State University and Hobart Institute of Welding Technology.

**Triangle Tech Pittsburgh Student Chapter**

**OCTOBER 2**

Activity: The Student chapter and Sky-Oxygen worked together to host a welding expo to showcase the students’ welding skills and have students meet fabrication employers in the area. The event was held at Sky-Oxygen in Carnegie, Pa. More than 100 company representatives and 50 welding students participated in the many hands-on projects. The refreshments and prizes were provided by Sky-Oxygen and Lincoln Electric. The organizers included Dave Bloom, Sky-Oxygen; Dave Daugherty, Lincoln Electric; J. Todd, Weld Tool Co.; and Donald Kowalski, Chapter advisor.

**District 8**

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

**CHATTANOOGA**

**OCTOBER 20**

Activity: The Section members met at Westinghouse Electric Co. Nuclear Services in Chattanooga, Tenn., for presentations by Mike Patch, program development manager; and Richard Frisbee, general manager. Patch discussed the boiling water reactor service center, and Frisbee detailed the new welding school facility. Bill Brooks was presented the District 8 Meritorious Award, and Robin Dykes received the Section education Award.
New Orleans Section members are shown at the October program.

**GREATER HUNTSVILLE**

**OCTOBER 15**
Activity: The section members met at Airgas to tour the facility and learn about its air-separation technology for producing argon, oxygen, nitrogen, and helium. **Phil Foster**, site manager, conducted the program for 12 attendees.

**HOLSTON VALLEY**

**OCTOBER 13**
Speaker: **Robert Thomas**, welding instructor
Affiliation: Unicoi County High School
Topic: Welding light intensity study: the effects of environment and distance
Activity: The program was held at River’s Edge Restaurant in Erwin, Tenn.

New Orleans Section members are shown at the October program.

November 7
Activity: The Chattanooga Section members met at the Tennessee Valley Railroad Museum in Chattanooga, Tenn., for a demonstration of blacksmithing skills by **Paul Huffman** from TVA. He crafted a large fork, a small fork, and a decorative leaf.

**GREATER HUNTSVILLE**

**OCTOBER 15**
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Activity: The program was held at River’s Edge Restaurant in Erwin, Tenn.

**District 9**

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

**NEW ORLEANS**

**OCTOBER 20**
Speaker: **Kevin Ford**
Affiliation: The Clean Air Group
Topic: New OSHA regulations and environmental solutions
Activity: This meeting was sponsored by the New Orleans Pipe Trades Local 60 for 105 attendees.

November 14
Activity: The New Orleans Section hosted its fifth annual student welding competition at Pipe Trades Local 60 with Petro Construction management, Inspection Specialists, Airgas, and Lincoln Electric supporting the event with prizes. Thirty-six students participated. The winners in the beginners class were Josh Roy, Joey Perez, Davis Tate, Zachary Honsinger, and Michael Carpenter with total prize money of $1500. The advanced winners were Matthew Blackwell, Jontrell Jeffery, Donald Murray, Leroy Hughes, and Leon Howard with total prize money of $1500. The judges were Travis Moore, John Pajak, Paul Hebert, and Tony DeMarco. In the instructors contest, Chris Fernandez, a teacher at New Orleans Pipe Trades Local 60, won the event for the second year in a row.

**Chair Dusti Jones presents Bill Brooks with the District Meritorious Award at the October Chattanooga Section program.**

**Blacksmith Paul Huffman demonstrates his talents for Chattanooga Section member in November.**

Shown at the Holston Valley Section program are (from left) speaker Robert Thomas, Brandon Spirio, Roger Painter, Gary Killebrew, Walt Rose, Mrs. Dennis Smith, and Dennis Smith.
Judging the New Orleans Section competition were (from left) Travis Moore, John Pajak, Paul Hebert, and Tony DeMarco.

Shown at the New Orleans Section October program are (from left) Chair Donald Berger, speaker Kevin Ford, and George Fairbanks, District 9 director.

The winners in the New Orleans Section advanced welding contest are (from left) Matthew Blackwell, Jontrell Jeffery, Donald Murray, Leroy Hughes, and Leon Howard.

The New Orleans Section beginning welder contest winners are (from left) Josh Roy, Joey Perez, Davis Tate, Zachary Honsinger, and Michael Carpenter.

Level 1 CCCTC welding students pose for a group shot at the Mahoning Valley Section event.

The Level 2 CCCTC welding class members are shown at the Mahoning Valley Section meeting.

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

DRAKE WELL
November 10
Activity: The Section members met at Cozumels Mexican Restaurant in Cranberry, Pa., to discuss plans for future meetings.

MAHONING VALLEY
CCCTC Student Chapter
February 19
Speaker: Harold Branch
Affiliation: Motoman
Topic: Affordable automation
Activity: The program was held at Columbiana County Career and Technology Center (CCCTC) in Lisbon, Ohio. Attendees included welders training at the Center and Student Chapter members. The welding instructor and Student Chapter advisor is Huck Hughes.

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

DETROIT
November 12
Speaker: Glen Jackson
Affiliation: Motoman Robotics
Topic: New welding robot technologies
Activity: The meeting was hosted by Motoman Robotics in Rochester, Mich. The event, attended by 62 members and guests, raised $172 for the scholarship fund.

District 12
Sean P. Moran, director
(715) 835-2800, ext. 2014
smoran@pdmbridge.com

MADISON-BELoit
October 13
Activity: The Section hosted a hands-on program at Madison Area Technical College (MATC) in Madison, Wis. Attendees toured the college then tried their skills with some of the new welding equipment. Assisting with the activity were Rob Stinson and Mike Kersey from Lincoln Electric, and Bryan Kwapis from Miller Electric. Michelle Zwolanek, a full-time welder at Jenkins Research and a part-time MATC welding instructor, won the grand prize drawing, a Speedglas 9100 autodarkening helmet donated by 3M representative Jeff Hedin.
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.
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 _______________________________
Title _______________________________ M.I. _______________________________
Birthday _______________________________

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

PAYMENT INFORMATION (Required)

ONE-YEAR AWS INDIVIDUAL MEMBERSHIP ……………………. $80
TWO-YEAR AWS INDIVIDUAL MEMBERSHIP ……………………. $160 $135 (New Members Only)

New Member?  √ YES  √ NO
If yes, add one-time initiation fee of $12 ……………………. $13 $13

International Members add $90 for optional hard copy of Welding Journal (note: digital delivery of WJ is standard) ……………………. $90 (Optional)
Domestic Members add $25 for book selection ($192 value), and save up to 78% ……………………. $25 (Optional)
International Members add $75 for book selection (note: $50 is for international shipping) ……………………. $75 (Optional)

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

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.

- 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

- 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. asstns.)
- Q  √ Misc. business services (incl. commercial labs)
- R  √ Government (federal, state, local)
- S  √ Other

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

- 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
Members of the CCCTC adult class are shown at the Mahoning Valley Section program.

Motoman Robotics hosted the Detroit Section program in November.

Richard Polanin (second from left), District 13 director, presents Silver Membership Awards to Chicago Section members (from left) Eric Krauss, Marty Vondra, and Andrew Johnson.

Don Maatz (left) chats with speaker Glen Jackson at the Detroit Section program.

Shown at the Chicago Section October meeting are (from left) Craig Tichelar, Chuck Hubbard, Eric Krauss, Cliff Ifiimie, Hank Sima, Marty Vondra, and Chair Jim Greer.

Michelle Zwolanek is shown with Madison-Beloit Section Chair Ben Newcomb.

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

CHICAGO
October 28
Activity: The Section board members met at Moraine Valley Community College for a planning meeting. Attending were
St. Louis Section members toured Trinity Products in October.

Shown at the L.A.K. Section program are (from left, seated) Zach Awad, David Reich, and John Willard; (standing) Mark Stevenson, District 13 Director Richard Polanin, and Adam Woodruff.

Shown at the National FFA Convention are (from left) Indiana Section Secretary Bob Richwine, Monica Pfarr, Sam Gentry, Chairman Tony Brosio, and Treasurer Mike Anderson.

Presented Greg Early is shown at the May meeting of the Indiana Section.

Shown at the St. Louis Section tour are (from left) Chair Vic Shorkey, presenter Ken Colletta, and Tally Parker, District 14 director.

Chair Jim Greer, Craig Ticheler, Chuck Hubbard, Eric Krauss, Cliff Iftimie, Hank Sima, and Marty Vondra.

November 15–18 Activity: The Chicago Section members participated at the FABTECH Int'l & AWS Welding Show. District 13 Director Richard Polanin presented Silver Membership Awards to Eric Krauss, Marty Vondra, and Andrew Johnson for 25 years of service to the Society.
Shown are the attendees at the Kansas Section program.

J.A.K.

October 18
Activity: The Joliet-Aurora-Kankakee Section held a planning meeting at Fisherman’s Inn in Elburn, Ill. Reports were presented by Mark Stevenson about the Instructors Institute held at AWS headquarters in Miami, Fla. Instructor David Reich of Elgin Community College discussed the welding program at the facility, Adam Woodruff of Joliet Ironworkers Local 444 reported on nuclear power-generating facility maintenance, and Richard Polanin, District 13 director, spoke on successful Section events.

District 14
Tully C. Parker, director
(618) 667-7795
tparke@millerwelds.com

INDIANA

May 20
Activity: The Section members met at Walker Career Center in Indianapolis, Ind., for a tour of the welding lab and a presentation and demonstration of some new welding equipment by Greg Early, a district sales manager for Miller Electric Mfg. Co.

October 22, 23
Activity: Several Indiana Section members assisted at the AWS Foundation booth at the FFA National Convention held at the Convention Center in Indianapolis, Ind. Working the booth were Chair Tony Brosio, Bob Richwine, Mike Anderson, AWS Foundation Executive Director Sam Gentry, and Solutions Opportunity Squad Corporate Director Monica Pfarr.

ST. LOUIS

October 15

Joe Clasen discussed nondestructive examination for the Kansas Section members.

Activity: The Section members toured Trinity Products, Inc., in St. Charles, Mo. Ken Colletta, director of operations, conducted the tour. Attending the program were Chairman Vic Shorkey and District 14 Director Tully Parker.

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

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

KANSAS

November 11
Activity: The Section members met at Cowley College in Mulvane, Kan., for a presentation on nondestructive examination using ultrasonics and radiography. Joe Clasen, the NDT instructor at the college’s Arkansas City, Kan., campus, demonstrated the processes.

KANSAS CITY

October 24
Activity: CWI Richard Blaisdell presented a CWI exam study guide seminar at Praxair in Kansas City, Mo. Eighteen members participated in the course.
Shown are the East Texas Section members at the Priefert Ranch Equipment Co. tour.

Shown at the Kansas City Section program are (from left) Speaker Steven Huffman, Dennis Wright, Sarah Hurt, Chair Jason Miles, Sam Newhouse, Brian McKee, Mike Vincent, and Michael Williams.

Nebraska Section members are shown at the November meeting.

Speakers Nick Weidenbach (left) and Scott Blankman (center) are shown with Rick Hanny, Nebraska Section chair.

Speaker: Steven Huffman, student
Affiliation: UMKC School of Engineering
Topic: The 2010 steel bridge competition
Activity: The Kansas City Section members met at University of Missouri, Kansas City campus, to learn about previous team bridge competition projects and requirements for the upcoming bridge competition.

NEBRASKA
November 19
Activity: Scott Blankman and Nick Weidenbach of Praxair discussed weld shielding gas properties, applications, and how to select the right gas. The meeting was held in Omaha, Neb.

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

EAST TEXAS
October 22
Activity: The Section members met at Priefert Ranch Equipment Mfg. Co. in Mt. Pleasant, Tex., to study its manufacturing processes. Johnny Harvill conducted the program for 28 attendees.

OKLAHOMA CITY
October 29
Speaker: J. Jones, District 17 director
Affiliation: Thermadyne, applications specialist
Topic: AWS update and Thermadyne product information
Activity: The meeting was held at Home Town Buffet in Oklahoma City, Okla.
Oklahoma City Section members are shown at the October meeting.

TULSA
OCTOBER 27
Speaker: Warren Price, regional sales manager
Affiliation: Chart Industries
Topic: Cryogenics
Activity: The event was held in Tulsa, Okla.

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

CORPUS CHRISTI
OCTOBER 22
Speaker: Carlos de la Garza
Affiliation: Chase Power Development, LLC, public relations
Topic: The expected impact of the Las Brisas Power Plant on the community
Activity: The program was held at the Radisson Hotel in Corpus Christi, Tex.

HOUSTON
OCTOBER 22
Speakers: Gary Gries and Mark Carte
Affiliation: Olympus NDT, field engineers
Topic: Phased array inspection
Activity: This was a joint meeting with members of the local ASNT chapter.
More than 140 members and guests attended the program, held at Brady’s Landing in Houston, Tex. Chairman John Stoll accepted the Henry C. Neitzel Award (2008-2009) from John Bray, District 18 director. Derek Stelly received the District Meritorious Award.

SABINE
OCTOBER 20
Speaker: John Stoll
Affiliation: Metrode Products, Ltd.
Topic: The effects of P-91 on welding
Activity: Advisor John McKeohan attended with his students from the Lamar Institute of Technology Student Chapter. Also attending was John Bray, District 18 director.

Houston Section Chair John Stoll (right) receives the Henry C. Neitzel Award from John Bray, District 18 director.

Warren Price (left) concocts a warlock’s brew using cryogenics to the amazement of Jamie Pearson, Tulsa Section chairman.

John Stoll (left) is shown with Morris Weeks at the Sabine Section program.

Carlos de la Garza addressed the Corpus Christi Section.

San Antonio Section Vice Chair Steve Sigler (left) presents a Texas-sized speaker gift to Kevin Ford.

Derek Stelly (right) receives the District Meritorious Award from John Bray, District 18 director.
Members of the Floresville High School Student Chapter attended the San Antonio Section program.

Joe Omt discussed flamespray applications at the September Olympic Section program.

Speaker Christine West is shown with Peter Macksey, Alaska Section chairman.

Gary Feaster (right) receives his Silver Membership Award from Alaska Section Chair Peter Macksey.

Speaker Bob Van Deelen (right) is shown at the British Columbia Section program with Neil Shannon, District 19 director.

Sid Capouillez (left) is shown with Victor Matthews, AWS president, at the Puget Sound Section program.

Sjon Delmore (left) is shown with speaker Jeff Sharpe at the October Olympic Section program.
AWS President Victor Matthews (center) is shown with his wife, Sally, and Rob Rothbauer, Olympic Section chairman.

SAN ANTONIO
November 10
Speaker: Kevin Ford, regional manager
Affiliation: Plymovent Corp.
Topic: Environmental regulations update and review
Activity: The program was held at St. Philip’s College in San Antonio, Tex. Members of the Floresville High School Student Chapter, Clifton Rogers, advisor, attended the program.

OLYMPIC
September 21
Speaker: Joe Ornt, owner
Affiliation: Flamespray NW
Topic: Thermal flamespray applications and advances
Activity: The program was held at Bates Technical College in Tacoma, Wash.

October 20
Activity: The Olympic Section members toured CK Worldwide in Auburn, Wash. Jeff Sharpe, vice president, discussed cost savings utilizing his company’s designs, then conducted a tour of the facilities.

OLYMPIC-PUGET SOUND
November 11
Speaker: Victor Matthews, AWS president
Affiliation: The Lincoln Electric Co.
Topic: Opportunities in the welding industries
Activity: This joint Olympic and Puget Sound Section program was held at Pacific Northwest Ironworkers #86 Hall in Tukwilla, Wash.

PUGET SOUND
November 5
Speaker: Elaine Thomas, director of metallurgy
Affiliation: Bradken-Atlas
Topic: Duplex stainless steel alloys
Activity: This was a joint meeting with members of the ASM Int’l. Seattle Chapter. Sid Capouillez received the District CWI Award. Jerry Hope received the District Meritorious Award. AWS President Victor Y. Matthews and Sally Matthews were special guests at the program.

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

ALASKA
October 16
Speaker: Christine West
Affiliation: The Business MD
Topic: Creating more productive employees
Activity: Jeff Dietz, FAA, made a presentation on the new restrictions for transporting compressed gases in aircraft. Gary Feaster of Greatland Welding and Machine was awarded his Silver Membership Award for 25 years of service to the Society.

BRITISH COLUMBIA
October 20
Speaker: Bob Van Deelen, technical manager for NAFTA operations
Affiliation: Sandvik Materials Technology
Topic: The evolution of stainless steels
Activity: District 19 Director Neil Shannon attended the program, held at the UA Piping Trades School in Delta, B.C., Canada.

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

COLORADO
September 10
Activity: The Section members met at EagleSpan Steel Structures in Loveland, Colo., for a tour and presentation by Sergio Plaza Sr., vice president of operations. The company sponsored the entire program.

October 8
Activity: The Colorado Section members met at the Lincoln Electric Denver, Colo., office for a presentation on the latest welding equipment and procedures made during the past year by Dave Fullen, district manager, and Myron Delgado.

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

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

SAN FRANCISCO
November 3
Speaker: Victor Matthews, AWS president
Affiliation: The Lincoln Electric Co.
Topic: Careers in welding
Activity: Scott Miner, a welding instructor at Las Positas College in Livermore,
Germany Section members are shown with AWS officials (from left) Jeff Weber (standing), and (seated) Ray Shook, Earl Lipphardt, and Victor Matthews, president.

Colorado Section Chair Dean Mitchell (left) chats with presenters Myron Delgado (center) and Dave Fuller.

Shown at the San Francisco Section program are (from left) Liisa Pine, AWS President Victor Matthews, Sally Matthews, and Dale Flood, District 22 director.

International Section

Germany

SEPTEMBER 14
Activity: Chairman Christian Ahrens hosted the business meeting and luncheon during the Essen Welding and Cutting Fair in Essen, Germany. Attending were AWS officials Victor Matthews, president; Ray Shook, executive director; Jeff Weber, assoc. executive director; and Earl Lipphardt, treasurer. Discussed were future activities, mounting a Section home page, organizing seminars and activities possibly with the German Welding Society (DVS), and the feasibility for pursuing a double membership agreement between AWS and DVS to attract new members.
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**Answer the following about this paper**

- Original submittal? Yes □ No □
- Progress report? Yes □ No □
- Review paper? Yes □ No □
- Tutorial? Yes □ No □
- Tutorial? Yes □ No □

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

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

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**Guidelines for abstract submittal and selection criteria:**

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

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

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

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

- Check the category that best applies:
  - □ Technical/Research Oriented
  - □ Applied Technology
  - □ Education
Proposed Title (max. 50 characters):
Proposed Subtitle (max. 50 characters):

Abstract:
Introduction (100 words max.) – Describe the subject of the presentation, problem/issue being addressed and its practical implications for the welding industry. Describe the basic value to the welding community with reference to specific communities or industry sectors.

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

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

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

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

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

Return this form, completed on both sides, to
AWS Education Services
Professional Program 2010
550 NW LeJeune Road
Miami FL 33126
FAX 305-648-1655

MUST BE RECEIVED NO LATER THAN MARCH 31, 2010
Cable Tray Systems Standard Released

Recently released, the third edition of VE 1-2009, Metal Cable Tray Systems, has also been published as CSA C22.2 No. 126.1-09, by the Canadian Standards Assn. The standard specifies the technical requirements concerning the construction, testing, and performance of metal tray systems for use in North America. It supersedes the second edition published in 2002. The revisions include changes to the fill depth section and requirements for load testing for wire mesh. The load class designation table was split into separate tables for the United States and Canada. The contents and scope of VE 1-2009 may be viewed, or a hard copy or electronic copy purchased, for $64 on the Web site, or order by phone.

National Electrical Manufacturers Assn.
www.nema.org
(800) 854-7179

Laser Safety Guides Online

Four online pages present the basic guidelines needed to be a safe and educated laser user according to ANSI Z136.1, Laser Safety in the U.S.A., and EN 60825.1 — Laser Safety in Europe. The topics are Laser Basics, Laser Safety Regulations, Lasers and the Eye, and Laser Safety Filter Guide. Considered are the types of light, effect on the eyes, and why laser radiation is more dangerous than conventional light sources. The filter guide section clarifies filter technologies, optical density, and how to select laser protective eyewear.

Laservision
www.lasersafety.com
(800) 393-5565

Inspection Lamps Pictured

A 32-page catalog illustrates and describes the company’s wide variety of black light (UV-A) and blue light inspection lamps for use with liquid penetrant and magnetic particle inspection. Detailed are the OPTIMAX™ 365 and TRI-TAN™ models that use ultrahigh-flux LED technology, and superhigh-intensity UV HID lamps including the MAXIMA™ 3500, B1B-150P, and SB-100P series, and the UV-400 series of SuperFlood™ lamps. Pictured is the OPTIMAX™ 450, a lightweight, cordless, rechargeable flashlight with thin-film dichroic filter lens that improves contrast and fluorescent response. Included is a line of high-accuracy digital radiometers. The Spectroline® NDT Catalog may be downloaded from the Web site or call for a hard copy.

Spectronics Corp.
www.spectroline.com
(800) 274-8888

Fixturing Solutions CD Offered

A recently updated Fixturing Solutions CD includes an overview and video along with detailed information about the company's fixturing products and services, and links to the complete online catalogs. New items include dedicated manual fixturing and Jakob Antriebstechnik clamps with new CAD models, plus an ISO conversion calculator and measurement unit converter. The products offer high clamping forces with reduced machine setup and cycle times, improved operator safety, and reduced workpiece handling. The CD and other literature may be ordered from the Web site.

Advanced Machine & Engineering Co.
www.ame.com/requestbrochures.cfm
(815) 316-5277

OSHA Offers Scaffolding Training Slide Show

A 50-slide PowerPoint presentation offers new training and reference mate-
mials on scaffolding designed to enhance the safety of the 65% of all construction workers who work on scaffolds frequently. The well-illustrated program can be downloaded or viewed online. The purpose of the program is to update existing standards to include types of scaffolds such as catenary and step trestle, allows flexibility in the use of fall-protection systems to protect employees, simplifies language, eliminates duplicative outdated provisions, consolidates overlapping requirements, and allows employers compliance flexibility. Details are provided on platform construction for supported and suspension scaffolds, mobile scaffolds, pump jack, ladder jack, single-point adjustable and two point swing stage, multilevel, aerial lifts, personnel access requirements, clearance near overhead lines, guardrail specifications, protection from falling objects, training and retraining, plus a listing of the common OSHA citations.

OSHA

Video Teaches Tip Care for Lead-Free Solders

The video, Soldering Iron Tip Care (DVD-15C), is designed to train technicians on the proper care for soldering iron tips to avoid many of the pitfalls associated with lead-free soldering. Arranged in three sections, the first provides an overview of the tip-life issues. The second section details oxidation buildup, recommended tip maintenance, and the effects of overusing tip tinders and other abrasive products. The last section describes the typical mechanisms that damage tips and discusses the recommended procedures to minimize these damaging effects. Included are a leader’s guide, review questions, English subtitles for hearing-impaired students, and IPC training certification documents for presentation to the students who successfully complete the final exam. The program is also available electronically for online study.

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ASM Offers Free Articles from Its Latest Handbook

The company offers three articles that may be downloaded free of charge from its Web site in celebration of the launch of the latest addition to the ASM Handbook series, Vol. 22A, Fundamentals of Modeling for Metals Processing. The titles include Introduction to Fundamentals of Modeling for Metals Processing, Crystal-Plasticity Fundamentals, and Neural-Network Modeling. Written for modeling practitioners and those needing to learn modeling methods, the new handbook provides an overview of the development of models of metallic materials and how the materials are affected by processing. Background information is provided on fundamental modeling methods and the underlying physics that supports the mechanistic method of many industrial simulation software packages, and equal coverage is provided for the phenomenological method.

ASM International
www.asminternational.org
(815) 316-5277

Aluminum Alloy ‘Pink Sheets’ Updated

The Designations and Chemical Composition Limits for Aluminum Alloys in the Form of Castings and Ingot, also known as the Pink Sheets, has been updated to include the chemical compositions for more than 260 aluminum alloy castings and ingots registered with the association. Superseding the 2008 edition, it also contains useful information on former designations and a list of previously registered alloys that are currently inactive. The document lists for $40, $20 for association members.

The Aluminum Association
www.aluminum.org
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**Vianco Named ASM Fellow**

Paul T. Vianco, an AWS Fellow, was inducted as a Fellow of ASM International, Class of 2009, “for significant and sustained contributions toward understanding the physical and mechanical metallurgy of solders, and the long-term reliability of soldered interconnects.” Dr. Vianco is a Distinguished Member, Technical Staff, at Sandia National Laboratories, Albuquerque, N.Mex. He has been an AWS member since 1988, chairs the AWS C3 Technical Committee on Brazing and Soldering, and is a member of the Technical Activities Committee. He is the author of the AWS Soldering Handbook, third edition, 1999, and is currently drafting the first C3 Committee soldering specification, C3.11M/C3.11, Specification for Torch Soldering. He has published numerous articles and peer-reviewed papers in the Welding Journal, including AWS Breaks New Ground with Soldering Specification and Soldering Technology: The Environmental Mandates and the Path Forward.

He received the Robert L. Peaslee Brazing Award in 2001 for his paper, Titanium Scavenging in Ag-Cu-Ti Active Brazing Joints, cited as the “paper considered to be the best contributing to the science or technology of brazing published in the Welding Journal during the previous calendar year.”

His latest papers of note include Corrosion Issues in Solder Joint Design and Service, and Determining the Mechanical Strength of Soldered Joints.

Dr. Vianco has made significant and sustained contributions to the advancement of the science and technology of lead-free soldering and modeling of solder joint reliability. His extensive research has included filler metal alloy development, interfacial wetting behavior, three-dimensional solid-state growth kinetics, thermomechanics, and lifetime predictions. He has investigated metal-metal and ceramic-metal brazing technologies, and holds two patents. He also has served as proceedings cochair/editor on technical program planning committees for the International Brazing and Soldering Conference cosponsored by AWS and ASM International. He has advanced the careers of many others through his strong mentorship and encouragement.

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**Member Milestone**

**Vianco Named ASM Fellow**

Paul T. Vianco

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**Precision Metalforming Names 2010 Board Chair**

Precision Metalforming Assn., Cleveland, Ohio, has named Gretchen Zierick chair of the board of directors for 2010, a one-year term. Zierick is president of Zierick Manufacturing Corp. based in Mount Kisco, N.Y.

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**SME 2009 College of Fellows Announced**

The Society of Manufacturing Engineers (SME), Dearborn, Mich., has named nine to its College of Fellows for outstanding accomplishments in engineering, research, or business. Inducted were David Cole, chairman, Center for Automotive Research; Jerry Y. H. Fuh, professor, National University of Singapore; Chia-Hsiang Meng, professor, The Ohio State University; Sudhakar M. Pandit, professor, Michigan Technological University; Albert J. Shih, professor and associate director, Medical Innovation Center, University of Michigan; David A. Stephenson, research assistant, University of Michigan; Albert J. Wavering III, acting deputy director, National Institute of Standards and Technology, Gaithersburg, Md.; Kazuo Yamazaki, professor, University of California, Davis; and John C. Ziegert, professor, Clemson University.

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**Toshiba Imaging Appoints Sales Director**

Toshiba Imaging Systems Div., Irvine, Calif., has appointed Paul Dempster director, medical imaging and factory automation. Dempster, with 20 years of experience in the diagnostic imaging community, previously served as president of NAI Tech Products, a supplier of video interface technology.

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**Kaman Industrial Appoints VP and COO**

Kaman Industrial Technologies Corp., Bloomfield, Conn., has appointed Steven J. Smidler to the newly created position of senior vice president and COO. Before joining the company, Smidler served Lenze Americas Corp. as executive vice president for marketing, sales, finance, business systems, and product technology for the Americas.

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**Industrial Scientific Appoints VP Global Operations**

Industrial Scientific, Pittsburgh, Pa., a gas detection provider, has named Tom Cunningham vice president, global operations. Before joining the company, Cunningham served as director of design and manufacturing for Medrad’s cardiovascular disposable products.

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**Hypertherm Fills Four Key Posts**

Hypertherm, Hanover, N.H., has named four new members to its management team. Jeff Deckrow now serves as
vice president of North American sales; Peter Vickers now serves as vice president of international; Dave LaPrade is now vice president and general manager of systems; and Gordon Rice serves as vice president and general manager of consumables. Previously, Deckrow was regional director for North America; Vickers served as regional director for Europe; LaPrade was team leader for mechanized business; and Rice served as team leader for the torch and consumables business.

Aluminum Assn. Names Boultinghouse Awardee and Board Members

The Aluminum Association, Arlington, Va., has named Bob Longenecker to receive its Marian Boultinghouse Award to acknowledge his “gift for bringing together leaders holding contrasting views, and his work that has promoted metal and made the Aluminum Association stronger.” Longenecker is chairman of KB Alloys, LLC, and a founding member and past chairman of the Master Alloy and Additives Division.

The association named several new members to its board of directors. Steven J. Demetriou was named chairman, Thomas A. Brackmann was elected vice chair; and Jean Simon, Marie D. Kistler, and Kevin Kramer were named to the board of directors. Demetriou is chairman and CEO of Aleris International, Inc. Brackmann is president of Nichols Aluminum. Simon serves as president of Primary Metal — North America; and Kistler is the North America marketing manager — Primary Metals at Air Products and Chemicals, Inc. Kramer, also appointed to the board’s executive committee, is president, Alcoa Growth Initiatives.

Regional Manager Appointed at Reed Mfg.

Reed Manufacturing Co., Erie, Pa., has named Jeff Esmont regional manager for Ohio, Kentucky, southern Michigan, western New York, and northwest Pennsylvania. Previously, Esmont worked at Milwaukee Electric Tool for 25 years where he most recently managed accounts in northeast Ohio and western Pennsylvania.

AMT Elects New Board Members

The Association for Manufacturing Technology (AMT), McLean, Va., elected new 2009-2010 officers Oct. 23 in Orlando, Fla. Daniel D. Janka was named chairman, Eugene R. Haffely Jr. was appointed first vice chair, and Timothy B. Dining was named second vice chair and treasurer. Janka is president of MAG Global. Haffely is COO, Assembly & Test Worldwide, Inc. Dining is president and CEO, Greeneer Press and Machine Co., Inc.

Terry Peshia Receives AISC Stupp Award

The American Institute of Steel Construction (AISC), Chicago Ill., has presented its prestigious Robert P. Stupp Award to Terry Peshia. Peshia, chairman and CEO of Garbe Iron Works, Inc., Aurora, Ill., was cited for his “unparalleled leadership in the fabricated structural steel construction industry that has had an outstanding impact on advancing the use of structural steel in the construction industry.”

Obituary

George Griebeler

George Griebeler, 68, died Oct. 5 in Mesa, Ariz., following a brief illness. Griebeler is credited with developing the Burny B, one of the first NC controls for welding and thermal plate cutting in the U.S. The controls are currently manufactured by ITT and are used in a wide variety of shape-cutting applications. He made the invention together with his brother Elmer, and input from Richard Mills of Mills Alloy, and manufacturing assistance from Cleveland Machine Controls. He is survived by his wife, Rita, four children, and five grandchildren.

STAINLESS Q&A

— continued from page 20

outside of the region where solidification mode boundaries are known, its position suggests solidification as primary ferrite by extrapolating the boundary between FA and AF solidification. So 15-5PH should be free of solidification cracking issues. The 304L position is at slightly less than 4 FN, in the FA region of primary ferrite solidification — this is normal for 304L commercial products. The tie-line indicating all possible mixtures of 304L and 15-5PH lies almost exactly along the 4 FN iso-ferrite line in the diagram. The midpoint of this tie-line is marked but not labeled and indicates what can be thought of as a synthetic base metal consisting of half 15-5PH and half 304L. The ER308L position is in the FA region of primary ferrite solidification, at about 8 FN. Then a second tie-line is drawn from the ER308L to the synthetic base metal composition at the midpoint of the tie-line connecting the two base metals. Finally, the position of the dissimilar metal weld at 30% dilution is indicated along the second tie-line.

Examination of Fig. 1 indicates that ER308L is metallurgically a very safe choice for the weld between 15-5PH and 304L. The possible diluted weld metal compositions along the second tie-line are all in the region FA of primary solidification, so no difficulty with solidification cracking is expected. Further, the possible compositions of diluted weld metal are all above the martensite boundary except for nearly 100% dilution (near the synthetic base metal composition), which is highly unlikely unless you use autogenous GTAW instead of pulsed GMAW. So the weld metal can be expected to be highly ductile. Finally, the diluted weld metal will be low enough in ferrite (8 FN or less) so that no serious embrittlement due to sigma phase formation during the H1100 heat treatment would be expected.

ER308L is not the only appropriate choice, but it has the lowest cost and is the most readily available. ER316L and ER16-8-2 would also be suitable choices, following a similar analysis as was done in Fig. 1.

DAMIAN J. KOTECKI is president, Damian Kotecki Welding Consultants, Inc. He is a past president of the American Welding Society, currently treasurer and a past vice president of the International Institute of Welding, and a member of the AWS ASD Subcommittee on Stainless Steel Filler Metals, and the AWS DJK Subcommittee on Stainless Steel Structural Welding. He is a member and past chair of the Welding Research Council Subcommittee on Welding Stainless Steels and Nickel-Based Alloys. E-mail your questions to Dr. Kotecki at damian@damiankotecki.com, or send to Damian Kotecki, c/o Welding Journal, 550 NW LeJeune Rd., Miami, Fl. 33126.
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Repairing an Underwater Pipeline

Divers followed these steps to repair a heavily corroded flange underwater in the Caribbean Sea

BY UWE W. ASCHEMEIER AND KEVIN S. PETERS

During the annual inspection of the nonmetallic transfer hoses at a hydrocarbon unloading facility in the Caribbean, a heavily corroded flange (Fig. 1) on an 8-in. stationary steel pipe was discovered.

The hoses are part of a system in which two parallel 8-in. Schedule 80 pipelines of API 5L Grade B steel connect a tank farm onshore with the flexible nonmetallic transfer hoses on the bottom of the sea. The ends of the hoses are connected to tankers, moored during the unloading process on mooring buoys. Annual inspections of the hoses are required. This inspection process calls for divers to disconnect the hoses, which are then pulled out of the water for a thorough visual inspection on land.

In late 2008, major maintenance work was performed on the pipeline, including the removal and inspection of the hoses, as well as changing bolts and gaskets.

A routine inspection with a remotely operated vehicle (ROV) this summer revealed a heavy calcium layer on the flange of the stationary pipe on the south pipeline. Further investigation with the ROV confirmed heavily corroded and eroded material around the bolt holes in the flange of that pipe.

It was discovered that during the maintenance work performed in late 2008, stainless steel bolts without insulation were used on the mild steel flanges. Without insulated bolts, galvanic corrosion—an electrochemical action of two dissimilar metals in the presence of an electrolyte and an electron conductive path—could take place.

The owner of the facility contacted Miami Diver Inc., Miami, Fla., to remove the corroded flange from the stationary pipeline and replace it with a new flange.

After reviewing the pictures taken by the ROV and the original project specifications, it was decided to cut off the damaged flange and weld a slip-on ANSI Class 150 flange onto the pipeline. The flange material was ASTM A 105 with the bore to match the existing API 5L Grade B, 8-in. Schedule 80 steel pipe.

Welding Procedure Development and Welder Qualification

The first step for Miami Diver was to write a repair and welding procedure, which the client and a governmental organization had to approve. The procedure listed a step by step approach for the repair, including the welding procedure specification (WPS) and welder performance qualification (WPQ) for the underwater welding work that would be performed.

It was decided to use the wet shielded metal arc welding (SMAW) process, with Hydroweld FS electrodes. Diver welders qualified to the requirements of AWS D3.6M:1999, Specification for Underwater Welding, would make the repairs.

Once all the approvals were obtained, welder qualification took place at the Miami Diver facility in Miami. A PQR for welding fillet welds on pipe had already been established and approved by Lloyds Registrar. A WPS for the welder qualification was written, as is practice with the classification societies. Three diver
welders and the H. C. Nutting welding engineer retained by Miami Diver practiced for one day, prior to the tests being witnessed by the Lloyds surveyor.

The tests were performed in a 35,000-gal tank at a water depth of 18 ft on a 5-in.-diameter Schedule 80 pipe, welded to a 1-in.-thick base plate in the 5F position. The progression of the welds was downhill. The fillet weld between the pipe and the plate was a \( \frac{3}{8} \)-in. multilayer weld containing three passes.

In accordance with AWS D3.6, this test qualifies the diver welders for welding pipe diameters between 2.5 and 10 in. (70 and 280 mm), with production weld sizes between 1.5S and a minimum production weld size of 0.5S (where S is the leg length of the qualification weld), with the SMAW wet process.

During the practice run, every welder was able to weld two test coupons under the test conditions — Fig. 2. The test pieces were tested as required per AWS D3.6: four fillet weld break tests and four macroetch tests — Fig. 3. At the end of the day, the welders and welding engineer were satisfied with the results and were ready for the surveyor to witness the tests the next day.

The tests witnessed by Lloyds Registrar occurred without any problems. The tests were welded in the tank and visually inspected. After acceptance under the critical eyes of the welding engineer and Lloyds surveyor, four fillet weld break tests and four macro samples were removed from every test assembly welded — Fig. 4. All three welders passed the tests on the first attempt.

**Removal of the Damaged Flange**

The repair procedure called for the damaged flange to be cut off underwater. To produce a quality cut, a very precise saw was needed. A split frame low clearance saw, manufactured by the E. H. Wachs Co., Lincolnshire, Ill., seemed to be the right tool for the job. E. H. Wachs agreed to send a technician to Miami to explain the saw to the team assigned to do the flange repair.

The saw features a ring that clamps around the pipe, and two cutting tools offset 180 deg from each other that rotate around the pipe and perform the cut. The hydraulically driven machine produces a high-quality cut. The machine can make a 90-deg cut, or it can produce any other joint geometry with any opening angle possible.

Upon arrival in the Caribbean, a
Fig. 6 — This concrete mat over the pipe prevented the use of lift bags.

Fig. 7 — Dive supervisor Peter Joenson dressing the diver.

Fig. 8 — A diver installs the saw on the pipe.

Fig. 9 — The saw performing the cut underwater. A stingray came by to check everything out.

Fig. 10 — Diver Chris Miezen employs the wet SMAW process and a Hydroweld FS electrode to weld the slip-on flange to the pipeline.
meeting was scheduled at the client’s facility. The team split in two groups. The welding engineer and the dive supervisor met with the client to discuss the project and to receive a safety orientation. Two divers met with the rest of the crew, who had arrived with the dive boat, which was already waiting at the dive site — Fig. 5.

The nonmetallic hoses had already been disconnected and stored on land. The repair work was scheduled for three days, during which an inspection dive needed to be performed to evaluate the extent of the damage, and then the corroded flange had to be cut off and replaced. After welding the new flange onto the pipe, the hoses had to be reconnected, a pressure test performed, and finally a last inspection dive made. During that dive, video footage of the submarine facility would be taken for the client to view.

**The Crew**

The dive crew consisted of the dive supervisor, welding engineer, and two divers. The dive boat crew included the captain, one diver, and two deckhands.

The first dive was to inspect for and to videotape the extent of the damage. The diver also evaluated the discussion on how to proceed with the repair. It was critical to have enough room underneath the pipe to install the saw and to allow the diver welder to weld in the overhead/6 o’clock position.

The object of the second dive was to create the necessary space underneath the pipe. The first thought was to raise the pipe at the end with lift bags, but that had to be reconsidered since a concrete mat was installed over the pipe, approximately 15 ft from the end — Fig. 6.

Since lifting was out of the question, the sand underneath the end of the pipe had to be jetted. Jetting proved to be more challenging than initially thought, because the sand was so fine and kept slipping back into the jetted area. However, the diver (Fig. 7) finally removed enough material to create sufficient space to weld in the overhead/6 o’clock position.

**Cutting the Pipe**

It took two divers approximately 45 min to install the saw for cutting the pipe — Fig. 8. The first thought was to raise the pipe at the end with lift bags, but that had to be reconsidered since a concrete mat was installed over the pipe, approximately 15 ft from the end — Fig. 6.

Since lifting was out of the question, the sand underneath the end of the pipe had to be jetted. Jetting proved to be more challenging than initially thought, because the sand was so fine and kept slipping back into the jetted area. However, the diver (Fig. 7) finally removed enough material to create sufficient space to weld in the overhead/6 o’clock position.

**Installing the Hoses**

The four flexible nonmetallic transfer hoses on the north and south pipeline needed to be reinstalled. The hoses were capped to make them buoyant and float on the surface to the approximate location where they needed to be connected. To sink the hoses, the divers removed the caps and flanged the hoses together, using insulated fasteners and new gaskets. The last hose on each side received a blind flange to seal the system prior to pressure testing.

**Welding the Flange**

Before welding began, the coating and marine growth needed to be removed from the weld area and the nearby heat-affected zone. The paint in the weld area and heat-affected zone of the new flange was also removed with a grinder. In addition, the paint in the flange’s inside hole was removed.

The diver slipped the flange over the pipe end, and leveled it with a protector and distance holders made out of welding rods to ensure a uniform root opening around the pipe.

The plate was tack welded to the pipe near the weld zone to serve as a connection piece for the ground clamp.

The flange was first tacked with four tack welds placed in the 3, 6, 9, and 12 o’clock positions. Next, the slag was removed from the tack welds and welding of the root pass started. The diver welder started in the 12 o’clock position to weld downhill toward the 6 o’clock position — Fig. 10. Two cover passes followed to complete the joint.

The completed weld was visually inspected and passed the acceptance criteria for Class B welds in accordance with AWS D3.6, *Specification for Underwater Welding*. The finished weld was also videotaped for the client to evaluate.

To protect the finished weld, underwater epoxy was applied to create a strong, permanent seal — Fig. 11.

**Pressure Test and Final Inspection**

The client requested a pressure test to be performed at 225 lb/in.². The pressure needed to be held for 15 min without any leaks. The leak test showed a pressure loss in one location. After the fasteners in the location in question were retightened, the pressure held.

The last task was an inspection dive along the pipeline and the transfer hoses, with the buoys reconnected at the ends. This dive was videotaped and witnessed by the client.
Air vs. Water Cooled: Which GMAW Gun Type Is Right for Your Application?

Ergonomics and amperage are two important factors affecting productivity

BY ANDY MONK

For some companies, choosing between an air-cooled or a water-cooled gas metal arc (GMA) welding system is pretty cut and dry. Mobile fabrication and repair companies that weld sheet metal for only a few minutes every hour will have little need for the benefits provided by a water-cooled system. Likewise, shops with stationary equipment that repeatedly weld at 800 A probably won’t be able to find an air-cooled system that can handle the heat of the application.

Air vs. Water Cooling — Which Method Is Right for You?

For many companies though, choosing...
between air and water cooling is not an easy decision. Each type of cooling system has its advantages and disadvantages, and deciding which is right for your company requires a careful analysis of the following factors:

- Amperage requirements
- Duty cycle
- Welding gun weight and operator comfort
- Work site location
- Costs

Keeping GMA welding equipment cool is necessary to protect the power cable, gun, and consumables from damage from the radiant heat of the arc and the resistive heat from the electrical components in the welding circuit. Cooling also protects the operator from heat-related injuries and provides more comfortable working conditions.

Comparing Water- and Air-Cooled Systems

A water-cooled GMA welding system pumps the cooling solution from a radiator unit, usually integrated inside or near the power source, through connecting hoses inside the power cable and into the gun handle, neck, and consumables. The coolant returns to the radiator where the radiator’s baffling system releases the heat absorbed by the coolant. The ambient air and shielding gas further disperse the heat from the welding arc.

In an air-cooled GMA welding system, cooling relies solely on the ambient air and shielding gas to dissipate heat that builds up along the length of the welding circuit. Air-cooled systems use much thicker copper cables than water-cooled systems, which allows the cable to transfer the electricity to the gun without building up excessive heat from electrical resistance — Fig. 1. By contrast, water-cooled systems use relatively little copper in their power cables because the cooling solution carries away the resistive heat before it builds up and damages the equipment — Fig. 2.

Amperage Requirements

The welding amperage will be an important factor to consider when deciding between an air- or water-cooled system. In general, air-cooled systems are recommended for low amperages and water-cooled systems are better for high-amperage applications.

Air-cooled guns are available with ratings from 150 to 600 A. Water-cooled guns range from 300 to 600 A. These ratings represent the current loads under which the guns become so warm that they are uncomfortable for the average operator to hold. Because guns are rarely used to the limits of their duty cycle, it's often a good idea to purchase a gun that's rated to a lower amperage than the maximum to which it will be exposed. For example, a 300-A gun can handle more than 400 A, and it is substantially lighter and more maneuverable than a 400-A gun.

Duty Cycle

Closely related to a gun's amperage capacity is its duty cycle — the amount of time during a 10-min period that the gun can operate at its rated capacity without becoming uncomfortably hot. Exceeding a gun’s duty cycle can lead to operator pain and will also reduce weld quality and decrease the service life of the gun and consumables.

There is no industry standard for establishing amperage ratings based on duty cycle, so two guns both rated to 400 A could have significantly different duty
cycles. This makes it important for the customer to consider a gun’s amperage rating and duty cycle together in order to form an accurate assessment of the GMAW gun’s capabilities.

**Gun Ergonomics**

Working all day long in an industrial or construction environment can take a significant toll on the welder’s hands, arms, shoulders, and back, as well as most other body parts. A heavy, bulky, and difficult-to-maneuver gun only exacerbates these aches and pains, and it accelerates the time they take to set in.

One of the benefits of water-cooled guns is their reduced size and weight. Because water is more efficient than air at carrying away the heat that builds up from the heat of the arc and electrical resistance, water-cooled guns use fewer wires for their cables and smaller gun components, resulting in reduced operator fatigue.

Although air-cooled guns are generally heavier and more difficult to maneuver than water-cooled guns, significant differences in gun design between manufacturers can also have a big impact on how quickly the gun contributes to fatigue. It’s a good idea to physically hold the gun to determine its comfort level prior to making a purchase.

**Welding Site Location**

Because water-cooled guns require more equipment than air-cooled systems, they can be impractical for applications that require portability — Fig. 3. Transporting the cooling system and coolant hoses of a water-cooled GMAW gun can reduce productivity and cause additional downtime. Water-cooled systems are most practical for applications where the equipment remains stationary or is seldom moved. By contrast, air-cooled GMAW guns are easily carried and transported from site to site within a shop or out in the field.

**Comparing Costs**

Finally, it is important to consider the costs of the two systems before making a purchasing decision. Doing so, however, is not as simple as looking at their respective price tags. In addition to the sticker price of the systems, purchasers should consider the maintenance costs as well as the productivity and downtime costs associated with operator fatigue and equipment longevity.

**Water-Cooled System Concerns**

A water-cooled system requires the purchase of a coolant flow system (including radiator, pump, hose lines, etc.) that leads to a higher up-front cost than an air-cooled system. Because water-cooled systems require a special coolant solution in order to avoid mineral or algae buildup in the coolant lines and radiator, they require more extensive maintenance and higher operational costs than an air-cooled system. Furthermore, coolant leaks can lead to equipment damage and weld discontinuities that add to the cost of owning a water-cooled system.

**Air-Cooled System Features**

In addition to being less expensive initially, an air-cooled system also offers the advantage of being better suited to low-amperage applications. Thus, for example, a company that needs to weld at 150 A and 600 A in the same weld cell can keep its costs down by purchasing a single air-cooled system rather than a water-cooled system for the high-amperage applications and an air-cooled system for the low-amperage applications.

That doesn’t mean, however, that a water-cooled system is more expensive than an air-cooled system. As mentioned earlier, a water-cooled GMAW gun is smaller and lighter than an air-cooled gun, which can help decrease operator fatigue and increase productivity over the course of a day.

When set up properly, a water-cooled GMAW gun can provide significant long-term cost savings compared to an air-cooled gun. The coolant in a water-cooled system also extends the service life of the consumables by drawing away the heat absorbed from the arc. Longer consumable life means less downtime for changeovers and lower consumables inventory.

**Conclusions**

Unfortunately, there is no one-size-fits-all formula for choosing between an air-cooled and a water-cooled GMAW system. Each company must analyze its welding operations to determine which type of cooling system offers the most benefits. Considering all of the factors — cost, work site location, gun weight, operator comfort, duty cycle, and amperage requirements — will provide a good start toward making a wise decision.
Getting the Most Out of Your Exothermic Cutting Equipment

A set of guidelines is provided for operating and performing this technology

BY CURT WILSONCROFT

The exothermic process, which has been around for many years, releases energy in the form of heat. When used in cutting, the exothermic process uses oxygen as an exciter, thus the steel rod becomes the fuel.

As long as the oxygen flow is maintained through the torch and rod, the rod will continue to burn and consume at a temperature between 8000° and 10,000°F.

Exothermic cutting is a technology that allows cutting, piercing, and gouging on almost any ferrous or nonferrous material including steel, iron, aluminum, and magnesium — Fig. 1. Some torches, such as the SLICE® by Thermadyne, can virtually cut anything placed in front of it including copper, brass, concrete, and brick.

Used predominately for plant maintenance, building renovation or demolition, scrap cleanup, and salvage work, exothermic cutting removes edges on loaders for repair or replacement and even burns through mud or rust-covered machinery frames — Fig. 2.

One of the most common applications for exothermic cutting is pin removal on heavy equipment — Fig. 3. When a pin in heavy machinery will not budge, it must either be cut or have a hole burned through the center for removal. When piercing a hole right through the middle of the pin, the metal from it is physically removed, so the pin will actually shrink allowing for easy abstraction once cooled.

Another application that is becoming popular is fire and rescue. Since the exothermic cutting process has come a long way, many manufacturers now sell packs that come complete with a torch,
power supply, and oxygen cylinder case, which can all be worn as a backpack or carried by handles, making it practical and easy to use. This allows firefighters and rescue teams to be able to access anything that is in front of them.

While many may understand the basics of exothermic cutting strategies, real professionals must know how to operate and perform with this technology. To help educate the industry, here are some helpful tips on how to use your cutting equipment to the fullest.

**Cutting Steps to Follow**

While cutting procedures will vary from job to job, normal cutting is done by using a drag technique, where once the rod is in contact with the piece to be cut, the professional drags the rod in the direction of the cut. Described below are useful tips for a perfect cutting experience.

- Maintain proper travel speed at all times.
- The speed of the cut is too fast if the operator can’t see the kerf, and metal is being blown back at the operator.
- Always keep in mind cutting rods are consumed as long as the oxygen is flowing.
- If the operator does not keep the rod in contact with the workpiece as the rod is consuming, the rod is being used without cutting.

- Use a sawing motion when material to be cut is thicker than 1/2 to 2 in. to ensure a complete melt through the material.
- Be sure to use a smooth motion to complete the cut.
- After completing the cut, release the oxygen control level in the handle.
- Note: The cutting rod will continue to burn as long as oxygen is supplied, so be sure to hold the torch safely away from your body until the rod cools.

**Strategies for Piercing Surfaces**

Special procedures must be used when piercing to promote safety for the end user and a high-quality finish on the product. When piercing, use a collet extension, which adds life to the torch, and hand shield to greatly improve operator safety and comfort. Be sure to hold the torch at arm’s length and wear proper protective clothing, and eye and ear protection. If possible, remove the cutting rod from the hole before releasing the oxygen lever to help prevent the cutting rod from getting stuck inside the pierced hole.

To pierce solids follow these instructions:

- Strike the cutting rod on the striker.
- Hold the torch at arm’s length.
- Keep the cutting rod at a 90-deg angle (perpendicular) to the pierce point.
- Slowly push the cutting rod in at the pierce point until you’re at proper depth or until you’ve achieved melt-through.

**Oxygen Usage**

Another crucial aspect of exothermic cutting is oxygen usage. The cutting process uses standard industrial grade oxygen to support the exothermic reaction and to remove the molten metal. All SLICE equipment uses standard oxygen fittings. The most commonly recommended operating pressure is 80 lb/in.². Applications such as cutting material sections 3 in. and thicker might require higher operating pressures. Operating pressures as low as 40 lb/in.² have been used to perform operations such as washing off rivet heads and scarfing out small cracks for repair.

The oxygen consumption rate for cutting rods at 80 lb/in.² is 7 to 7.5 ft³/min for the 3/8-in.-diameter cutting rods and 11 to 12 ft³/min for the 5/8-in.-diameter cutting rods. Of course, these rates will vary if a different operating pressure is used.

**Conclusion**

Even the best techniques for exothermic cutting equipment will change from job to job. Please be aware, as in many applications, some adjustments in operating conditions may be necessary in order to ensure you get the most out of your cutting equipment and achieve optimal safety requirements.
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- Only those abstracts submitted on this form will be considered. Follow the guidelines and word limits indicated. Complete this form using MSWord. Submit electronically via email to techpapers@aws.org or print and mail.
- Any technical topic relevant to the welding industry is acceptable (e.g. welding processes & controls, welding procedures, welding design, structural integrity related to welding, weld inspection, welding metallurgy, etc.).
- Submittals that are incomplete and that do not satisfy these basic guidelines will not be considered for competition.
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- Students enrolled in 2 yr. college and/or certificate programs at time of submittal.
- Presentation need not represent actual experimental work. Rather, emphasis is placed on demonstrating a clear understanding of technical concepts and subject matter.
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MUST BE RECEIVED NO LATER THAN April 16, 2010
Three fundamental dimensional changes that occur during welding cause the distortion found in fabricated structures. These are as follows:

1. Transverse shrinkage that occurs perpendicular to the weld interface
2. Longitudinal shrinkage that occurs parallel to the weld interface
3. An angular change that consists of rotation around the weld interface.

While welding is frequently performed in one pass, especially for thin plates, when it is performed in a number of passes, particularly when welding thick plates, shrinkage accumulates. Most transverse shrinkage that occurs in single-pass butt joints results from the contraction of the base metal. The base metal expands during welding, but when the weld metal solidifies, the expanded base metal shrinks. This accounts for a major portion of the transverse shrinkage. Shrinkage of the weld itself comprises only about 10% of the actual shrinkage.

The amount of transverse shrinkage that occurs across a fillet weld is much smaller than that which occurs across a butt joint. The amount of longitudinal shrinkage that occurs in butt joints is approximately 1/1000 of the weld length. This is much less than transverse shrinkage.

Angular change often occurs in butt joints when transverse shrinkage is not uniform in the thickness direction. The Shipbuilding Association of Japan has conducted extensive research on angular change in butt-joint welds. Figure 1 shows the groove shape that most successfully minimizes angular change in butt joints of various thicknesses.

If a joint is free from external restraint during fillet welding, the contraction of the weld metal causes angular distortion about the joint axis, as shown in Fig. 2. However, if the members are restrained in some way, the distortion depends on the degree of restraint. For example, when the movement of stiffeners welded to a plate is prevented, the plate distorts in a wave pattern, as shown in Fig. 2B.

**Controlling Distortion**

Distortion due to welding can’t be totally avoided, but steps can be taken to minimize its magnitude and effects. Following are some of the steps that help minimize distortion.

**Design**

The most economical design for a welded fabrication is that which requires the fewest number of parts and a minimum of welding. Economical designs also help reduce distortion. The type of joint preparation is important, particularly for unrestrained butt joints, because it can influence the amount of angular distortion.

With respect to fillet welds, the smallest weld that meets the shear strength requirements can be expected to produce the lowest residual stress and distortion. Thus, the use of small fillet welds will prevent overwelding and excessive distortion.

**Assembly Procedure**

Distortion can best be controlled by using one of the following assembly methods:

1. Estimating the amount of distortion likely to take place during welding and presetting the members to compensate for it.
2. Assembling the job so that it is nominally correct before welding, then using some form of restraint to minimize distortion.

Method 1 is attractive because the parts have almost complete freedom to move during welding, resulting in lower residual stress than with Method 2. However, it is difficult to apply, except on relatively simple fabrications. A good approach is to fabricate subassemblies using Method 1. These subassemblies can be welded without restraint. They then can be assembled together and welded to complete the job. Often, this final welding has to be carried out under conditions of restraint.

The restrained assembly method is generally preferred because of its comparative simplicity. The restraint can be accomplished through the use of clamps, fixtures, or tack welding.

**Elastic Prestraining**

Elastic prestraining involves bending a plate elastically before stiffeners are fillet welded to it — Fig. 3. This method significantly reduces angular changes after removal of the restraint.

**Preheating**

The application of preheat on the top of the flange plate of a T-section increases the angular distortion for some combinations of thickness and welding conditions, and decreases it for other combinations. However, preheating the bottom of the flange plate, which helps balance the heat of welding, reduces angular distortion in all combinations of thickness and welding conditions.

AWS FELLOWSHIPS

To: Professors Engaged in Joining Research

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

The American Welding Society (AWS) seeks to foster university research in joining and to recognize outstanding faculty and student talent. We are again requesting your proposals for consideration by AWS.

It is expected that the winning researchers will take advantage of the opportunity to work with industry committees interested in the research topics and report work in progress.

Please note, there are important changes in the schedule which you must follow in order to enable the awards to be made in a timely fashion. Proposals must be received at American Welding Society by **February 16, 2010**. New AWS Fellowships will be announced at the AWS Annual Meeting, November 2010.

THE AWARDS

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

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

DETAILS

The Proposal should include:

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

In addition, the proposal must include:

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

The technical portion of the Proposal should be about ten typewritten pages; maximum pages for the Proposal should be twenty-five typewritten pages. Maximum file size should be 2 megabytes. It is recommended that the Proposal be typed in a minimum of 12-point font in Times, Times New Roman, or equivalent. Proposal should be sent electronically by **February 16, 2010** to:

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

Yours sincerely,

Ray W. Shook
Executive Director
American Welding Society
Compton Celebrates His Long Career in Welding Education

BY HOWARD M. WOODWARD

Jack D. Compton, chairman of the AWS San Fernando Valley Section and an AWS Distinguished Member, has retired after teaching welding for three decades at the College of the Canyons in Santa Clarita, Calif.

Compton's peers laud him for doing much more than just teaching his students how to join two pieces of metal. He has an infectious enthusiasm for welding that successfully motivated them to learn. “If we work together,” Compton said, “we’ll accomplish good things. Synergy,” he added, “is one of my favorite words.”

He joined the American Welding Society in 1974, and is a Life Member with 35 years of service to the Society.

Compton served on the AWS board of directors from 2004 to 2008 as District 21 director. He also has distinguished himself by achieving Winner’s Circle status in the Society’s Member-Get-A-Member Campaign for recruiting 20 or more new AWS members every year for the past seven years.

He is an AWS Certified Welding Inspector, a Certified Welding Educator, and the author of the popular Guide to Certified Welder Examinations, which has sold more than 14,000 copies.

Regarding his retirement, Compton gave a lot of thought before deciding to take advantage of the college’s retirement-incentive program. He said he hopes to return to teaching soon as a part-time instructor to continue guiding students to instill in them his passion for welding.

Compton noted that during his years at the college he saw the welding classes grow from about 20 students in the first year to 250 students in the welding program now.

The welding topics he taught ranged from the basics to more complex processes. He often clocked 80 hours a week to work with his students. He also led the welding certification class, and provided the necessary texts to students who showed interest in becoming certified welders.

Compton is proud of students like Ingrid Edwards (Fig. 1) who graduated from his class last June with an associate’s degree in welding technology. He is gratified that her education in welding will serve as the foundation for her future career plans. Edwards, who received assistance from the AWS District 21 and San Fernando Valley Section scholarships, plans to pursue a bachelor’s degree in business administration then start her own welding business.

Marty Coronel studied welding with Compton from 1995 to 1997 then went on to earn her AWS Certified Welder certificate. Coronel is currently a welding sales engineer for Airgas West and a part-time welding instructor at College of the Canyons. She said that an important factor in maintaining her motivation during the training was Compton’s energy and enthusiasm for welding.

For Compton, welding is an important part of daily life. “Everything people use is made possible because of welding,” he contends. “If it’s not welded, then the thing that made it was welded.”

Compton became interested in welding as a child observing his father, who was a sheet metal welder. After high school, he worked as a gas tungsten arc welder for an aerospace company in California. Following a tour of duty in the U.S. Army as a combat engineer explosives expert and mine sweeper in Vietnam, he returned...
home where he attended Los Angeles Pierce College (LAPC) where he received an associate’s degree. He continued his education at California State University, Los Angeles, where he earned his bachelor’s degree. While still a student there, he taught welding part time at LAPC and also continued to work full time at Stainless Steel Products, Inc. (SSP), as an aerospace welder.

In 1976, Compton left SSP to teach at College of the Canyons as a drafting and welding instructor. He also taught welding for the William S. Hart Union High School District’s Regional Occupational Program.

Through difficult times and the threat of eliminating the welding program at the College of the Canyons, Compton was able to maintain and actually grow the college’s welding program. He even ran in four Los Angeles marathons to promote awareness and raise money to support the school’s welding program.

He has devoted more than 33 years training welders; serving the industry by developing the next generation of professional workers. He has served as an expert witness for a number of litigations regarding various aspects of welding.

Compton’s lifelong passion has been welding and welder training. Throughout his career he continued to keep his welding skills sharp. He has done structural welding on a number of buildings in California including the Diablo Canyon Nuclear Power Plant, and worked as a welder in the motion picture industry on such films as *Batman*, as well as serving as a certified welding inspector and consultant for several welding fabrication shops.

Most recently, Compton was honored at the AWS 90th Annual Meeting Convention and Show in Chicago, Ill., by presenting the Plummer Memorial Education Lecture titled, *Teaching Human Development Skills to Welders*. While at the Show, he also received his AWS Life Membership Certificate celebrating his 35 years of active membership in the Society.

Compton’s son, Ryan, became a member of AWS when he was only 6 years old. Ryan is 29 now, an AWS member for 23 years, and working as a special effects technician and welder. He wrote a touching letter to his father upon his retirement. In the letter Ryan said, “He provided a comfortable learning environment with food and beverages and weekly class barbecues” — Fig. 2. Ryan said in closing, “My hope today as Jack retires is that we can all carry at least an ounce of his passion for life and service to others in sight of a better world, one person at a time.”

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Eighty years ago in 1930, William Hobart Sr. recognized the need to train people to join metals using welding. Thus, the seed for what was to become the Hobart Institute of Welding Technology (HIWT) was planted. Initially, four welding booths in a corner of the Hobart Brothers Co. welding department in Troy, Ohio, were set aside for training purposes. Free training was offered to buyers of Hobart machines to make sure they operated the equipment safely and had the skills to make acceptable joints.

The next year, a director was hired to oversee the training program and within a short time the operation expanded to 15 welder booths to accommodate the increasing number of customers. When the operation expanded to 30 welding booths, the training was moved to a separate area within the factory in 1937.

On May 3, 1940, the school was incorporated as a nonprofit organization named Hobart Trade School, and the following year, the school moved into its own building near downtown Troy, featuring 52 arc welding booths and 12 gas welding stations.

The War Years

The increased need for welders during the World War II years forced the school into a two-shift operation for classes of primarily female students who found ready employment in the factory positions vacated by men serving in the armed forces — Fig. 1. Following the war, the G.I. Bill training program kept the school operating at capacity in 1946. At that time, 90% of the student body consisted of former military men who completed the entire welding program in 16 weeks. Metal-cutting equipment training and a tool and die course were added to prepare students for jobs offered by several local automobile subcontractors.

The First Major Expansion

In 1957, Hobart built a new, state-of-the-art 80,000-sq-ft building on Trade Square East known as the Hobart Brothers Technical Center, with half of the facility dedicated to the Hobart Welding School.

In 1958, a course in gas tungsten arc welding was introduced, as well as classes to train students for construction jobs in welding cross-country pipelines.

It was in the early 1960s that technical instruction was added to supplement the hands-on classes. Technical workshops and seminars were begun, and field training was instituted at other sites around the country. It was the field training that led to formalizing the training programs and the preparation of training manuals. Some of the early textbooks were titled: Electric Arc Welding: Procedure and Practice; Modern Arc Welding; Essential Lessons in Arc Welding; Essential Lessons in Practical Arc Welding; Pipe Welding Procedures; and Howard B. Cary’s legendary text, Modern Welding Technology. The school later developed national welder training programs for Algeria, Columbia, Costa Rica, Indonesia, Italy, Saudi Arabia, The Netherlands, Philippines, Trinidad, United Kingdom, and Venezuela.

Unique Library Established

Hobart’s welding library was established in 1964, spearheaded by John H. Blankenhuehler, a Hobart engineer and AWS president (1962–1963). Now named in his memory, the resource has since grown into one of the largest libraries in the country devoted exclusively to welding.

A landmark feature of the Hobart campus is the 20-ft-high welded-metal Unity of Man fountain that was custom designed to express vigor, life, growth, enthusiasm, and strength — all attributes of welding and the welding industry — Fig. 2. Created to commemorate Hobart Brothers Company’s 50 years of progress, it was first publicly displayed on June 20, 1967.

Expansion in Training

In 1970, Hobart became the first welding school approved by the Ohio State Board of Schools and College Registration. The following year, its name was changed to Hobart School of Welding Technology to better describe the broad range of training that was offered. In 1972, the school was granted accreditation by the National Association of Trade and Technical Schools, and later received approvals for various student loan and

HOWARD M. WOODWARD (woodward@aws.com) is associate editor of the Welding Journal.
Three shifts of classes were taught around the clock and enrollment was at its all-time peak in October 1976. To cope with the need, ground was broken in April 1978 for a 50,000-sq-ft addition to the facility.

The school allowed students to take courses in four-week increments up to 36 weeks to meet national qualification standards, and students were allowed to pay by the week.

In 1989, the facility initiated a new service of qualifying operators and procedures to various welding codes, which it continues to do today.

In 1990, the school offered two associate degree options in cooperation with Sinclair Community College in nearby Dayton. Also that year, the two-week, 70-hour course Pipe Layout for Fitters and Welders was added to teach the fundamentals for layout and fabrication of typical pipe connections including the required mathematics topics.

**The School Becomes an Institute**

In 1991, under the direction of Ray Shook, then school president and currently AWS executive director, the school changed its name to Hobart Institute of Welding Technology, and a new mission statement was adopted:

*The Hobart Institute of Welding Technology is a nonprofit institution dedicated to welding training and education excellence. The Institute educates and trains individuals in the use and application of welding technologies; develops and disseminates welding training and educational material; and conducts certification research and qualifications for the welding industry. Based in North America, the Institute continues to enhance its reputation worldwide through affiliations with leading international training organizations, assuring continued growth and self-sufficiency. The long-range mission of the Institute is to be the premier welding institute worldwide.*

The HIWT became the first independent organization in the United States to be authorized by the American Welding Society to conduct Certified Welding Inspector (CWI) examinations in 1993. Three Hobart scholarships were established in 1994, and the [www.welding.org](http://www.welding.org) Web site was launched on the Internet in 1996. The Hobart Institute joined with Edison Welding Institute in 1998 to establish a Columbus, Ohio, training center.

**Facilities Receive Major Upgrade**

An extensive renovation of the Institute’s facilities began in 2003 — Fig. 3. Improved classrooms and equipment added more capacity for skill training. The number of skill and technical students has doubled in the last six years, and a new technical course, Preparation for the AWS Certified Welding Supervisor Examination, was added to the curriculum.

André A. Odermatt, HIWT president, said, “With these improvements, Hobart training is in demand which has resulted in the hiring of additional instructors and an addition of a second shift of training. Recruiters from across the country travel to Troy displaying a preference to hire HIWT graduates who have a reputation of possessing a proven core of welding competencies.”

“As it moves into the next decade of training welders, Hobart Institute of Welding Technology will be doing its best to provide America with well-trained men and women to mitigate the country’s welder shortage problem.”

To learn about the HIWT course offerings and activities, visit [www.welding.org](http://www.welding.org); or call (800) 332-9448; (937) 332-5300; FAX (937) 332-5200; [HIWT@welding.org](mailto:HIWT@welding.org).
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BY R. SARRAFI AND R. KOVACEVIC

ABSTRACT

In-process cleaning of oxides facilitates the high-quality welding and cladding of aluminum alloys when GTAW arc is used for melting aluminum in an open atmosphere. However, in order to understand the mechanism of cathodic cleaning, direct observation is needed. In this work, in order to visualize the physical processes underlying cathodic cleaning, a machine-vision system is developed, and the interaction of the variable-polarity arc with the aluminum surface is captured in real time by a high-speed camera. Surface studies are also performed to assist with the understanding of the oxide cleaning process. Real-time images and surface topography suggest that the cathode spots are responsible for removing oxides from the cathode surface during direct current electrode positive (DCEP) polarity. The cathodically cleaned zone expands over time. However, after the diameter of the cleaned zone reaches a specific value, the rate of its expansion decreases and stops. Unlike cathode spots of vacuum arc, the cathode spots of atmospheric welding arc form on the surface with original oxides, as well as on the surface already scanned by cathode spots (possibly because of the re-formation of a thin layer of oxides on the surface). Two phases of cathode spot behavior were observed during each pulse of DCEP polarity. In the first phase, small spots scan the surface with a very high speed. In the second phase, larger spots form on the area previously scanned during the first phase and move outward with a slower speed. Among the process parameters, the duration of the DCEP polarity (the DCEP duty cycle) has the most significant effect on the size of the cleaned zone and its rate of growth.

Introduction

In-process removal of surface oxides is a very important element of the welding procedure when high-quality welds or deposits of aluminum alloys are to be achieved by gas tungsten arc welding (GTAW) in an open atmosphere. The melting temperature of aluminum oxide (2050°C) is much higher than that of aluminum alloys. The high melting temperature of aluminum oxide and its tenacious behavior in the weld pool can cause weld defects. The presence of the oxide layer on the molten pool can cause fusion defects (Refs. 1, 2), inclusions, and porosities (Refs. 1, 3).

To remove the oxides during melting of aluminum alloys by GTAW, alternative current can be used. During the direct current electrode positive (DCEP) polarity of the arc, the cathodic cleaning of oxides occurs. Because of the oxide cleaning function of the variable-polarity arc during DCEP polarity, variable-polarity plasma arc welding (VP PAW) and variable-polarity gas tungsten arc welding (VP GTAW) are used for high-quality welding, cladding (Refs. 4, 5), and rapid prototyping (Refs. 6, 7) of aluminum alloys.

There are some reports in the literature discussing the feasibility of methods for real-time oxide cleaning during aluminum melting other than cathodic cleaning. Jarvis and Ahmed (Ref. 8) showed that the oxides can be thermally removed by a direct current electrode negative (DCEN) arc under helium shielding gas. Ryazantsev et al. (Ref. 9) showed that the oxides can be partially removed by the forces induced by the fluid flow in the molten pool. However, the success and popularity of these methods are far less than oxide cleaning by using the DCEP polarity of the arc.

Background information on the physics of atmospheric arcs is needed to study the mechanism of cathodic cleaning. Therefore, before discussing the possible mechanisms of cathodic cleaning, some basic information on arc physics is presented in the next few sections.

Arc Cathode Physics

The typical distribution of voltage across the arc plasma is shown in Fig. 1. There is a sharp gradient of voltage in the vicinity of both electrodes (cathode and anode). The potential gradient in the vicinity of the cathode is called cathode fall voltage, which is in the range of 10 to 20 V for the welding arc (Ref. 10), and is greater than the voltage gradient near the anode. The cathode fall zone acts as a transition zone between the metallic and plasma states and is necessary for sustaining the arc on the cathode.

As schematically shown in Fig. 2, the cathode fall zone has an internal structure and consists of two distinct zones (Ref. 11): the cathode sheath (or cathode space charge zone), and presheath (or ionization zone...
Fig. 1 — Typical distribution of arc voltage (modified from Ref. 13).

Fig. 2 — General configuration of cathode region of an arc, not true to scale (adapted from Ref. 11).

Fig. 3 — Schematic drawing of the cross section of a cathode spot (not true to scale, redrawn from Ref. 16). 1 — Metal cathode under spot (solid), 2 — molten metal layer (0.2–0.5 μm), 3 — cathode sheath (less than 0.01 μm), 4 — presheath (0.1–0.5 μm), 5 — dense plasma over cathode spot, 6 — plasma expansion region, 7 — ejection of molten droplets.

Fig. 4 — Schematic drawing of sputtering mechanism performed by incident ions from plasma. A — The schematic drawing of bombarding ions and material lattice; B — possible ejection of a surface atom by a reflected ion.

Fig. 5 — Schematic drawing of the machine-vision system.

The current transportation is done by three agents in the cathode region (Ref. 11) (Fig. 2): 1) the electrons emitted from the cathode surface and repelled from the cathode zone by cathode fall voltage, 2) the ions formed in the presheath and accelerated toward the negative cathode, and 3) some plasma electrons that reach the cathode surface by diffusion in the reverse direction of the potential gradient. Generally, the attraction of ions by the negative cathode and repulsion of electrons from it cause the formation of a net positive charge in the cathode sheath (so-called space charge). The presence of a positive space charge establishes high electric fields in the vicinity of cathode surface, which in turn helps sustain the electron emission from the cathode, and therefore assists continuation of the arc.

Arc cathodes can be categorized into two types based on their electron emission mechanism: thermionic and nonthermionic. The thermionic emission mechanism refers to the emission of surface electrons when they overcome the bonding energies in high temperatures and detach from the material as a consequence. Only specific types of refractory materials such as tungsten and molybdenum (thermionic cathodes) can withstand the high temperatures necessary for thermionic emission. The lower boiling-point materials (nonthermionic cathodes) such as aluminum, iron, and copper undergo a phase transformation and evaporate before very high temperatures can be generated on their surface. Although nonthermionic cathodes cannot withstand very high temperatures, it is reported that these
cathodes can provide very high electron emission rates (high currents) by the thermo-field emission mechanism (Ref. 11). In the thermo-field emission mechanism, the synergic effect of high temperatures and a strong electric field creates a high electron current. The thermo-field emission is basically a temperature-assisted field emission mechanism. In this mechanism, the electrons escape the surface under the influence of a strong electric field through the quantum mechanical effect of tunneling (field emission) and overcome the energy barrier that is significantly reduced under the effect of a high temperature. The strong electric field (e-field) and high thermal energy concentration needed for the thermo-field emission can only be met locally in cathode spots on the non-thermionic cathodes. In fact, the current is localized at a number of tiny spots (a few µm) in order to provide the high temperature and e-field necessary for a sustainable production of arc current by a relatively cold surface of a nonthermionic cathode. Therefore, the generation of cathode spots is necessary for supplying the arc current from a nonthermionic cathode.

Very high rates of material evaporation have been reported at the cathode spots (Refs. 11, 14) because of the high energy density (10^{10} to 10^{11} A.m^{2}.current density (Refs. 11, 15)). The intensive evaporation accompanying the formation of cathode spots is shown to be necessary for the electron generation by cold cathodes (Ref. 14). The high evaporation rate and the high level of energy available for ionizing the evaporated atoms together provide a high density of positive ions on the surface of the cathode spot, which in turn generates the high e-field required for thermo-field emission (Refs. 11, 14). A schematic cross section of a cathode spot is shown in Fig. 3 (Ref. 16). The extensive evaporation can push the liquid material out of the cathode spot, and a crater may be left as a result — Fig. 3. The ejection of droplets out of the cathode spots may also occur — Fig. 3, item 7.

The region of arc attachments to the nonthermionic cathode can consist of a number of spots. For example, Coulombe (Ref. 11) shows that the arc is attached to the copper cathode through a number of mobile macrospots (much bigger than a single cathode spot); each of which consists of several microspots. The lifetime of a macrospot is much higher than that of small cathode spots (ms compared to µs) (Ref. 11).

The cathode spots, which are the attachment points of arc to nonthermionic cathodes, are highly mobile unlike the attachment point of the arc to the thermionic cathode. The attachment point of the arc to the thermionic cathode is a relatively large, fixed area (Refs. 11, 15). The cathode spots usually do not stay in their place more than a few microseconds. They repeatedly extinguish and reignite on the neighboring surface of nonthermionic cathodes. In contrast, in thermionic cathodes, the arc attachment covers a large area and is fixed. The reason for the mobility of the cathode spots is not well understood. However, studies of the cathode spots in vacuum arcs show that a certain degree of randomness exists in the motion.
Mechanism of Cathodic Cleaning during Aluminum Welding

Three main mechanisms are suggested in the literature of aluminum welding to describe the cathodic cleaning of oxides during the electrode positive polarity. According to the first suggested mechanism (Refs. 3, 10, 18), the positive ions that are accelerated toward the aluminum cathode are assumed to “sputter” the surface oxide layer. Sputtering is the ejection of substrate atoms by the effect of the high-energy bombarding particles. In the second hypothesis (Ref. 19), the surface oxides are assumed to be destructed because of the dielectric breakdown phenomenon. When the electric field exceeds a critical value, the materials that are considered dielectric can conduct electricity. This phenomenon, which is often destructive to the dielectric medium, is called dielectric breakdown. In the third hypothesis, which can be found in more recent literature (Ref. 20), the evaporation of the oxide layers at the cathode spots of nonthermionic cathodes is considered to be a possible mechanism for cathodic cleaning. However, there is no paper in literature dedicated to the experimental investigation using the direct observation method of the physical processes underlying the cathodic cleaning of oxides by a welding arc.

Sputtering is a process by which the surface of a solid is etched using a high-energy beam of ions or particles. The incident particles transfer energy to the surface atoms, causing them to escape the material. The Monte Carlo modeling approach is used in literature to predict the sputtering phenomenon (Refs. 21, 22). The software TRIM (transport of ions in matter) (Ref. 21) was developed based on the Monte Carlo binary collision approach. The incident ions and all atoms they collide with are tracked within a finite volume of material by this program. Atoms and ions are followed until their energy is damped below a certain level needed to escape the lattice (Ref. 23). When either the reflected ion or atom reaches the surface and hits a surface atom, the energy of the hitting particle is compared with the surface binding energy of the material by the program. If the particle energy in the perpendicular direction exceeds the surface binding energy, the struck atom escapes the material and is sputtered. If the energy of the striking particle is less than the surface binding energy, it is reflected back into the bulk of material and the process continues (Ref. 23). This program has shown a high degree of accuracy for incident particles of less than 1000 eV energy (Ref. 23). The sputtering method is used as an etching process (e.g., in the semiconductor industry), and as a thin film deposition process, where the sputtered atoms are transferred to be deposited on the desired location. Usually, ions within the energy range of
300–800 eV are used for sputtering (Ref. 23).

The sputtering of the aluminum oxide layer by positive ions was the first mechanism hypothesized for the cathodic cleaning (Refs. 3, 18). Herbst (Ref. 18) qualitatively describes the cathodic cleaning as a miniature sandblast. The most important evidence to form this hypothesis is the observation of the higher rate of cleaning when argon shielding gas is used compared to the case of helium gas. Later, Pattee et al. (Ref. 3) performed a statistical and thermal analysis of the arc and suggested that sputtering can qualitatively be responsible for cathodic cleaning.

After the advancement of sputtering models and development of accurate simulation programs that could predict the sputtering yields accurately, Pang et al. (Refs. 19, 24) calculated the sputtering yield of aluminum oxide by the welding arc plasma using TRIM software. The sputtering yield obtained by bombarding ions of the welding arc was too low to be responsible for the cathodic cleaning of oxides. According to the computations of Pang (Ref. 19, 24), ions with at least 45 eV of kinetic energy are needed to obtain a considerable rate of oxide removal. For the welding arc, they assumed a maximum of 2 eV from

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**Table 1 — Process Parameters Tested in the Experiments**

<table>
<thead>
<tr>
<th>Test Parameter</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current level (A)</td>
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<td>120</td>
<td>180</td>
</tr>
<tr>
<td>DCEP duty cycle</td>
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<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>30</td>
<td>60</td>
<td>90</td>
</tr>
</tbody>
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**Fig. 11 — The evolution and mobility of cathode spots during a single DCEP polarity of the arc after 1 s from arc ignition; current = 180 A, DCEP duty cycle = 0.4, frequency = 30 Hz.**
thermalization, and a maximum of 8 eV for the cathode fall voltage, which accounts for a maximum total energy of 10 eV for incident ions. The assumption of 2 eV of thermalization energy for positive ions is based on the spectroscopic measurement of arc temperature by Pang et al. (Ref. 24). The computational work of Pang et al. (Ref. 19, 24) suggests that sputtering is improbable to be the mechanism of cathodic cleaning. Some information on the measurement of the thermal energy of ions is presented in the next paragraph.

The average energy of the bombarding ions is often considered to be the superposition of the thermal energy (gained in the presheath and arc column) and the kinetic energy (gained in the cathode fall zone) (Ref. 11). The measurement of arc temperature can provide the average thermal energy of ions. Because the condition in the column of the atmospheric arc is close to the local thermodynamic equilibrium state (Ref. 25), the electron temperature in the arc column is almost equal to the ion temperature, and the measurement of the electron temperature can provide a good estimate of the ion temperature in this zone. The electron temperature of the arc plasma can be approximated using an emission spectroscopy technique.

After rejecting the sputtering mechanism through a TRIM simulation, Pang et al. (Ref. 19) proposed the dielectric breakdown as the possible mechanism of cathodic cleaning. However, no evidence for the dielectric breakdown process being responsible for oxide removal is shown in the paper.

The cathode spots of a vacuum arc can remove surface contaminations and dielectric layers from the surface of a nonthermic cathode (Refs. 26–28). Coulombe (Ref. 11) reports that the cathode spots can play the same role in an atmospheric arc with a nonthermic cathode. However, the applicability of this mechanism is not well investigated in the welding context. Scotti et al. (Ref. 20) discussed the possibility of the cathode spots being the mechanism of cathodic cleaning. However, the focus of their report is the effect of cathodic cleaning on the arc stability and bead formation, and the basic mechanism of cathodic cleaning is not addressed in their work.

In the papers and books related to welding, an uncertainty about the mechanism of cathodic cleaning is still observed. Several papers (Refs. 3, 18–20) discuss the possibility of some mechanisms being responsible for cathodic cleaning, but these mechanisms are not evaluated in a single report. Because there is no direct observation of the mechanism of cathodic cleaning, it has been difficult to determine which mechanism is responsible for the cathodic cleaning. Direct real-time observation of cathodic cleaning can provide a better understanding of this process compared to the investigations performed after extinguishing the arc. The purpose of this paper is to study the mechanisms of cathodic cleaning by directly observing the cleaning process using a high-speed machine-vision system, and examining the surface cleaned by the arc.

Experiments

Al 6061 plates with the dimension of 50 × 30 × 6 mm were used as test coupons. A stationary variable-polarity arc was established between a pure tungsten electrode and the test coupon’s surface using a Miller Dynasty DX® square-wave AC power source. A tungsten electrode of 3.2 mm in diameter with a semispherical tip was used. Argon gas with 99.8% purity (industrial grade) and the flow rate of 12 L/min was used as the shielding gas. The arc length was about 3 mm. The variable-polarity arc was ignited for 5 s in each experiment, and its interaction with the surface was recorded with a high-speed CCD camera assisted by a green laser as an illumination source in order to visualize the cathodic cleaning process. Three levels of current, DCEP duty cycles, and frequencies were tested as shown in Table 1. The current levels in DCEP and DCEN polarities were equal. The DCEP duty cycle quantifies the contribution of DCEP polarity duration in one cycle of current.

The main challenge in visualizing the interaction of the arc with the surface is the strong light emission from the arc plasma in a broad range of wavelengths. A combined illumination and filtration approach based on specular reflection was used to overcome this problem. The schematic of the integrated machine-vision system used in this study is shown in Fig. 5. The machine-vision system consists of four main components: 1) a 5-W continuous-mode Coherent Tracer Compact® green laser source (532-nm wavelength) with a collimated light output, which was used to illuminate the surface exposed to the arc; 2) the appropriate neutral-density filters; 3) a narrow-band-pass filter to bypass only the green laser light; and 4) a high-speed CCD camera, which is described in more detail in the next paragraph. Most of the light emitted by the plasma is filtered out by the narrow-band-pass filter, while the green light reflected from the area of interest, which carries the visual data of the processing area, passes through the filter and is captured by the camera.

Because the cathodic cleaning occurs during a very short period of time while the specimen is the cathode of the arc, the use of a high-speed camera is needed to capture the events during this process. In this research, a high-speed CCD camera was used with a frame rate of 2074 frames per second (fps) and a frame size of 240 × 240 pixels with a density of 72 pixels per inch. This frame rate allows for taking six consecutive pictures during the DCEP polarity of the arc when the current frequency is 60 Hz and 20% of the current cycle is devoted to the DCEP polarity. The pictures were stored in a PC for studying the interaction of the arc with the specimen’s surface.

The machine-vision system used in this research is similar to that used in the work of Sarrafi et al. (Ref. 29) except they used a regular camera (60 fps). They showed that the presence of oxides on the molten pool can be monitored using a machine-
Cathodically cleaned surfaces were examined by optical and scanning electron microscopy. Optical microscopy was used to give an overview of the area affected by the arc. Scanning electron microscopy, which can provide a larger depth of focus, was used to observe the surface topography of the area affected by the arc. A focused ion beam was used to locally cut through different locations of the affected surface in order to measure the average thickness of the surface oxide. An optical profiler based on the chromatic aberration principle was used to measure surface roughness as needed.

**Results and Discussion**

**Original Condition of Surface Oxide**

Figure 6 shows a cross section of the base metal surface cut by a focused ion beam to measure the thickness of the oxide layer existing on the base metal surface. As shown in the picture, the surface of Al 6061 samples was covered by a fairly uniform oxide layer with the thickness between 450 and 500 nm before any treatment by the arc.

**Appearance of Arc in DCEN and DCEP Polarities**

Figure 7A and B shows the arc during DCEN and DCEP polarities. The arc in DCEN polarity is much brighter than the arc in DCEP polarity as shown in Fig. 7A and B. The low intensity of arc emission during DCEP polarity makes the viewing through the DCEP arc easier than through the DCEN arc. The observed difference in arc brightness agrees with the conclusion of Pang et al. (Ref. 24) and Qingdong et al. (Ref. 30) that the temperature of the arc column is lower in the DCEP polarity than in the DCEN polarity.

**General Observations during Cathodic Cleaning**

Figure 8 shows the arc and condition of the affected surface during the initial current cycles after the arc is ignited. Figure 8A was taken during the DCEN polarity. Figure 8B–D are consecutive images of the arc and the affected area on the surface. These images were taken during one DCEP polarity pulse, which was subsequent to the DCEN pulse of Fig. 8A. Figure 8E and F shows the status of the arc and affected area on the surface during the next DCEN pulse, where Fig. 8E shows the beginning of the DCEN period and 8F shows the end of it. Figure 8G–I shows the arc and its effect on the surface.
during the DCEP period subsequent to image 8F. The time interval between the images is equal (3.3 ms) except for the interval between the images shown in Fig. 8E, and F, which is 7.0 ms. A darker appearance distinguishes the area affected by the arc from the surface not affected by the arc as seen in Fig. 8. The size and surface conditions of the affected area do not change during DCEN polarity (Fig. 8E, F), but expands during the DCEP polarity (Fig. 8B–D, G–I).

Subsequent surface studies showed the area appearing dark in the real-time images is cleaned from oxides. Figure 9A and B shows the typical SEM images of the surface appearing dark in the real-time images. The porous structure of the surface is probably the cause for the dark appearance of this area. Figure 10A shows a typical focused ion beam (FIB) section of the surface of Fig. 9B. The white layer covering the surface in Fig. 10A is the platinum layer that protects the surface during FIB milling. Figure 10B shows a higher magnification of the section shown in Fig. 10A. Base aluminum, a thin oxide layer, and the protective layer are seen in this figure. As shown in Fig. 10B, the surface oxide layer on the arc-treated area is very thin (40–50 nm) on the arc-treated area. This thin oxide layer cannot be the original oxide layer remaining on the surface but was probably formed after the surface cleaning action of the arc (secondary oxide). Therefore, the dark area in the real-time images is considered cathodically cleaned from oxides.

The images taken during DCEP polarity show the evolution of some bright spots on the oxidized aluminum surface and their movement across the surface (Fig. 8B–D and G–I). The surface images during DCEP polarity also suggest the role of observed mobile bright spots on the removal of surface oxide. The cleaned area grows in synchronization with the movement of bright spots across the surface. What we see as bright spots in these images are the major clusters of cathode spots whose local plasma have intense enough emission. We also see the shiny trace they leave after scanning the surface. The movement of cathode spots is linked to their decay at one surface spot and the re-ignition at the neighboring surface (Refs. 11, 14).

It is worth noting that many cathode spots of different sizes and lengths of duration evolve on the surface of a nonthermionic cathode. What we see in these images are the most energetic clusters of cathode spots that produce bright local plasmas as well as the traces they leave after scanning the surface. Not all of the cathode spots can be seen in the pictures because their visibility can be limited by their short lifetime as well as their very small size when they cannot gather in big clusters and produce significantly bright local plasma and cannot leave a wide enough trace. The behavior of the visible cathode spots is the basis for discussing the real-time images in this research.

The visibility of cathode spots increases with time. During the initial pulses of DCEP, the cathode spot clusters are small and weak. However, as more pulses of DCEP hit the surface, the spots become larger and cause more surface melting. Figure 11A–N shows the consecutive real-time images of the affected area during DCEP polarity after one second of arc ignition. The spots seen in Fig. 11 are more intense than those seen in Fig. 8. They leave wider traces while scanning the surface and causing more melting. When the cathode spots cause too much surface melting, they can make the surface smoother, as discussed in the following sections.

Based on the real-time observations and surface topography of the cleaned area, it can be concluded that the cathode spots are responsible for the cathodic cleaning of oxides. Real-time high-speed movies clearly show that the cleaned area forms and expands by mobile cathode spots. In fact, the cathode spots sweep the surface and consume the oxides by vaporizing a thin layer of the surface. The topography of the cathodically cleaned surfaces (surfaces of Fig. 9A, B) agree well with the typical surfaces affected by cathode spots as reported in literature (Ref. 31). The cleaned surface consists of an array of micrometer-sized depressions embedded with thin ridges. The depressions seem to be the sites of cathode spots, and the ridges are formed because the pressure of evaporation pushes the liquid out of the cathodes spots (as shown schematically in Fig. 3). Based on the observations, it is hypothesized that the mechanism of cathodic cleaning is similar to the schematic drawing shown in Fig. 12. It is worth noting that this hypothesized mechanism is very general in nature, and the details of the mechanism should evidently be studied in the future. This schematic presentation is similar to the mechanism shown in the work of Araki et al. (Ref. 31) on the cleaning of a metal surface by vacuum arcs.

Surface Condition after Cathodic Cleaning

Different areas are formed on the surface of the aluminum specimen after exposing it to a variable-polarity arc as shown in Fig. 13. A quarter of a weld crater (marked as area A in Fig. 13) is seen at the right upper-corner of the picture. The cathodically cleaned area on the solid surface contains two different zones marked as B and C in Fig. 13. Most of the cleaned area has a matte appearance (area C in Fig. 13) and is roughened by cathode spots similar to the surface of Fig. 9B. This area appears dark in the real-time images. The arithmetic mean deviation of the roughness profile, Ra, is about 0.7 μm in this area. The cleaned area adjacent to the molten pool (marked as B in Fig. 13) is, however, shiny and smooth. This area appears shinier than area C in real-time images. The arithmetic mean deviation of the roughness profile, Ra, is about 0.3 μm in area B. Scanning electron microscopy showed the sign of extensive surface melting, such as hot cracks, on this area. The real-time images suggest that the smoothness of this area is related to the frequent scanning of this area by the cathode spots, which leads to extensive surface melting. The real-time images suggest that the density of the cathode spots is lower at areas located farther from the arc axis compared to areas located closer to it. Therefore, in areas located farther from the arc center, such as area C, the cathode spot marks are usually individual. Whereas, on areas closer to the arc center, such as area B, the frequent scanning of the surface by cathode spots and a higher heat input during DCEN polarity cause a uniform surface melting that makes the surface smooth. The area marked as D in Fig. 13 is not affected by the arc.

The Behavior of Cathode Spots during Cathodic Cleaning of Oxides

As already stated in the literature of plasma physics, the behavior of cathode spots of nonthermionic cathodes is highly sensitive to local surface conditions (surface layers, surface dirt and oil, oxide condition, roughness, and surface defects), electrode material, shielding gas composition, and its impurity (Refs. 11, 15). The absolute numerical values related to the cathode spots behavior, therefore, may easily vary by a small change in the experimental conditions. Thus, in this paper, the focus is not on the absolute values in describing the cathode spots behavior, but the trends in their behavior.

Based on the pictures taken by high-speed camera, the cathode spots occur everywhere on the surface covered by the atmospheric arc of welding; they can form on the surface with the original oxide, as well as on the surface already scanned by cathode spots. Literature (Refs. 26, 28, 31, 32) reports an opposite behavior of cathode spots in the case of a vacuum arc. It is reported that when an area is scanned by cathode spots of a vacuum arc and cleaned from the surface impurities, the cathode spots seldom come back to that area (Refs. 26, 28, 31, 32). Therefore, the cathode spots of the vacuum arc preferentially attack the surfaces that are not yet scanned.
by cathode spots, which is referred to as the “intelligent” behavior of the vacuum arc during cleaning (Ref. 31). The surface oxide layers are supposed to facilitate the thermo-field emission because of the generation of a high electric field (Ref. 11) as well as their lower work function compared to metals (Refs. 10, 32). The vacuum arc needs a voltage increase at the completion of oxide cleaning in order to be sustained (Ref. 33), or it may be extinguished at this stage (Ref. 10). The surface oxide layers feed the cathode spots of the arc during DCEP polarity and help sustain the DCEP arc. In the welding arc, the reformation of cathode spots on the surface already scanned by cathode spots could be related to the re-oxidation of previously-treated areas (the quick formation of very thin layers of oxide on the surface already scanned by cathode spots). Further experimental confirmation is needed to verify this hypothesis. Based on the frequent occurrence of the welding arc cathode spots on the surfaces that are already scanned, it can be said that the vacuum arc acts “more intelligently” and more efficiently in cleaning oxides compared to the atmospheric arc of welding. However, the cleaning efficiency of a variable-polarity atmospheric arc is practically sufficient for welding purposes.

Real-time pictures show two distinct phases in the behavior of cathode spots during each single pulse of DCEP. At the beginning of the DCEP pulse (the first 0.5 ms of each DCEP polarity period), cathode spots are formed randomly on the surface. We may call the first phase as the random hit of cathode spots. Then, an outward movement of cathode spots from the center to the edge of the cleaned area is observed until the end of the DCEP polarity pulse. In the second phase, the cathode spots are more visible (have a brighter plasma) and leave shinier traces. The expansion of the cleaned zone occurs during both phases of a DCEP pulse.

As already stated, the high-speed camera images show that the surface affected by the arc expands during the DCEP period of the arc. The area cleaned by the VP arc nonlinearly varies with time when the surface is treated by many pulses of DCEP. The growth of the cleaned zone is very fast at the first few pulses of DCEP current but slows down later, as shown in Fig. 14. In the experiments, when the diameter of the cleaned zone reaches some value between 9 and 12 mm, the cleaned zone continues to grow linearly at a lower rate, as shown in Fig. 14. Tracking the variation of the diameter of the cleaned zone in a longer timeframe showed that the growth of the cleaned zone stops after a certain diameter is cleaned. For a typical case (I = 180 A, DCEP duty cycle = 0.2, and frequency = 60 Hz), the growth of the cleaned zone over time nearly stopped when the size of the cleaned zone reached about 15.5 mm, as shown in Fig. 15.

Increasing the current level enlarges the cleaned zone, but the difference is not significant, as shown in Fig. 14. Images show that when the current level increases, the cathode spots become stronger with a higher level of energy, especially during the second phase of the cathode spots behavior (the phase during which the outward movement of spots occurs).

Figure 16 shows the significant effect of the DCEP duty cycle on the size of the cleaned zone and its rate of growth. Increasing the DCEP duty cycle enlarges the cleaned zone and quickens its rate of growth. Images show that increasing the DCEP duty cycle provides more time for the cathode spots to move around on the surface and expand the cleaned zone.

As typically shown in Fig. 17, varying the frequency does not cause a significant change in the diameter of the cleaned zone at the beginning of arc ignition, but causes significant variation in the growth rate of the cleaned zone in the longer run. The change in the rate of growth is especially significant when the frequency increases from 30 to 60 Hz. A higher frequency provides a higher number of DCEP pulses with a shorter length compared to a lower frequency. Images suggest that increasing the frequency causes a faster growth of the cleaned area by providing a higher number of random hits of the cathode spots (phase 1 of the DCEP polarity period).

Conclusions

The mechanism of the cathodic cleaning of oxides from aluminum surface variable-polarity arc was investigated in real-time using a machine-vision system and a high-speed camera (about 2000 fps). Surface studies were also performed after the cathodic cleaning process. The following conclusions can be drawn based on the experiments:

1) The surface oxide layer is removed by the mobile cathode spots during the DCEP polarity.
2) The cathode spots of the welding arc form on the oxides that originally exist on the specimen’s surface and the areas already scanned by the cathode spots.
3) The specimen’s surface after welding with the variable-polarity arc consists of three distinct regions: 1) molten metal; 2) a cleaned, smooth surface adjacent to the weld pool, where repetitive scanning by cathode spots caused smoothness; and 3) a rough, porous, cleaned surface located farther from the arc center, where craters are related to the locations of the cathode spots.
4) Two phases of cathode spots behavior were observed during each DCEP polarity period. At the very beginning of a DCEP pulse (first 0.5 ms), the cathode spots randomly form on different locations on the surface (the first phase). Then, a number of stronger cathode spots form at the surface close to the arc center and grow outward (the second phase). The expansion of the cleaned zone occurs during both phases.
5) With a stationary arc, the cleaned zone expands nonlinearly with the elapsed arcing time. During the initial pulses of DCEP, the rate of expansion is very fast. Later on, this rate decreases, and subsequently, after reaching a certain diameter, the cleaned zone stops expanding.
6) Increasing the current level, frequency, and DCEP duty cycle in the tested range enlarged the cleaned zone. The DCEP duty cycle has the most significant role on the size of the cleaned zone.

Acknowledgments

This work was financially supported by NSF’s Grant EEC-0541952. The work of Andrew Socha, researcher engineer at the Research Center for Advanced Manufacturing, in the design and integration of the machine-vision system is highly appreciated. The authors would like to thank David N. Ruzic, professor at the University of Illinois at Urbana-Champaign, for his valuable guidance.

References

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Double-Sided Arc Welding of AA5182-O Aluminum Sheet for Tailor Welded Blank Applications

The conduction-mode double-sided arc welding process may be a viable alternative to traditional welding processes for aluminum tailor welded blanks

BY J. A. MOULTON AND D. C. WECKMAN

ABSTRACT

The viability of using the double-sided arc welding (DSAW) process, comprised of a plasma arc welding torch above and gas tungsten arc welding torch below the joint, to produce autogenous square welds between 1.0- and 1.5-mm-thick AA5182-O aluminum sheets for applications such as tailor welded blanks (TWB) has been studied. Visually acceptable complete-joint-penetration, conduction-mode DSA welds were produced with good cathodic cleaning of the oxide from both sides of the sheets over a wide range of welding speeds and powers from 10 mm/s when using 1.8 kW to 70 mm/s when using 4.6 kW. Transverse tensile tests showed that the weld strength was similar to the thinner base metal sheet; however, the displacement to failure was always less than the base metal. Hydrogen porosity was observed in the welds; however, this was significantly reduced by stainless steel wire brushing all affected surfaces prior to welding. SEM-EDS analysis and microhardness tests showed that there was no significant variation in composition and hardness between the base metal and weld metal. The DSAW process was found to be capable of producing welds with excellent visual quality at welding speeds that exceed those of traditional arc welding processes, thus demonstrating the potential for attaining the high productivity rates required for aluminum TWB applications.

Introduction

Automotive manufacturers are coming under increasing regulatory pressure to continually improve the overall fleet mileage of their automobiles and to move toward use of more environmentally friendly fuels and energy sources such as hybrid and all-electric drive systems. Consequently, there is much interest in development and assessment of new materials and manufacturing technologies that will allow fabrication of lighter automotive bodies and structural components that continue to meet or exceed current safety and crash worthiness standards. For example, CO₂ laser welding of tailor welded blanks (TWB) of automotive steel sheets is a relatively new technology that has been shown to provide many advantages over the use of monolithic blanks including up to 30% weight savings for structural components (Refs. 1, 2). Tailor welded blanks are composite blanks made from combinations of different sheet steel and galvanized coating thicknesses that are joined together along butt joints using long, complete penetration square welds. Once welded, the TWB is stamped and formed into a structural component such as an inner door panel. Manufacturing of TWBs for the automotive industry requires welding processes capable of making high quality, complete joint penetration welds between two sheets of different thicknesses at high welding speeds (Ref. 1). This is a very demanding application for any welding process, as not only must the weld have strengths comparable to the base metal, but it must also have sufficient ductility that it does not fail during drawing or stretching in the forming operation (Refs. 1, 2).

Further savings in automotive body weight can be realized by making TWBs from lighter aluminum alloys such as AA5754 and AA5182 for semistructural and internal closure applications and AA6111 for inner and external closure panels (Refs. 2, 3). These alloys have been used in the automotive industry for their good strength-to-weight ratio and forming characteristics; however, the high thermal conductivity and thermal expansion coefficient, low absorptivity, a tenacious aluminum oxide, and a sensitivity to hydrogen porosity make the welding of wrought aluminum alloys more challenging than the welding of traditional sheet steel alloys. To facilitate manufacturing of aluminum alloy TWBs in a high-speed production environment, new welding techniques must be identified and assessed. Recent studies suggest that electron beam welding (EBW), laser beam welding (LBW), and variable-polarity plasma arc welding (VPPAW) are the welding processes most likely to be successful for welding of aluminum alloy TWBs (Refs. 4, 5).

While CO₂ laser welding is commonly used to fabricate steel TWBs, aluminum has a low absorptivity at the CO₂ wavelength, which prevents absorption of the laser beam energy (Refs. 6, 7). Nd:YAG laser welding is preferred for welding aluminum alloys due to the higher absorptivity of aluminum at the Nd:YAG wavelength (Ref. 8). Deutsch et al. (Refs. 9, 10) reported that single-beam Nd:YAG laser welds on 1-mm-thick AA 5182-O aluminum alloy sheet exhibited spiky underbead surfaces that they attributed to preferential vaporization of the Mg in the alloy and resultant keyhole instabilities. No combination of welding parameters could be found to eliminate this surface defect.

KEYWORDS

Aluminum Alloys
Double-Sided Arc Welding
Hydrogen Porosity
Tailor Welded Blanks

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However, Deutsch et al. (Refs. 9, 10) and Punkari et al. (Refs. 11, 12) later showed that visually acceptable dual-beam Nd:YAG laser welds could be produced in 1-mm-thick 5182 and 5754 aluminum alloy sheet using total welding powers of 4.5 to 5.0 kW and travel speeds of 6 to 7.5 m/min.

The high energy density typical of laser beams has been reported to cause loss of alloying elements such as magnesium by vaporization during CO₂ laser welding (Refs. 13, 14). Moon and Metzbower (Ref. 13) reported that the loss of magnesium in the weld metal contributed to a loss in strength in AA5456 aluminum alloy welds since this alloy derives its strength through solid solution strengthening from the magnesium. Porosity is another problem that has been reported in laser welding of aluminum alloys. Pores have been attributed to either hydrogen gas porosity or occluded vapor pores caused by keyhole instabilities induced by the high vapor pressure of magnesium in the aluminum alloy (Refs. 10, 12, 14, 15).

The feasibility of applying VPPAW to the manufacture of TWBs has been investigated by Deutsch (Ref. 9) and Punkari (Ref. 11) using 1.6-mm-thick AA5182 and AA5754 aluminum sheet. A maximum welding speed near 3 m/min was reported, which was limited by the arc’s ability to cathodically clean the surface oxide at higher speeds (Ref. 9). A stainless steel backing bar was required to control the under-bead geometry. This acted as an additional heat sink and restricted cathodic cleaning of the oxide to the top weld bead surface. Thus, oxide inclusions and incomplete fusion defects were sometimes evident on the underside of the weld. In addition, Punkari (Ref. 11) found that substantial welding power was required to prevent oxide inclusions, which resulted in wide welds with nonsymmetric weld profiles and pronounced angular distortion of the sheets.

Double-sided arc welding (DSAW), shown schematically in Fig. 1, is a relatively new arc welding process that was patented by Zhang and Zhang (Ref. 16) in 1999. The DSAW process uses one welding power supply and two torches, frequently a plasma arc welding (PAW) and gas tungsten arc welding (GTAW) torch each connected directly to one of the power supply terminals. The torches are positioned on opposite sides of the work-piece such that the welding current flows from one torch through the workpiece to the opposite torch. The plates to be welded are grounded and not part of the electric welding circuit. Zhang et al. (Refs. 17-22) have examined the feasibility of using the DSAW process to make uphill, keyhole-mode welds in 6- to 12-mm thick plain carbon steel, stainless steel, or aluminum alloy plates.
Kwon and Weckman (Ref. 23) recently examined the feasibility of using the DSAW process for conduction-mode welding of 1.2-mm-thick AA5182-O aluminum sheet. It was noted that the opposing welding torches successfully cleaned the oxide from both sides of the joint and produced visually acceptable welds at speeds up to 3.6 m/min. Through-thickness heating was more uniform with DSAW than with VPPAW allowing symmetric welds to be produced with minimal angular distortion of the sheets.

The demonstrated potential for welding aluminum sheet and the low capital cost compared to laser welding systems makes the conduction-mode DSAW process a potential candidate for welding aluminum TWBs; however, research to date has been limited to DSAW of similar thickness welds and the mechanical properties and quality of these welds have not been well characterized (Ref. 23). Therefore, the objective of the present study was to examine the feasibility of applying the double-sided arc welding process to the manufacture of aluminum tailor welded blanks (Ref. 24). More specifically, it was of interest to identify the welding process parameters capable of producing high-quality welds between 1.0- and 1.5-mm-thick AA5182-O sheets in the butt-joint configuration such as might be required for TWB applications.

**Experimental Method**

The material used in this study was nonheat-treatable AA5182-O aluminum alloy (cold rolled, annealed, and recrystallized) sheet in 1.0 and 1.5 mm thicknesses. The AA5182 alloy is solution strengthened by alloying with 4.5 wt-% Mg giving it good strength and reasonable ductility (Refs. 25, 26). This alloy is known for its good weldability (Refs. 26, 27). The aluminum sheet was sheared into specimens that measured 35 x 220 mm and 150 x 430 mm. The larger specimens were used to produce transverse tensile specimens. All specimens were sheared to size perpendicular to the rolling direction, as this was found by Deutsch (Ref. 9) to provide the best cathodic cleaning of the aluminum oxide from the weld metal. Prior to welding, rolling lubricants and other contaminants were removed from the surface with acetone followed by a rinse with methanol. In a comparative study, a 200-mm (8-in.) bench grinder and stainless steel wire wheel with 0.3-mm-diameter wire were used to break up and remove the preexisting surface oxide from the area to be welded (Ref. 28).

A Miller® Aerowave® hybrid AC/DC constant current power supply was used to provide a balanced square-wave AC welding current at a frequency of 60 Hz, as previous DSAW research using this system showed that these settings provided the best cathodic cleaning of the aluminum oxide from both sides of the sheets (Ref.
As shown schematically in Fig. 1, a Thermal Arc® WC100B, Model 300 PAW torch was positioned above the weld specimens and a Weldcraft® Model WP-27 GTAW torch was mounted below. A Thermal Dynamics® Thermal Arc® WC 100B plasma arc welding console was used to control the plasma and shielding gas flow rates and to provide pilot arc current for the PAW torch. This facilitated arc initiation between the two torches. The PAW torch was connected to the positive terminal of the power supply via the plasma arc console, and the GTAW torch was connected to the negative terminal. Table 1 shows the preset PAW and GTAW torch parameters used in the experiments.

The clamping system shown schematically in Fig. 1 was used to hold the two specimens in the butt-joint configuration while they were moved on a carriage between the two torches at the desired welding speed. Prior to welding, the weld specimens were shimmed as shown in Fig. 1 so that the top surfaces of the specimens were flush. This was done to minimize weld metal sag or drop-through.

A LabView 6.0-based control and data-acquisition system was used to control the welding carriage speed and to measure the welding current and voltage. The variable polarity welding current was measured using a LEM LT505-S Hall-effect current transducer and the voltage between the two torch electrodes was measured using a LEM LV100 Hall-effect voltage transducer. Voltage and current waveforms were sampled at 1 kHz and the data were used to calculate the root mean square...
(RMS) values of current, voltage, power, and arc resistance.

Prior to each weld, the PAW pilot arc was started and then a free-standing arc of the desired peak welding current was created directly between the PAW and GTAW torches. Double-sided arc welds were then made by moving the weld specimens between the fixed torches at the desired welding speed. Initial experiments were performed to evaluate the effects of electrode tip geometry on electrode tip life. Following this, conduction-mode DSA welds were made at welding speeds ranging from 10 to 80 mm/s and welding powers ranging from 1.8 to 4.8 kW. Using the electrode gaps shown in Table 1, the total welding voltage was a dependent parameter that ranged between 32 and 35 V. A desired welding power was obtained by adjusting the peak welding current of the constant current power supply. Thus, peak welding currents ranging from about 40 to 150 A were used. The effect of torch position in the transverse direction relative to the weld joint was also evaluated. Finally, the effects of removing the oxide in the area of welding by stainless steel wire brushing on weld quality and welding speed were examined.

Metallographic examination and measurements of polished and etched specimens were performed using an Olympus® optical microscope with an Image-Pro 4.5™ image analysis system. Two different reagents were used to etch the specimens: Keller’s reagent was used to reveal the solidification microstructure, while Beck’s reagent was used to reveal the grain structure (Ref. 29). Top and bottom weld width and weld area of each weld were measured. Mechanical properties were evaluated using Vickers microhardness tests and transverse tensile tests using the ASTM E8/ESM-08 (Ref. 30) Standard Sheet-Type Tensile Specimen geometry where the weld was located at the center of the modified 60-mm-long gauge length. Shims were used in the grips to avoid creating an induced couple due to the difference in sheet thicknesses and the sheet offset. The results were left as tensile load-displacement curves rather than stress-strain curves due to the three unique sections (1.0-mm-thick sheet, DSA weld and 1.5-mm-thick sheet) contained in the gauge length of the tensile specimen.

The melting ratio, $MR$, was calculated for each weld in order to determine the effects of welding process conditions on the overall energy coupling efficiency. The melting ratio is the fraction of the total incident power that is used to heat and melt the weld metal. The equation used to calculate $MR$ is (Ref. 31)

$$MR = \frac{\rho \left[ C_p \left( T_{mp} - T_{m} + \Delta H_f \right) \right] L_w A_w}{v_w}$$

where $L_w$ is the length of weld metal, $A_w$ is the weld metal area, $\rho$ is density, $C_p$ is the specific heat, $\Delta H_f$ is the latent heat of fusion, $v_w$ is welding speed, $T_{mp}$ is the solidus temperature, $T_{m}$ is room temperature, and $P_L$ is the power from the power supply. The thermophysical properties of A5182 used for this calculation were $\rho = 2.65 \text{ Mg/m}^3$, $C_p = 1.043 \text{ kJ/kg \cdot K}$, $\Delta H_f = 397 \text{ kJ/kg}$, and $T_{mp} = 850 \text{ K}$ (Ref. 25). The values for $\rho$ and $C_p$ are averages of values between room temperature and $T_{mp}$.

### Results and Discussion

When welding TWBs of different sheet thicknesses, the sheets are normally aligned center to center and then welded so that drop-through or sagging of the weld pool during welding due to gravity does not cause problems with stacking of the welded blanks, excessive forming die

<table>
<thead>
<tr>
<th>Torch Parameter</th>
<th>PAW</th>
<th>GTAW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrode gap (mm)</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Orifice diameter (mm)</td>
<td>3.2</td>
<td>—</td>
</tr>
<tr>
<td>Plasma gas</td>
<td>UHP Ar</td>
<td>—</td>
</tr>
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<td>Plasma gas flow rate (L/min)</td>
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<td>—</td>
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<td>Shielding gas</td>
<td>Ar</td>
<td>Ar</td>
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<tr>
<td>Shielding gas flow rate</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Electrode composition</td>
<td>W-0.8% Zr</td>
<td>W-0.8% Zr</td>
</tr>
<tr>
<td>Electrode diameter (mm)</td>
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<td>4.8</td>
</tr>
<tr>
<td>Electrode included angle (deg)</td>
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<td>60</td>
</tr>
<tr>
<td>Electrode truncation (mm)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
wear, and the need for left- or righthand ed tools during the blanking welding process (Ref. 2). Figure 2A shows a typical transverse section of a DSA weld produced between 1- and 1.5-mm-thick AA5182 sheets when the bottom two sheet surfaces were aligned during welding. There is significant drop-through due to the force of gravity acting on the weld pool during welding. Alternatively, Fig. 2B shows a transverse section of a weld produced with the top sheet surfaces aligned using the shims shown in Fig. 1. The drop-through and geometric discontinuity is significantly reduced. This is important for TWBs as surface and geometric discontinuities have been shown to negatively impact the formability of TWBs (Refs. 2, 32).

The Thermal Arc® PAW torch used in this study was originally designed for direct current electrode negative (DCEN) PAW. The electrode for this torch is normally ground to a point with a 20-deg cone angle and setback into the orifice a specified distance as shown in Fig. 3A (Refs. 33, 34). However, Deutsch (Ref. 9) and Punkari (Ref. 11) reported excessive melting and formation of a molten metal bead at the electrode tip and very high rates of electrode tip degradation of the conical ground W-0.8% Zr electrodes when this torch was used for VPPA welding AA5182 and AA5754 aluminum alloy sheet. The significant changes in electrode tip geometry and arc length severely limited reproducibility between experiments. These same deficiencies were observed during the initial experiments in the present study. Figure 4 shows, for example, melting and balling that occurred on the tip of a ground W-0.8% Zr electrode after only 1 min of DSAW using 100-A peak current and 3-kW welding power.

Melting and formation of a molten ball on the electrode tip during manual AC or DCEP gas tungsten arc welding of aluminum alloys is common practice (Ref. 28); however, such large changes in electrode tip geometry is problematic during VPPA welding due to the resultant changes in arc length, welding voltage, and power, as well as the close proximity of the orifice cup. In extreme cases, this can cause the electrode to short circuit against the PAW orifice cup, hindering further operation of the welding torch. Overheating of the pointed electrode tip during VPPAW is largely due to the differences in energy balance between the electrode and workpiece during DCEN and DCEP portions of the variable polarity current waveform. During DCEN welding, approximately 70% of the total arc heat goes into the workpiece (the anode) and only 30% into the electrode (cathode) (Ref. 35). In this case, heating of the electrode is not sufficient to cause appreciable melting or thermal degradation of the electrode tip during DCEN PAW. This helps the electrode to maintain its initial shape and stabilizes the torch operating characteristics for long periods of operation. However, during VPPAW with a balanced AC waveform, an average of 50% of the arc heat is introduced into the anode and 50% into the cathode for each current cycle. As a result, the electrode tip can overheat and a molten ball of tungsten can form at the end of the initially pointed electrode.

It has been suggested that VPPAW should be performed with a blunt electrode to prevent melting and balling of the electrode tip (Refs. 36, 37). A blunt electrode tip increases the surface area interacting with the arc and improves the ability of the electrode to conduct heat away from the tip, thus extending the electrode life by preventing the formation of a molten ball during welding. However, as shown in Fig. 3B, the geometry of the blunt electrode required that the electrode setback be increased from 2.25 to 6.25 mm (+4 mm) to prevent direct contact between the electrode and PAW orifice cup. When welding with 100 A and 3 kW, this caused the welding voltage to increase from 32.1 to 38.7 V for a total increase in voltage of 6.6 V. Figure 5 shows the end of the blunt electrode after a
VPPA weld using 3-kW power. The blunt electrode had only a small molten spot indicating that the tip of the blunt electrode was much cooler than the tip of the pointed electrode. Also, there was no significant change in shape of the electrode tip geometry and arc length. Thus, the blunt electrode was found to be a superior geometry when using the PAW torch for variable polarity DSAW as it can be expected to provide repeatable and consistently reliable arc lengths and voltages for many welds.

The increased welding voltage associated with using the blunt electrode at a 6.25-mm setback was problematic, because the constant current power supply was designed to provide a maximum voltage of ±44 V. Although the steady-state DSAW voltage was less than this limit, as shown in Fig. 6, the normal start-up transient voltage was observed to exceed 44 V and this caused the power supply to shut down. At the beginning of a DSA weld, as the sheets are initially fed between the two torches, there is a transition between the free-standing arc voltage and steady welding conditions. Kwon (Ref. 23) has shown that during this transition the welding arc initially wraps around the leading edge of the sheets, and the arc becomes longer and the arc voltage increases. Eventually, a maximum arc length and voltage is reached and the arc begins to couple with the workpiece. The voltage subsequently falls to the steady welding voltage as a stable weld pool is established. To eliminate the problem of the power supply cutting out during the start-up transient due to excessive arc length, an electrode ground to a 20-deg included angle and truncated to a 3.2 mm diameter was used. This geometry allowed the setback distance to be reduced to 5 mm, which in turn reduced the arc voltage sufficiently that the ±44 V limit of the power supply was never exceeded during the initial transient. This optimized electrode shape is compared to a blunt electrode in Fig. 5. A larger molten spot was created on the truncated electrode, but the melting was not sufficient to form a molten ball at the electrode tip and the electrode tip geometry was not substantially changed. This facilitated good consistency between results with minimal electrode degradation. Thus, 4.8-mm-diameter W-0.8% Zr electrodes ground to a 20-deg cone angle and truncated to a 3.2 mm diameter were used in the PAW torch throughout the remainder of this study.

**Effects of Welding Speed and Power**

To identify the range of acceptable welding conditions for joining 1.0- to 1.5-mm-thick AA5182 aluminum sheet, a series of welds were produced using the preset torch parameters shown in Table 1, total welding powers from 1.8 to 4.8 kW and welding speeds between 10 and 80 mm/s. The PAW and GTAW torches were centered over the joint. Prior to welding, the specimens were cleaned with acetone and methanol, but were not stainless steel wire brushed. Thus, oxide removal from the weld pool surface was entirely by cathodic etching from the arc.

The top weld surfaces of representative welds produced with 2.6-kW total welding power at welding speeds from 10 to 50 mm/s are shown in Fig. 7. The bottom weld bead surfaces were very similar in appearance. As shown in Fig. 7A, blowholes were produced when the welding speed was too slow or the welding power was too large. The mechanism for forming blowhole defects in DSA welded A5182 sheet is described in greater detail by Kwon (Ref. 23). Visually acceptable welds such as those shown in Fig. 7B were produced at higher welding speeds between 20 and 40 mm/s. As may be seen in Fig. 7C, welds produced at speeds greater than 50 mm/s were erratic with inconsistent arc coupling and cathodic cleaning of the oxide. In some locations, the original faying surface of the weld joint was not melted, resulting in incomplete fusion defects.

The weld bead surfaces of the welds produced in these experiments typically exhibited black patches along the weld centerline on the top and bottom weld surfaces — Fig. 7B, C. Leong et al. (Ref. 38)
also reported similar formations. Using energy dispersive X-ray spectroscopy, they identified these regions to be rich in magnesium and oxygen. Thus, the black spots observed on weld surfaces in this study are believed to be magnesium oxides.

Cathodic etching of the oxide from the weld metal surfaces in the present study was similar to that observed in previous studies using VPPAW by Deutsch (Ref. 9) and Punkari (Ref. 11) and using DSAW by Kwon (Ref. 23). However, as shown in Fig. 8, the cathodically etched regions on the bottom GTAW torch side of the DSA welds produced in the present study using dissimilar 1.0- to 1.5-mm-thick sheets were not symmetric. The cathodically etched region was generally wider and extended well into the base metal of the thicker 1.5-mm sheet. As may be seen in Fig. 8, however, cathodic cleaning of the oxide was incomplete on the bottom of the thinner sheet where segments of the original oxide were left floating on the weld pool surface at the fusion boundary.

The observed preferential cathodic etching of the thicker sheet surface is believed to be caused by attraction of the GTAW arc on the GTAW electrode creating a sharp corner and a shorter path for the current that attracts the welding arc and causes the arc and cathodic etching to favor the bottom surface of the thicker sheet. This effect was less pronounced on the top surface because the top sheet surfaces were flush during welding — Fig. 7B, C.

Figure 9 shows a representative transverse section of the weld shown in Fig. 7B. The weld bead geometry is very good with a small amount of underfill and drop-through due to the effects of gravity acting on the weld pool during welding. All of the good DSA welds were symmetric, complete-joint-penetration welds with straight or slightly hourglass-shaped fusion boundaries. The welds exhibited epitaxial growth of columnar grains from the fine equiaxed base metal grains at the fusion boundary toward the center of the welds where there is a beneficial transition from columnar to equiaxed grains. This grain structure is similar to that reported previously by Kwon (Ref. 23) for DSA welded 1-mm-thick AA5182-O sheets.

The range of welding speeds and powers that produced visually acceptable DSA welds is shown in Fig. 10. In general, the welding speed increased with increased welding power. The maximum welding speed that produced acceptable welds was 70 mm/s when using 4.6 kW. For each welding power, a minimum welding speed was found to exist below which blowholes such as shown in Fig. 7A were created. Slightly lower heat inputs created excessively wide welds (greater than 10 mm) that frequently exhibited centerline cracks. As the welding speed was increased, visually acceptable welds were produced. The width of the good welds decreased as the welding speed was increased as a consequence of lower net heat input per unit distance during welding. A maximum welding speed was also found for each welding power above which inconsistent arc coupling was observed and erratic weld bead geometries and incomplete fusion defects such as shown in Fig. 7C were produced.

Figure 11 shows measured top and bottom weld widths of good welds vs. welding speed for welds made using two different welding powers, 2.6 and 4.2 kW. The top and bottom weld widths are almost the same for all welds. This is further indication that these welds were fully two dimensional with straight fusion boundaries through the sheets — Fig. 9. When using
2.6-kW welding power, the weld width decreased rapidly from 7 to 3 mm as the welding speed was increased from 20 to 50 mm/s due to decreasing heat input per unit distance. At a welding speed of 20 mm/s, the weld width was excessively large compared to the thickness of the specimens. The widths of the welds produced using 4.2-kW welding power were greater than those produced at 2.6 kW. Again, weld widths decreased to about 4 mm with increased welding speed. Inconsistent arc coupling and visually unacceptable weld beads were produced at speeds higher than those shown in Fig. 11.

Weld widths predicted using Kwon and Weckman's (Ref. 39) analytical heat transfer model of DSAW are also shown on Fig. 11. An average sheet thickness of 1.25 mm was assumed in the model and the thermophysical material properties used for the melting ratio calculations in Equation 1 were used. Following Kwon and Weckman (Ref. 39), the plasma arc distribution coefficient or arc radius, \( \alpha_{\text{PP}} \), was assumed to be 1.8 mm and \( \alpha_{\text{GP}} \) for the GTAW torch was assumed to be 2.1 mm. The arc efficiencies of the PAW arc and GTAW arc, \( \eta_{\text{PP}} \) and \( \eta_{\text{GP}} \), were adjusted until correlation between the measured weld widths as shown in Fig. 11 was obtained. In this case, correlation between measured and predicted weld widths was obtained when \( \eta_{\text{PP}} = 0.23 \) and \( \eta_{\text{GP}} = 0.38 \) were used. It should be noted that there are many simplifying assumptions used in an analytical heat transfer model such as this. Thus, while use of these values for arc distribution coefficients and arc efficiencies in the model facilitated correlation between the model predictions and experimentally measured weld widths, the actual values, may very well be somewhat different.

When using 2.6 kW, the maximum welding speed was predicted to be just above 50 mm/s. This is consistent with the measured results. At higher speeds, partial-penetration welds were predicted to occur. Above 60 mm/s, only heating of the sheets with no melting was predicted. When using 4.2 kW, welds produced at speeds greater that 60 mm/s exhibited inconsistent arc coupling. However, the analytical model predicted that complete-joint-penetration welds could be produced at significantly higher speeds up to about 85 mm/s before partial-penetration welds would be produced. This suggests that the actual welding speed was limited by the inability of the arc to cathodically clean the oxide at speeds greater than 60 mm/s.

Figure 12 shows plots of the melting ratio (see Equation 1) vs. welding speed and welding power. When using 2.6 kW, the melting ratio increased from 0.182 to a maximum value of 0.186 as speed increased from 20 to 50 mm/s. This is because the time available for heat conduction into the sheets or the environment decreases as welding speed increases. However, as the welding speed increased beyond 30 mm/s, the melting ratio variations increased and the average value decreased to 0.166. This decrease was accompanied by incomplete oxide cleaning and intermittent coupling between the arc and the sheet. When using a total power of 4.2 kW, the maximum melting ratio was greater at 0.216. This maximum value occurred at the slowest acceptable speed of 40 mm/s and decreased as the speed increased due to increasing incomplete cleaning of the oxide and inconsistent arc coupling.

The theoretical maximum melting ratio value was predicted by Swift-Hook and Gick (Ref. 31) to be 0.48 for two-dimensional keyhole-mode laser beam welds with perfect coupling between the laser beam and the weld metal. The melting ratios measured in the present study of DSAW of AA5182-O aluminum sheet is less than half this theoretical value. This is likely due to the reduced arc efficiency of both arcs and heat loss due to conduction into the highly conductive aluminum sheets. Deutsch et al. (Refs. 9, 10) and Punkari et al. (Refs. 11, 12) found that the maximum melting ratio of single-beam Nd:YAG laser welded AA5182 alloy sheet was approximately 0.3 and was only 0.2 for dual-beam laser welds. They also found that the maximum melting ratios of VPPA welds made using the same PAW torch and power supply in AA5182 and AA5754 aluminum sheet of similar thickness was only 0.07 to 0.13 (Refs. 9, 11). They suggested that the stainless steel backing bar used during welding to control the underbead geometry acted as a large heat sink and that this was responsible for the lower melting ratios observed in their VPPA welds.

### Effects of Torch-to-Joint Alignment

In laser beam welding of steel TWBs, the laser beam is sometimes offset toward the thicker sheet and beam weaving is used to promote additional melting of the thicker sheet. The additional molten metal from the thicker sheet helps to provide a smoother transition from the thick to the thin sheet (Ref. 2). In the present study, therefore, a series of tests were carried out to evaluate the sensitivity and effects on the weld quality and bead geometry when the welding torches are offset from the joint centerline. A positive welding torch offset was used to indicate that the welding torches were offset toward the thicker sheet, a negative offset indicated the torches were offset toward the thinner sheet and a zero offset indicated that the torches were aligned with the joint. Five torch-to-joint configurations were used: +2 mm, -1 mm, 0, 1 mm, and 2 mm. Welds were made using 2.2-kW total welding power and speeds of 20, 24, and 30 mm/s to examine the effect of decreasing the heat input while varying the torch-to-joint alignment.

As shown in Fig. 13A, using a torch-to-joint alignment of -1 mm or more resulted in blowholes in the thinner sheet and little evidence of melting or cathodic cleaning of the oxide of the thicker sheet indicating that minimal heat transfer occurred to the thicker workpiece. Torch-to-joint alignments in the positive direction showed a slightly different trend. A torch offset of 0 or 1 mm produced acceptable quality welds such as shown in Fig. 13B. As shown in Fig. 13C, offsetting the torches even further to 2 mm or more resulted in porosity in the thicker sheet similar to those produced in the thinner sheet when using a negative offset. In this case, there was little evidence of melting or cathodic cleaning of the oxide of the thinner sheet.

The cause of the blowholes in the thicker or thin sheets with positive or negative torch-to-joint alignment was initially suspected to be simply a result of applying excessive heat to the thicker or thinner workpiece; however, Kwon (Ref. 23) reported successful welding of 1- and 1.15-mm-thick sheet at the same welding powers and travel speeds. As a result, excessive heat input does not fully explain the presence of blowholes that was observed. It is thought instead that with the welding torches centered over the thin sheet (see Fig. 13A), there is insufficient cathodic cleaning of the oxide on the surface of the thicker sheet.
thicker sheet and at the faying surfaces and, therefore, insufficient heat being transferred from the welding arc to the thick sheet. As the thin sheet starts to melt and form a molten weld pool, the uncleaned oxide at the faying surfaces prevents wetting and heat transfer through these oxide layers and into the colder thicker sheet. As a result, very little heat conduction occurs from the weld pool to the thick sheet. As all of the heat transferred from the arc into the surrounding sheets is now limited to conduction in one transverse direction into the thinner sheet, the thinner sheet rapidly overheats causing an excessively wide weld pool and the formation of blowholes. As shown in Fig. 13C, when using a positive torch-to-joint alignment, failure of the arc to cathodically clean the oxide from the thinner sheet and faying surfaces also limits heat transfer into the thinner sheet, thereby causing overheating of the thicker sheet and formation of blowholes in the thicker sheet.

For the 1.0- to 1.5-mm sheet thickness ratio examined above, no noticeable benefit was observed by offsetting the welding torches from the joint. Offsetting the welding torches from the joint had a tendency to cause blowhole welding defects; however, slight offsets toward the thicker sheet of 1 mm or less were not detrimental to weld quality. The best weld quality was consistently obtained when the welding torches were aligned with the joint.

**Metalurgical and Mechanical Properties of the DSA Welds**

The 5000 series aluminum alloys derive their strength from solid-solution strengthening from the magnesium. Loss of magnesium due to preferential vaporization of the low vapor pressure Mg during laser welding of these alloys has been shown to result in a loss of strength (Refs. 13, 14). In the present study, discrete SEM-EDS measurements of composition were made at regular points along a line across the fusion zone of DSA welds produced at welding speeds of 20 and 50 mm/s using 2.6-kW total welding power and welding speeds of 40 and 60 mm/s when using 4.2-kW total welding power. Based on 36 measurements, the Mg content in the AA5182 base metal was 4.53 ± 0.30 wt-% and based on 81 measurements, the Mg content in the fusion zones of the specimens was 4.42 ± 0.65 wt-%. The differences observed between the mean base metal and the mean weld metal magnesium contents of each specimen were examined for a significant statistical difference using a t-test, at a 95% significance level, to test the null hypothesis that mean magnesium concentration was equal across both the base metal and fusion zone. No significant difference between means was found using the t-test, which indicates that there is less than a 5% likelihood that a difference in Mg composition exists between the base metal and the fusion zone.

Vickers microhardness profiles across the DSA welds showed no noticeable difference in hardness between the base metal, heat-affected zone (HAZ), and weld metal. The microhardness ranged between 73 and 78 VHN. The lack of softening adjacent to the weld is not unusual for AA5182-O aluminum alloys as it is not considered to be a heat-treatable alloy (Ref. 26) and the sheets have been annealed and recrystallized (O-temper) prior to welding. The lack of magnesium loss and change in microhardness during DSAW of the AA5182-O aluminum alloy sheets is thought to be advantageous for TWB applications where the retention of weld metal strength is believed to be important for postweld forming (Refs. 40, 41).

Representative transverse tensile load-displacement curves for welds produced at total welding powers of 2.6 kW are shown in Fig. 14A. The yield and ultimate strengths of the DSA weld specimens generally approach the strength of the thinner base metal; however, the displacement to failure of the weld specimens was generally about 50% of the base metal displacements. As shown in Fig. 14B, the welds produced at 4.2-kW welding power and higher travel speeds of 50 and 60 mm/s showed equivalent yield strength, but there was a notable decrease in tensile strength due primarily to the significant reduction in displacement to failure. In all cases, tensile specimen failure was observed to occur in the weld near the fusion zone centerline. These results are not unlike those reported by Leong et al. (Ref. 38) for laser welded AA5182 sheet.

The joint efficiency has been used to compare the failure loads for welds produced under different welding conditions. In this study, the joint efficiency is defined as the failure load of the weld specimens as a percentage of the failure load for the thinner base metal. Joint efficiency results are presented in Fig. 15 for welds produced with constant powers of 2.6 and 4.2 kW. Joint efficiencies between 94 and 97% were attained by all welds produced at 2.6 kW. The joint efficiency of the welds produced at 50 and 60 mm/s using a welding power of 4.2 kW were significantly lower with the joint efficiency falling to 82 and 65%, respectively. As before, this decrease is attributed to the significant decrease in displacement to failure observed in these welds.

**Hydrogen Porosity**

Transverse sections of DSA welds produced under a variety of welding conditions exhibited hydrogen porosity similar to that shown in Fig. 16A, B. Porosity in aluminum welds is generally known to be produced by hydrogen that is readily absorbed into molten aluminum during welding (Refs. 42, 43). Hydrogen may be introduced from water adsorbed on the base metal surface, from the hydrated oxide on the specimen surface or from moisture in the shielding gas (Refs. 28, 42, 43). As aluminum weld metal solidifies, any absorbed hydrogen is rejected from the solid into the liquid metal at the solid-liquid interface leading to nucleation and growth of hydrogen gas bubbles in the liquid. As may be seen in Fig. 16A, these bubbles will naturally try to float to the surface of the weld pool and escape into the atmosphere; however, at higher welding speeds, the weld may solidify before the hydrogen can escape or the oxide has not been completely removed from the weld pool surface and hydrogen is then trapped in the weld and gas pores are formed throughout the weld — Fig. 16B.

The volume fraction of porosity in the weld metal was inferred by measuring the area fraction of porosity on three transverse sections for each welding condition that tensile testing was performed on. As shown in Fig. 17, the average porosity levels ranged between 0.25 and 1.0 vol-% porosity for all of the welding conditions examined. No clear trends were identified between welding conditions as a great deal of scatter existed in the data; however, this scatter is not unexpected as metallographic porosity measurements do not consider the same proportion of a weld as density or radiographic testing methods (Ref. 44). Despite the scatter in the data collected, these porosity measurements did not exceed a threshold value of 1-2 vol-% porosity that has been shown to be the upper limit of porosity that can be tolerated in aluminum alloy welds without decreasing the strength of the weld metal (Refs. 45, 46). This is in close agreement with the tensile results obtained in this study where it was found that the joint yield strengths approached that of the thinner base metal sheet (see Figs. 14A and 15). Welds produced using a total welding power of 4.2 kW at 50 and 60 mm/s were the only exceptions. The cause for the decrease in weld strength at these welding speeds is not clear.

There are a number of standards and codes that place various limits on the porosity allowed in aluminum welds due to the impact porosity has on the strength of welds in static and dynamic loading. For example, the AWS D8.14M/D8.14:2000 specification for arc welded aluminum automotive components (Ref. 47) states that internal porosity must be <15% of the weld area. The porosity in the DSA welds shown in Fig. 17 is well below this value. In
AWS D1.2/D1.2M:2003, Structural Welding Code — Aluminum (Ref. 48), limits for porosity are based upon the number and sizes of pores evident in radiographic images of welds. For welds made in 1.5-mm-thick sheet, the total pore area fraction must be less than about 2%. The porosity shown in Fig. 17 is well below this value. Finally, the CSA W59.2 standard for welded aluminum construction (Ref. 49) permits a maximum weld metal porosity of about 0.12% area fraction in radiographic images using sheet material with a thickness of 3 mm or less. This tolerance is below the measured porosity contents shown in Fig. 17.

Weld metal ductility has been shown to be much less tolerant of porosity and can be reduced by very small amounts of porosity (Refs. 45, 50). Bayley and Pilkey (Ref. 52) have shown that even small amounts of porosity in aluminum TWBs reduces the strain to failure or formability of the welded blank by as much as 20%, as the onset of strain localization and failure was always predicted to occur at pores. Thus, the presence of hydrogen porosity in the DSA welds may explain the significant reduction in displacement to failure of the transverse tensile specimens (see Fig. 14).

Stainless steel wire brushing of aluminum specimens prior to welding has been proven to be effective in reducing the thickness of the oxide layer on the weld specimens with particular emphasis on removing hydrated oxides that have formed on the surfaces of this 5000 series alloy during extended storage periods (Refs. 28, 51). Two main benefits can be achieved: Hydrogen porosity can be significantly reduced, and the stability of the welding process can be increased (Refs. 25, 51). The reduction in porosity occurs as a result of removing the hydrated surface oxides that would otherwise dissociate in the welding arc and expose the weld pool to a source of hydrogen gas. The weld process stability arising from the reduction in cathodic cleaning that must take place to successfully remove the surface oxide and facilitate coupling between the arc and the weld metal. However, the need for cathodic cleaning is not eliminated by stainless steel wire brushing as the aluminum oxide will quickly form a thin new layer during the time lapse between brushing and welding.

**Effects of Stainless Steel Wire Brushing Prior to Welding**

To examine the effects of wire brushing on the weld quality and hydrogen porosity, a control study was performed to compare welds on specimens that had been stainless steel wire brushed prior to welding to those made on specimens that were not brushed prior to welding. Two welding conditions were used: 3.0 kW at 30 mm/s and 3.0 kW at 50 mm/s. Six transverse cross sections were mounted for each weld condition, and the area fractions of porosity in the fusion zone were measured. Representative cross-sectional images are shown in Fig. 16C, D, and the average porosity area fractions measured from six transverse sections of each weld are summarized in Table 2. The results showed a decrease in hydrogen porosity of 84% and 77% for welds produced at 30 and 50 mm/s, respectively. The porosity content in stainless steel wire brushed specimens was not found to exceed the 0.12% limit specified by the CSA – W59.2 standard (Ref. 49) or other AWS standards and codes (Revs. 47, 48). These results suggest that stainless steel wire brushing prior to welding can be very effective for controlling hydrogen porosity formation during welding; however, it should be noted that the presence of hydrogen porosity was not eliminated entirely by wire brushing. The small amounts of hydrogen porosity observed could have been caused by small oxide particles that were entrapped into the soft aluminum alloy during brushing (Ref. 28), or from small amounts of hydrogen present in the base metal from prior processing (Ref. 51).

Visual weld quality of both the top and bottom weld beads was improved on specimens that had been stainless steel wire brushed prior to welding. For example, the top weld surfaces of welds produced at 2.6 kW total welding power are shown in Fig. 18. These welds were produced at the same welding speeds and powers as the welds shown earlier in Fig. 7B, C. The stainless steel wire brushed specimens exhibit improved weld bead consistency compared to nonbrushed specimens. In addition, no surface contamination or black Mg oxide spots are present along the weld centerline of the wire-brushed specimens.

As was suggested previously by the analytical model predictions, the range of suitable welding conditions was also found to increase when stainless steel wire brushing was used to remove the surface oxide from the workpieces prior to welding. This can be seen by comparing the top surfaces of welds produced at 2.6 kW and 50 mm/s in Figs. 7C and 18B. Without wire brushing, the welds exhibit an inconsistent top and bottom weld bead, while the welds produced at the same welding conditions show very consistent weld beads when the specimens were wire brushed prior to welding.

Figure 19 shows the increase in welding speeds found to produce visually acceptable welds on wire-brushed specimens. Wire brushing prior to welding facilitated an increase of welding speed of about 20% for a given welding power. This is consistent with the predictions of the analytical heat transfer model shown previously in Fig. 11 where it appeared that the maximum welding speed for unbrushed weld specimens was limited by the ability of the arc to cathodically clean the surface oxide, rather than insufficient heat input to create a complete-penetration weld pool. Consequently, the increased consistency of the weld bead at high welding speeds observed in this study is believed to be a result of mechanically removing the hydrated oxide layers prior to welding. This would reduce the amount of cathodic cleaning required to remove the surface oxide and help to maintain a stable weld pool when low heat-input welding conditions are used.

There was no significant difference between the load vs. displacement curves obtained from transverse tensile tests and the resultant joint efficiencies of the unbrushed and brushed weld specimens. The results were similar to those presented earlier in Figs. 14 and 15 for weld specimens that were not brushed prior to welding. As before, the strength of the welds was similar to the thinner base metal sheet; however, the displacement to failure was 50% of the base metal and this decreased to less that 20% of the base metal values as the welding speed was increased. In all cases, specimen failure occurred near the weld centerline.

The transverse tensile strength of welded aluminum alloys has been reported to be proportional to the loss in cross-sectional area of the weld caused by porosity (Revs. 46, 50) and to be tolerant of 1 to 2 vol-% porosity without having a noticeable effect on the joint strength (Ref. 45). For this reason, the similarity in strength observed between wire brushed specimens and nonbrushed specimens is not unexpected because the hydrogen porosity volumes were not found to exceed 1% porosity by volume (see Fig. 17 and Table 2). In this case, a slight improvement in strength would be expected from the reduction in porosity; however, the improvement in strength would not be expected to exceed 1% based on the maximum porosity levels observed in nonbrushed specimens. Consequently, the improvement in strength would not be expected to be evident considering the 2 to 5% variance in measurements from tensile testing of the welded specimens.

**Conclusions**

The feasibility of conduction-mode welding 1.0- to 1.5-mm-thick AA5182-O aluminum alloy sheet in the butt joint configuration for tailor welded blank applications using a new and novel double-sided arc welding (DSAW) process has been as-
The balanced AC welding current used in this process was found to cause pointed W-0.8%Zr electrodes to melt and change tip geometry, electrode gap, and weld process conditions at excessively high rates due to the high arc heat input from the AC current. Flat or significantly truncated electrode tip geometries were found to be a superior geometry when using the PAW and GTAW torches for variable polarity DSAW as electrode tip melting is significantly reduced, thereby providing more consistent electrode tip geometry and repeatable and consistently reliable arc lengths and voltages for many welds.

Visually acceptable DSA welds could be produced in the 1.0- and 1.5-mm-thick AA5182-O sheets with good cathodic cleaning of the oxide from both the top and bottom surfaces of the weld bead over a wide range of welding speeds from about 10 mm/s when using 1.8-kW welding power to about 70 mm/s when using 4.6-kW welding power. These speeds are comparable to those reported possible when using VPPAW and are slightly lower than those reported for dual-beam Nd:YAG laser welding of these sheets. A zero torch offset from the weld joint was found to be optimal for the 1.0- to 1.5-mm-sheet thickness combination as this produced the most consistent and visually acceptable weld beads. The width of the DSA welds decreased with increased welding speed. In all cases, the maximum welding speed was limited by the onset of inconsistent arc coupling and cathodic cleaning of the oxide. Correlation between the measured weld widths and those predicted using an existing analytical thermal model of DSAW was possible provided reasonable values of the arc distribution coefficient and arc efficiency were used in the model for the PAW and GTAW arcs.

The melting ratio of this conduction-mode DSAW process was found to vary with process parameters, but a maximum value of about 0.216 was measured when using 4.6-kW welding power. This maximum value occurred at the lowest acceptable speed of 40 mm/s and decreased as the speed increased due to increasing incomplete cleaning of the oxide and inconsistent arc coupling.

The transverse tensile strengths of the DSA welds were found to be about the same as those of the thinner base metal sheet; however, in all cases, the displacement to failure was less, decreasing from about 50% of the thinner base metal sheet to less than 20% of the base metal as the welding speed was increased. In all cases, the specimens failed by fracture down the centerline of the welds. The overall joint efficiency of these DSA welds produced at the lower welding powers and speeds was as much as 97%, but this decreased to less than 85% as the welding power and speed were increased primarily due to accompanying rapid decrease in displacement to failure.

Hydrogen porosity was observed in the weld metal even with cathodic cleaning of the oxide by the AC welding arc. The hydrogen porosity was significantly reduced by stainless steel wire brushing the weld surfaces prior to welding. This improved the consistency of the weld bead geometries and facilitated an increase in the maximum welding speed of about 20%; however, there was little or no change in the transverse tensile strengths with reduced hydrogen porosity.

The DSA weld process has never before been applied to high-speed welding of two different sheet thicknesses such as is used in aluminum tailor welded blanks. It has a number of potential advantages over existing processes such as Nd:YAG laser beam welding and variable-polarity plasma arc welding. The DSAW process has been shown to provide cathodic etching of the aluminum oxide on both sides of the sheet, rather than just on the top side. The weld bead quality is as good as that possible on the top weld bead only of VPPA welds. This is beneficial to the formability and mechanical and fatigue strength of the welded blank. The weld bead is normally symmetrical through the sheet thickness. This can be expected to reduce the angular thermal distortion of the sheets that was observed in sheets welded using the VPPA process. Finally, unlike Nd:YAG laser welding, there is no loss of Mg, weld metal strength, or hardness in the AA5182-O aluminum DSA welds. The significant potential advantages of the DSAW process with respect to the welding of aluminum titanium welded blanks may make DSAW the process of choice for such applications. 

Acknowledgments

This research project was supported by the Natural Sciences and Engineering Research Council of Canada. The authors also wish to thank Frank Feng at Alcan International Inc., Kingston Research Laboratories and Newelis Global Technology Centre, Kingston, Ont., Canada, for supplying the AA5182-O project alloy sheet used in this study.

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Nominations Sought for Honorary Meritorious Awards

The Honorary Meritorious Awards Committee makes recommendations for the nominees presented to receive the Honorary Membership, National Meritorious Certificate, William Irgang 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.

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