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4 QUESTION SURVEY

WELDING *Journal*

April 2009



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• **Brazing and Soldering Technology**

Applications
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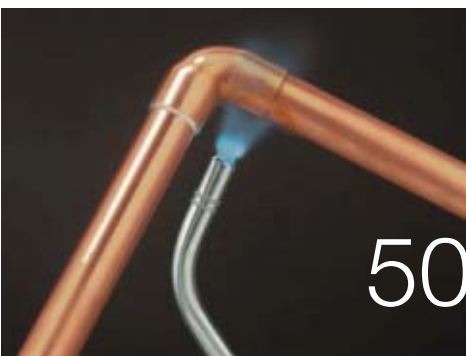
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On the cover: A conceptual drawing of an Urban Maglev transit track and vehicle. (Illustration provided by General Atomics Electromagnetic Systems Div., San Diego, Calif.)



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WASHINGTON

WATCHWORD

BY HUGH K. WEBSTER

AWS WASHINGTON GOVERNMENT AFFAIRS OFFICE

Hexavalent Chromium Standard Upheld

A federal court of appeals has upheld as valid the Occupational Safety and Health Administration (OSHA) rule regulating the occupational exposure of workers to hexavalent chromium (Cr(VI)). This rule, finalized in 2006, establishes a permissible exposure limit (PEL) of 5 micrograms of Cr(VI) per cubic meter. The petitioners in this case, a group of labor unions and advocacy organizations, made several challenges to the rule, the most significant of which was that the rule is insufficiently protective of workers. Specifically, they argued that, contrary to the assertions of OSHA, a PEL of just 1 microgram of Cr(VI) per cubic meter is technically feasible by most companies.

The petitioners particularly focused on the welding industry, saying that the methodology used by OSHA to make its feasibility findings for welding was flawed. The court disagreed: "OSHA's conclusion that a PEL of 1 microgram of Cr(VI) per cubic meter was technologically infeasible for welding operations is supported by substantial evidence, was adequately explained, and also comports with both past practice and prior decisions."

The court did rule in favor of the petitioners on one of their challenges to the OSHA rule. The rule currently provides that an employer must notify an employee whenever monitoring results indicate that the employee was exposed to Cr(VI) levels in excess of the PEL. This is different from every prior version of this rule, which required the employers to notify their employees of *all monitoring results*. The court concluded that OSHA has not sufficiently explained why the final rule deviated from the prior versions and therefore ordered OSHA to further examine and explain this portion of the rule.

Several industry representatives also opposed the OSHA rule as part of this same litigation, though on the narrower ground that the applicability of the rule to employees performing maintenance and repair work in coal and nuclear electric utility power plants was not justified. The court rejected all of these claims.

U.S.-Peru Free Trade Agreement Now in Force

The Free Trade Agreement between the United States and Peru became effective February 1, 2009. The agreement eliminates 80% of the duties imposed by Peru on U.S. exports of industrial and consumer products, effective immediately, and also removes barriers to U.S. services.

Federal Election Commission Adopts New Bundling Rules

The Federal Election Commission (FEC) has issued final regulations regarding the disclosure of information about so-called bundled contributions provided by lobbyists. The final rules require political committees to disclose certain relevant information about lobbyists who provide bundled contributions. Many have argued that the ability of registered lobbyists to collect or receive credit for campaign money they have collected from other donors and delivered to a candidate as a single bundle has been a key to their ability to influence legislation and policy.

New Department of Labor COBRA Web Site Established

The recently enacted American Recovery and Reinvestment

Act of 2009 includes a subsidy for laid-off employees who elect to continue participating in their employer-sponsored group health plans under the Consolidated Omnibus Budget Reconciliation Act of 1985 (COBRA). This COBRA subsidy covers 65% of the employee's premiums for up to nine months and is paid by the employer. The employer is reimbursed through reduced federal payroll tax obligations.

Further information is available at a new Department of Labor (DOL) COBRA Web site, www.dol.gov/ebsa/COBRA.html.

Stimulus Favorable to Federal Contractors

The American Recovery and Reinvestment Act of 2009 has a measure of good news for companies doing business with the government.

First, the requirement that federal, state, and local governments withhold 3% of their payments to contractors, representing federal tax obligations, which was to take effect in 2011, has now been pushed back to 2012. This also gives opponents additional time to try to kill this rule altogether.

Second, earlier versions of the stimulus legislation included a provision that would have required contractors working on projects funded with stimulus money to use the E-Verify system to determine their employees' eligibility to work in the U.S. The E-Verify system is currently a voluntary government program that tries to ensure employers do not hire undocumented aliens. When the final stimulus legislation emerged, this provision had been dropped.

Stimulus Favors Small Business Administration Loan Programs

The American Recovery and Reinvestment Act contains several provisions designed to bolster U.S. Small Business Administration (SBA) loan programs, including to allow for temporary fee reductions or eliminations on SBA loans and to create a new loan program to help small businesses meet existing debt payments. The current SBA Microloan and Surety Bond Guarantee programs also received additional funding for expansion.

Automakers Limited in Hiring H-1B Workers

The Employ American Workers Act, adopted earlier this year as part of the federal stimulus legislation, includes new restrictions on the hiring of foreign workers through the H-1B visa program. The H-1B program generally allows U.S. companies to temporarily employ foreign professionals in specialty occupations, including engineering.

The new restrictions apply to recipients of federal money under the Troubled Assets Relief Program (TARP), including two of the three major automobile manufacturers. Specifically, for each person these companies propose to hire through the H-1B program, they must show that they have taken affirmative steps to recruit for, and offer employment to, U.S. workers who are equally or more qualified than the prospective H-1B employee. In addition, any U.S. worker who believes he or she was denied a position that went to an equally or less qualified H-1B employee, may file a complaint with the U.S. Attorney General. ♦

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

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PRESS TIME

NEWS

Skills Certification System to Assist New and Transitioning Workers in Preparing for Welding Jobs



The Manufacturing Skills Certification System, recently introduced by the National Association of Manufacturers (NAM) and The Manufacturing Institute, will center on fundamental proficiencies needed for entry-level workers in all manufacturing sectors. Shown are representatives from various organizations who helped make this arrangement come together. Pictured (back row from left) are Ray Shook, AWS executive director; Leo Reddy, Manufacturing Skill Standards Council CEO; John Engler, NAM president; Mark Tomlinson, SME executive director; Steve Mandes, National Institute for Metalworking Skills executive director; Emily DeRocco, Manufacturing Institute president; and Dr. Richard Ferguson, ACT CEO; and (front row from left) are Peg Walton, National Center for the American Workforce director; Donald McCabe, Corning Inc. senior vice president; Jennifer McNelly, Manufacturing Institute vice president; and William Gaskin, PMA president.

competencies such as teamwork and applied technology; and industry-wide technical competencies such as supply chain logistics and health and safety.

The American Welding Society (AWS), Miami, Fla., has partnered with the NAM and The Manufacturing Institute for this certification system. It assists the welding industry with the workforce development challenge in helping to alleviate the shortage of welders. Also, it also offers young people a different career path to pursue as attending college after high school may not be for everyone. End users will ultimately benefit from this credential opportunity because it ensures individuals have met certain qualifications. Taking into account the AWS Foundation's Welder Workforce Development Program, the collaboration further allows synergies to be pulled together for alleviating the welder shortage in the manufacturing environment.

"We are pleased to be at the forefront as a partner with NAM in this important certification effort," said Ray Shook, AWS executive director. "Our certification programs are growing significantly around the world, and it makes sense to work with NAM in an area where there is a tremendous need and where AWS has successful programs."

Other organizations contributing to the system are ACT, Inc.; Manufacturing Skill Standards Council (MSSC); National Institute for Metalworking Skills (NIMS); and Society of Manufacturing Engineers (SME).

"At a time when millions of Americans face unemployment, manufacturing jobs with excellent salaries — and across all skill levels and sectors — are unfilled because of the lack of qualified applicants," Engler said. "These tough economic times call for clear pathways to skills in demand to help new and transitioning workers prepare for good manufacturing jobs."

Web Site Highlights the Advantages of HSLA-V Steel

The Vanadium Technology Partnership (VTP) has launched www.HSLA-V.org to promote increased awareness, visibility, and understanding of high-strength, low-alloy steel microalloyed with vanadium (HSLA-V steel).

At this Web site, potential users of the product have an opportunity to reference the case studies of research and applications, determine appropriate uses of HSLA-V steel, read about environmental sustainability, and learn where this type of steel is available. Also featured is a product availability search tool that step by step allows visitors to choose a steel producer, product, and size/specification/grade. A results page then displays the carriers of that specific product as well as ordering information.

The National Association of Manufacturers (NAM), Washington, D.C., and The Manufacturing Institute have launched a new NAM-endorsed Manufacturing Skills Certification System. According to NAM President and CEO John Engler, this "will revolutionize education and training for the 21st century manufacturing workforce."

Initially the system will focus on core, basic skills required for entry-level workers in all sectors of manufacturing from alternative energy and computers to aerospace and life-saving pharmaceuticals. Included are personal effectiveness competencies such as willingness to learn and dependability; academic competencies such as applied science and presentation skills; workplace

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EDITORIAL

We're in Need of a Stimulus

Are you feeling it yet — that soothing sense of recovery? By the time you read this, the American Recovery and Reinvestment Act signed by President Obama will have been in effect for about six weeks. Of course, it's a bit early to answer the question, but I think we can start asking when, if ever, we will have that good feeling, and what does it mean for those of us who depend on welding for a livelihood.

Shortly after the signing, the *Wall Street Journal Online* posted a funding breakdown of items contained in the 1073-page, \$787-billion bill, as well as a list of the tax reductions. The breakdown included a one-line description of the project and the individual funding for that program. Since it is touted as a job creations bill, I was curious as to how many of the programs sounded like they might create jobs for welders, welding equipment manufacturers, welding inspectors, end users of welding products, and all the jobs that go with the welding community.

I must admit this was a very unscientific analysis, since it was difficult to determine the job-generating ability of all of the 274 items described. In fact, there are items funded that one would be hard pressed to say are job creators. Although the \$19.9-billion allocated for food stamp payments is admirable, I don't think it will be a big job generator. Nor will the \$26.9 billion allocated to extend jobless benefits up to 33 weeks. Again, an admirable program, but probably the only job stimulus it might provide is for more people to administer the program. But that doesn't mean there weren't items that appeared to be job creators for us in the welding community.

I decided to go through the list and choose those programs with the key words construction, repair, maintenance, refurbish, and modernization, thinking they would be likely prospects. I came up with about \$48 billion for projects as diverse as NASA shuttle construction (\$400 million) to repair of schools, detention centers, roads, bridges, housing, irrigation and dams on Indian reservations (\$490 million). Two of the larger items in this grouping were the modernization of the electric grid (\$4.4 billion) and public transit and infrastructure improvements (\$8.4 billion).

Next, I selected all the proposed grants that seemed likely to provide jobs related to welding. There is plenty of grant money available, but much of it is for items such as youth training (\$1.2 billion), dislocated worker employment and training (\$1.25 billion), special education programs (\$12.2 billion), and community and economic development projects (\$1.0 billion). I found about \$49 billion in grants that fit into my category. At \$29 billion, the grant for highway improvement was by far the biggest. Other projects included grants for capital investments in high-speed rail corridors (\$8.0 billion), improvements to small domestic shipyards (\$100 million), advanced battery manufacturing (\$2.0 billion), and funding to states to buy alternative fuel buses and trucks (\$300 million).

Then there are items that probably will lead to jobs down the road but didn't seem as immediate as the ones above. Items such as grants for wireless and broadband infrastructure (\$4.35 billion), fossil energy research (\$1.0 billion), and research in nuclear physics and fusion energy sciences (\$1.6 billion). This total came to about \$11 billion.

In this highly subjective survey, I came up with \$108 billion in spending that I think could impact the welding community. The bill also contains more than \$300 billion in tax relief that will affect individuals and companies. Is it a perfect bill? It surely isn't, but even in a day and age where a "billion here and a billion there" is mentioned without a blink of an eye, a \$108 billion infusion into projects that could benefit the welding community is nothing to be ignored.

The caveat, though, is the Congressional Budget Office (CBO) admits there is going to be a lag from the signing of the bill until its effects are felt. Planning, bids, contracts, and regulatory and environmental reviews all take time. The CBO estimates 2009 funding will also be slowed by the built-in inertia of government. Don't look to get too much stimulation until the latter half of 2009, and more likely into 2010 and beyond.



Andrew Cullison
Publisher, Welding Journal



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When James came to LeTourneau University to pursue a mechanical engineering degree, he brought the kind of hands on experience many others his age lack. He's the lead designer and engineer for LeTourneau's SAE Baja team – a student group that builds off-road racing vehicles for competition.

“THE SAE BAJA COMPETITIONS ARE ALL ABOUT DURABILITY AND MECHANICAL DESIGN,” HE SAYS. “PROFESSIONAL ENGINEERS JUDGE OUR BAJA CARS ON DESIGN, PHYSICAL LIMITATIONS AND A FOUR HOUR ENDURANCE RACE.” THAT’S WHY JAMES AND HIS TEAM PREPARE WITH PROFESSIONAL GRADE TOOLS.

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JAMES WOLFE

Head Engineer, LeTourneau Baja Race Team
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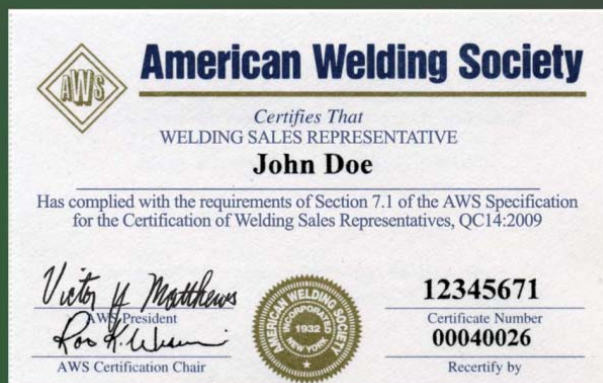
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**NEWS OF THE
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Special Welding Course Prepares U.S. Sailors to Make Critical Repairs at Sea

Six U.S. Navy sailors participated January 26–30 in a fast-paced welding training course held at the Carver Campus of Bishop State Community College, Mobile, Ala.

The sailors are assigned to the Navy warship *USS Independence* (LCS-2), an aluminum vessel contracted to General Dynamics and being built by Austal USA, a shipbuilder located in Mobile. The vessel is the first U.S. Navy combat ship to be built in Mobile since World War II. The sailors will use what they learned to make emergency structural repairs once the ship is out to sea until a port stop can be made.

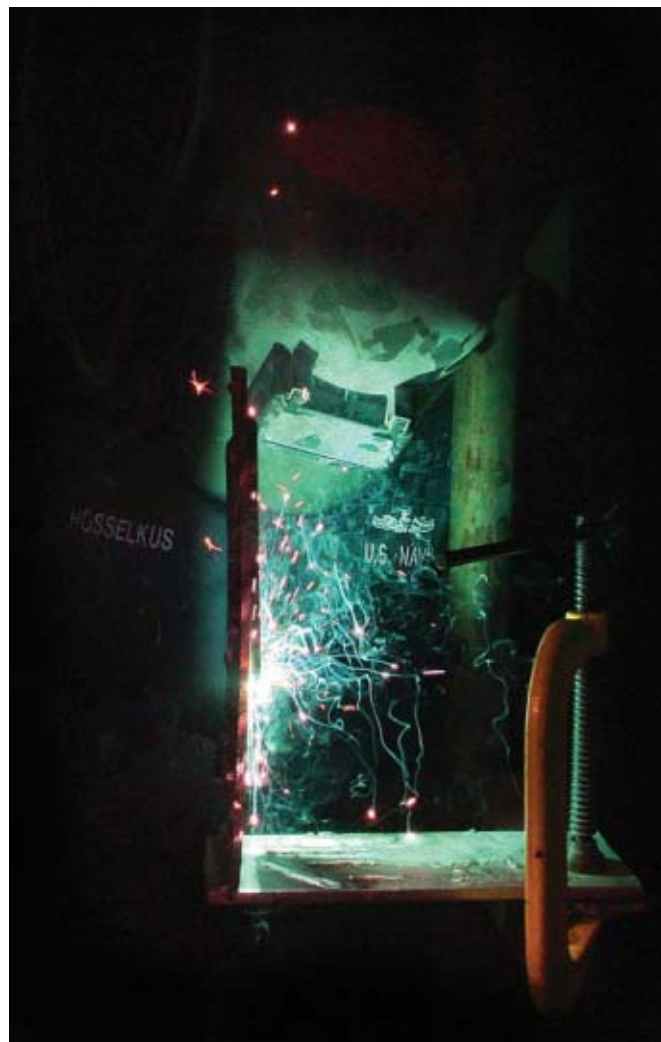
The event took place tuition free thanks in part to Dr. Matthew Hughes, director of Alabama Governor Bob Riley's Office of Workforce Development, and Bradley Byrne, chancellor of Alabama's two-year college system. Byrne also chairs the State Workforce Planning Council, which approved the training activity. Jim Payne, a Navy logistics representative, brought attention to the need for specialized training to Bishop State welding instructor Tim Wilson.

These students, most of whom had little welding experience, trained for a total of 35 hours. Todd Donald, an AWS Certified Welding Inspector who is BuildMobile's welding director at the college, along with Annette Brown, a structural and pipe instructor and former student of the BuildMobile welding program, taught the class.

"I was very excited to be able to work with the Navy sailors. It was a wonderful opportunity," said Brown. "I was amazed at how quickly the sailors picked up the intricacies of the welding process."



During five days of welding instruction provided tuition free at Bishop State Community College's Carver Campus in Mobile, Ala., six U.S. sailors learned various tasks. As shown above, ENC(SW) Gary Thomas carefully marks an aluminum strip before cutting. (Photo courtesy of DCCS(SW) William Oeltjen, United States Navy.)



EN1(SW) Todd Hosselkus welds aluminum during a course held in January. The skills he acquired will be used to accomplish jobs needing quick fixes while aboard the USS Independence (LCS-2), the first U.S. Navy combat ship built in Mobile since World War II. (Initially published on February 3, 2009, this photo is courtesy of the Press-Register 2009©. All rights reserved. Reprinted with permission.)

Most training sessions were tailored with a goal of proficiency in emergency repairs, especially double plate-type fixes. Instruction included making fillet welds, which were challenging to accomplish in all positions given the short time frame, and lap-joint welds. Donald informed the students of three successful keys: first, pay attention to detail; second, use proper time management; and third, do not make the same mistake twice.

Curriculum included the theory of the aluminum gas metal arc welding process, plasma arc cutting, welding defects/discontinuities, necessary hand tools, and safety. Demonstrations taking place in the shop included equipment setup, welding T-joints and lap-joints in all positions, cutting materials with power tools and plasma arc cutting, and diagnosing problems with welds and equipment. Minimum classroom work occurred as well. Evaluation came from observing progress.

The following Petty Officers, who are all Surface Warfare (SW) qualified and included two Damage Controlmen (DC) and four Enginemen (EN), received training: DCCS William Oeltjen; DCC Emmanuel Lone Elk; ENC Gary Thomas; EN1 Justin Bishop; EN1 Todd Hosselkus; and EN1 Benjamin Stanton. While aboard *USS Independence*, they will also run the ship's entire engineering plant at sea.

"I thought they digested the instruction very quickly. I believe the rapport that was established initially and keeping the training informal, yet structured, created an excellent learning environment," Donald said. "Because of circumstances that we encountered during the training, I observed that even in areas where one sailor may be weak, two others may be strong. I thought they (as a crew) complemented each other quite well."

Additionally, Donald suggested another five-day instructional period to be held soon with these same students for intensive training on pipe repair using gas tungsten arc welding. This will fully prepare them to take care of structural damage to the ship.

A consultation-type visit will also be made once the welding equipment has been delivered to the ship during its initial equipment outfitting. Different scenarios can be created to ensure its setup, along with the consumables needed, works correctly.

"If they were as pleased as they said, then we look forward to a long relationship if Austal continues to receive LCS contracts," Donald added. — *Kristin Campbell, associate editor.*

Selectrode Industries Creates "Green" Welding Electrode Manufacturing Facility



This architectural rendering displays Selectrode Industries' new Aliquippa, Pa., building that will be operational in the late fall of 2009. It is being designed and built by U.H.L. Engineering.

Construction is expected to commence soon for Selectrode Industries' new 75,000-sq-ft welding electrode manufacturing plant situated on a ten-acre parcel. Located at the Hopewell Industrial Park, Aliquippa, Pa., just 1000 ft from the company's present manufacturing facility, its operations should start late this fall.

Features of this facility will include four electrode extrusion



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lines, one of which will be dedicated to the manufacture of flux coated aluminum electrodes. The entire extrusion, flux mixing, and wire cutting operations will be situated in a closely controlled humidity and temperature environment. Packaging, warehousing, and distribution areas will be fully air-conditioned.

U.H.L. Engineering has been chosen to design and build this plant due to its experience with environmentally friendly concepts. Current solar and geothermal systems will be employed along with electricity and water conservation, natural light utilization with windows and sky lights, high-efficiency lighting, and a closed loop water chilling unit.

The expansion will generate 40 jobs. Starting in September, interviews will be conducted for purchasing specialists, extrusion press operators, quality control technicians, flux mixers, and packaging laborers. Interested persons may contact Chuck Dickinson, human resources director, at chuckd@selectrode.com for more information.

Underwater Friction Welding Machine Meets Mil-Spec Standards



The Fusion Bonding System, an underwater portable friction welding machine developed by Fusematic Corp., Palm City, Fla., has been qualified and certified under Mil-Spec Standards by the Department of Defense, Naval Sea Systems Command (NAVSEA), to weld studs both underwater and on the surface as per NAVSEA Procedure # WPF-UFSW-001. The lightweight portable air tool — displayed in use by a diver — welds studs, bolts, and nuts on the surface or underwater in seconds to similar or dissimilar materials by utilization of proven friction welding techniques. According to the company, its Fusion Bonding System is the only automatic stud welding machine to be qualified under NAVSEA Mil-Spec Standards for underwater stud welding.

Hinds Community College's Rankin Campus Holds Open House

To celebrate Hinds Community College's acquisition of the Rankin Career & Technical Building in Pearl, Miss., an open house held on February 2 allowed more than 100 state and local officials to tour the new facility.

"This is a wonderful day for not only the alumni and supporters of Hinds Community College and not only Rankin County, but also the young people who will come through this facility, who will leave with a trade and be able to work, support their families, and contribute to society," said Lt. Gov. Phil Bryant.

Hinds paid \$3.2 million for this space, formerly belonging to



The Rankin Career & Technical Building of Hinds Community College in Pearl, Miss., officially opened recently. Coby Gaines, an attendee of night classes, uses shielded metal arc welding with a 1/8-in. 7018 electrode to perform a fillet weld on an inside corner joint in the 1F position. (Photo courtesy of Barin von Foregger/Hinds Community College.)

the United Association of Plumbers and Pipefitters Gulf Coast Regional Training Center, with a fiscal year 09 state bond appropriation and capital funding support from Rankin County.

Thanks to the help of Rankin County Board of Supervisors and the 2008 Legislature, especially Finance Committee Chair-

man Sen. Dean Kirby and Rep. Percy Watson, chairman of the House Ways and Means Committee, the college's Board of Trustees finalized the purchase in December 2008.

The two-story, 40,000-sq-ft building sits on nearly five acres of land. Located approximately five miles from the main campus, it houses various construction-related career programs such as welding, electrical, and plumbing. The 5500-sq-ft welding lab features 20 welding booths complete with machinery, an area for 5 grinding machines, and 5 gas tungsten arc welding booths.

W Industries Set to Expand in Detroit

W Industries, a provider of processing, fabricating, and welding metals, is set to invest \$36 million in Detroit, Mich.

State Senator Martha G. Scott recently announced the Michigan Economic Growth Authority Board's approval of a \$9.7 million, 10-year tax credit for the company's owner, Metal and Welding Industries of Detroit, due to the expansion. This will allow diversification into the aerospace and defense sectors.

The proposed project features two components: The first relates to a contract for a military material handling vehicle, and the other associates to the addition of a large gantry mill. The project also includes a combination of renovations to an existing facility, as well as the purchase and renovation of a new facility.

Approximately 501 jobs will be created over the next five years, and it is estimated the facility will generate a total of 943 jobs in the state by the year 2018. The Michigan Economic Development Corp. also approved job training funds for this project through the Economic Development Job Training program.

— continued on page 110



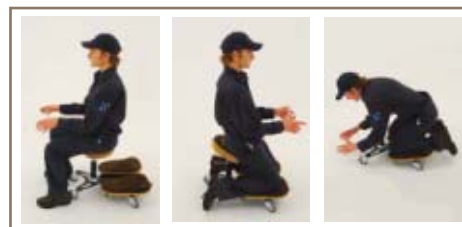
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**American Welding Society**

Friends and Colleagues:

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

For specifics on the nomination requirements, please contact Wendy Sue Reeve at AWS headquarters in Miami, or simply follow the instructions on the Fellow nomination form in this issue of the *Welding Journal*. Please remember, we all benefit in the honoring of those who have made major contributions to our chosen profession and livelihood. The deadline for submission is July 1, 2009. The Committee looks forward to receiving numerous Fellow nominations for 2010 consideration.

Sincerely,

Nancy C. Cole
Chair, AWS Fellows Selection Committee



CLASS OF 2010
FELLOW NOMINATION FORM

(please type or print in black ink)

DATE _____ NAME OF CANDIDATE _____

AWS MEMBER NO. _____ YEARS OF AWS MEMBERSHIP _____

HOME ADDRESS _____

CITY _____ STATE _____ ZIP CODE _____ PHONE _____

PRESENT COMPANY/INSTITUTION AFFILIATION _____

TITLE/POSITION _____

BUSINESS ADDRESS _____

CITY _____ STATE _____ ZIP CODE _____ PHONE _____

ACADEMIC BACKGROUND, AS APPLICABLE:

INSTITUTION _____

MAJOR & MINOR _____

DEGREES OR CERTIFICATES/YEAR _____

LICENSED PROFESSIONAL ENGINEER: YES _____ NO _____ STATE _____

SIGNIFICANT WORK EXPERIENCE:

COMPANY/CITY/STATE _____

POSITION _____ YEARS _____

COMPANY/CITY/STATE _____

POSITION _____ YEARS _____

SUMMARIZE MAJOR CONTRIBUTIONS IN THESE POSITIONS:

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

SEE GUIDELINES ON REVERSE SIDE

SUBMITTED BY: PROPOSER _____ AWS Member No. _____
Print Name _____

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

NOMINATING MEMBER: _____ NOMINATING MEMBER: _____
Print Name _____ Print Name _____
AWS Member No. _____ AWS Member No. _____

NOMINATING MEMBER: _____ NOMINATING MEMBER: _____
Print Name _____ Print Name _____
AWS Member No. _____ AWS Member No. _____

SUBMISSION DEADLINE July 1, 2009



American Welding Society

Fellow Description

DEFINITION AND HISTORY

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

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

RULES

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

NUMBER OF FELLOWS

Maximum of 10 Fellows selected each year.

AWS Fellow Application Guidelines

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

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

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

Supporting Letters

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

Return completed Fellow nomination package to:

Wendy S. Reeve
American Welding Society
Senior Manager
Award Programs and Administrative Support
550 N.W. LeJeune Road
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ALUMINUM

Q&A



Fig. 1 — The GTAW process using AC current to produce an arc between a tungsten electrode and the aluminum plate and protecting the molten aluminum with pure argon shielding gas. (Reproduced by permission, TWI Ltd.)

Q: I am a pipe welder who has worked on many projects over the years including petrochemical and power generation. I have worked with many types of materials including carbon steel, stainless steel, and chrome molybdenum low-alloy steels. There is one group of materials that I have not yet worked with, and they are the aluminum alloys. I would like to know more about the open root joint welding procedures used for aluminum pipe. Is this type of welding of aluminum pipe any different to the welding of pipes made of steel and can you recommend a source of reference on this subject?

A: The procedures that are used for open root joint welding of aluminum alloy pipes are different to those used for welding steel pipe. See my detailed explanation below.

Open Root Joint Welding of Steel Pipes

The all-important root bead or root run in steel pipe is often welded with one of three processes — gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), and shielded metal arc welding (SMAW). A typical weld joint used for welding steel pipe is a single V-groove weld with an open root using a feathered edge or land that is welded from one side only. With the correct welding procedure, the root run in this type of joint in steel

BY TONY ANDERSON

may be completed using any of these three welding processes. The GTAW process is frequently used with or without a consumable insert to produce excellent root profiles in steel pipes. The GMAW process in the short-circuit transfer mode, or using pulsed arc characteristics, is sometimes used for root runs in open root joint welds made in steel pipe. With the correct procedure this process can produce very good results. The SMAW process is used extensively for completing root runs in open root joints when welding various grades of steel pipe. With SMAW, the E6010, E7010-P1, and E8010-P1 deep-penetration cellulosic-type electrodes are often used to produce excellent root runs in the uphill and downhill positions when employed by a skilled pipe welder.

Open Root Joint Welding of Aluminum Pipes

A significant difference between welding aluminum alloys and steel is that the root runs of open root joints in aluminum pipes are almost always performed by using the GTAW process — Fig. 1.

The GMAW process in most instances fails to provide the consistent control necessary for performing root runs in open root joint welding of aluminum pipe. The problem that occurs is inadequate control over heat input and penetration for such a sensitive and demanding joint configuration in a material with such high thermal conductivity. The GMAW process is more appropriately suited for welding heavier walled aluminum pipe and used after the GTAW root run to deposit subsequent weld beads to fill and cap the weld. In this way, one may take advantage of the GMAW process's high deposition rate and travel speed without concern of inconsistent root profiles.

The SMAW process, which is rarely ever used for aluminum welding, would never be used for this type of weld joint.

As stated above, the root runs of open root joints in aluminum pipe are most often successfully achieved by using the GTAW process. A typical procedure for GTAW of aluminum would make use of AC current, unlike GTA welding of steel that conventionally uses DCEN, which, if used on aluminum, can result in poor weld quality. With AC welding, we take advantage of the positive half cycle of the current for aluminum oxide film removal and the negative half cycle for electrode cooling. The cathodic cleaning of the positive half cycle that helps to disperse the aluminum oxide film during welding is a very

important feature of this method of welding. Without this cleaning action during the welding process such discontinuities as incomplete fusion and oxide entrapment in the completed weld would be difficult to avoid. This type of procedure would typically use pure argon shielding gas and pure or zirconiated tungsten, and there would be no requirement for a purging gas to be used during welding as is sometime required for the welding of some steel alloys. The use of a consumable insert or EB insert, as it is sometimes known, is not a viable option when welding aluminum. By definition, an open root joint is an unwelded joint without backing or consumable insert. However, the consumable insert that I mentioned earlier is widely used for pipe welding of steel and is often seen as a convenient method of acquiring excellent root profiles in welded pipes. For those pipe welders who have used consumable inserts, there will be a great appreciation for the quality of root runs that can be achieved by simply fusing the prefitted insert using the GTAW process with little or no additions of filler metal during the root run. Unfortunately, the consumable insert is generally accepted as being unsuitable for aluminum pipe welding. The reason for this is that the surface areas of the insert that are hidden beneath the joint preparation are inaccessible to the welding arc during the welding process. Consequently, the cathodic cleaning action of the arc, which is the principal method of removing the aluminum oxide and impurities during welding, is unable to adequately clean the entire joint during the welding process. This can result in unacceptable discontinuities in the completed weld.

Type of Weld Preparation

Aluminum pipes are welded with backing rings; both temporary and permanent backing rings are used. Permanent backing usually have as a requirement that they must be made from the same aluminum alloy number group as the pipe material being welded, and temporary backing may be made from stainless steel, anodized aluminum, or grooved ceramic material.

When welding aluminum pipe without backing and using an open root joint, the joint preparation becomes extremely important for various reasons. One joint preparation that is used to assist the open root welding for aluminum pipe is the extended land preparation — Figs. 2, 3. This joint preparation is designed to provide a relatively thin section at the root of the joint

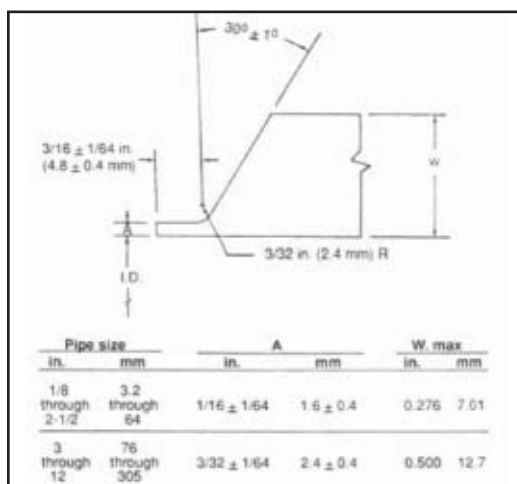


Fig. 2 — The general dimensions used for the extended land preparation.

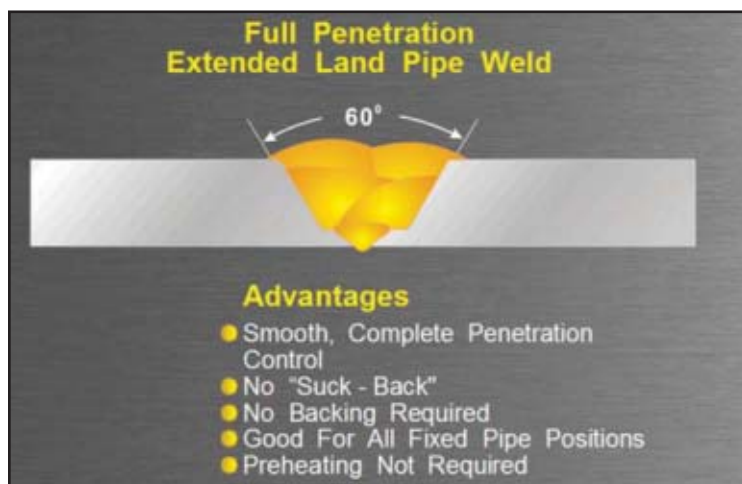


Fig. 3 — An extended land pipe weld with the advantages listed for this type of weld preparation when used for aluminum pipe joints.

that can be used to more easily control root penetration. Care must be taken to add sufficient filler alloy when performing the root run as aluminum piping is often manufactured from alloys that are unsuitable for autogenous welding and without adequate addition of suitable filler alloy the root run will invariably crack.

Reference Material for Welding Aluminum Pipe

There may be a number of publications available that address this subject in some form or another, however, the one that comes to mind for me is the American Welding Society publication AWS D10.7, *Guide for the Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe*. This publication was developed as a guide to facilitate the selection and specification of welding processes and procedures for aluminum and aluminum alloy pipe. This recommended practice has been prepared by the Subcommittee on Aluminum Piping of the AWS Committee on Piping and Tubing, and is intended to provide information needed to minimize or avoid difficulties in the welding of such pipe. The data given in this document are presented as initial guides to operating conditions. The first edition of this document, AWS D10.7-60, was written to present the advances made

in aluminum pipe welding during and subsequent to WWII. The second edition of this document was AWS D10.7-86, which updated AWS D10.7-60. The AWS D10.7M/D10.7:2000, third edition, changed the document from a 'Recommended Practice' to a 'Guide' and updated the processes and procedures. The most significant change in the current AWS D10.7M/D10.7:2008, fourth edition, was the inclusion of a comprehensive guide for

the selection of filler metal. In addition to the new filler alloy selection chart and associated information, the current standard introduces the reader to the properties of aluminum that are important to a successful welding operation. Precise welding procedure specifications, including joint designs, are provided with a discussion of welding technique and heat treatment considerations that are unique to welding aluminum alloys. ♦

TONY ANDERSON is corporate technical training manager for ESAB North America and coordinates specialized training in aluminum welding technology for AlcoTec Wire Corporation. He is a Registered Chartered Engineer and holds numerous positions on AWS technical committees. He is chairman of the Aluminum Association Technical Advisory Committee for Welding and author of the book *Welding Aluminum Questions and Answers* currently available from the AWS. Questions may be sent to Tony Anderson c/o *Welding Journal*, 550 NW LeJeune Rd., Miami, FL 33126, or via e-mail at tanderson@esab.com.

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LETTERS TO THE

EDITOR

Reader Questions Fillet Weld Measurement Technique

This letter concerns the magazine's recent feature article 'How to Accurately Measure Fillet Welds' by Joe Pavlanis. The author's response follows.

There may be an error on page 39 of the February 2009 *Welding Journal*. Specifically, Mr. Pavlanis's article states that the caliper attachment can measure the actual throat of a fillet weld. However, this is true only if the fillet weld is fully fused to the intersection of the pieces that were welded.

Figure 25(c) in my copy of AWS A3.0:2001, *Standard Welding Terms and Definitions*, is a sketch of a fillet weld with incomplete fusion. In that figure the actual throat is labeled as the distance from the bead face to the bead inner surface. In this case the bead inner surface does not extend to the intersection of the welded pieces. Therefore, the caliper attachment cannot measure the actual throat, only the theoretical throat.

While composing this I noticed that AWS A3.0 Figure 25(c) does not label the leg lengths in an incompletely fused fillet weld. If a leg length is similar to the actual throat, in that it extends between the weld metal-to-base metal intersections, then the caliper attachment cannot measure the true leg length.

Al Cedilote
Wabtec Corp.
Wilmerding, Pa.

Point well taken. Yes, I agree that complete fusion must be present. That would be the first requirement of a weld in general. The intent of this instrument is to provide variable data where the conventional tools used do not provide that data nor do they have the ability to obtain variable data that is provided with an instrument that is traceable to the National Institute of Standards and Technology. It is very difficult to calibrate a printed scale, much less obtain accurate data.

This article takes into consideration that a weld is fully fused. I do appreciate your observation and comments. If you have any additional information, we are very eager to learn and become more knowledgeable regarding all areas of manufacturing.

Joe Pavlanis
Process/Quality Engineer
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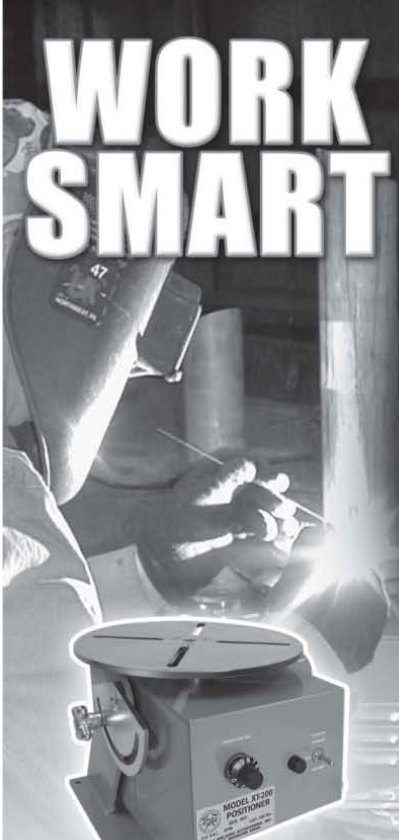
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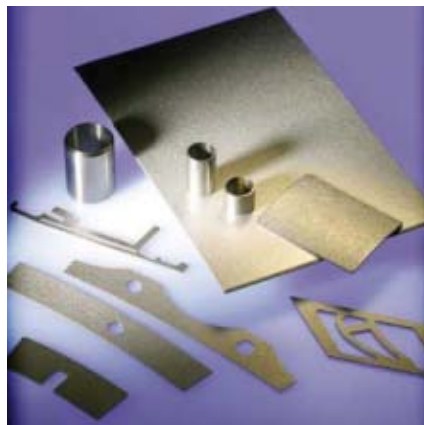


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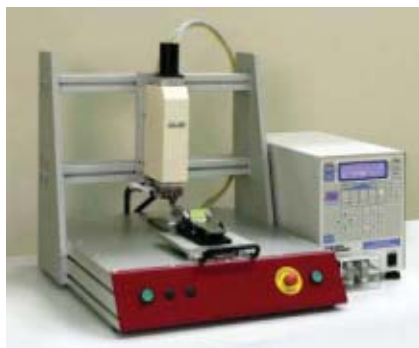
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WELDING JOURNAL 29



Matching a filler metal to a base material requires careful consideration of both the mechanical properties and chemical composition of the metal, along with its shape and thickness.

Know the Keys for Matching Filler Metals to Your Base Material

Careful consideration of factors such as a material's chemical and mechanical properties can make filler metal selection easier and help ensure quality welds

BY DEAN C. PHILLIPS

Selecting filler metals can be a difficult task as there are a multitude of factors that contribute to making the decision. The available welding equipment, the necessary welding position, the joint design, and the service environment the final weld will encounter each need to be considered, as does the welding operator's skill level. But there are also some slightly more complicated aspects to consider when determining how to match filler metals to a given base material. The material's chemical and mechanical properties, its shape and thickness, and the welding procedures to which welding operators must adhere are some

factors that dictate filler metal choice. Carefully considering each of these can help ease the selection and ensure quality welds with fewer complications.

Consider the Material

In order to properly match a filler metal to a base material, begin with the general properties of that material. First, the filler metal must be compatible with the chemical composition or alloy of the base material. For example, welding on ASTM A387/A387M, Grade P11 of chrome-moly pipe requires a low-alloy

filler metal, typically an AWS A5.XX, 1¼% Cr-½% Mo product, while welding on A36 steel requires a carbon steel product, such as an AWS A5.XX, 70 ksi tensile strength carbon-steel filler metal.

Secondly, consider the mechanical properties of the base material. These properties, which are usually identified by ASTM or similar material standards, include tensile and yield strengths, as well as the elongation and toughness (Charpy V-notch (CVN)) properties. The filler metal should possess similar mechanical properties to ensure the integrity of the final weld.

DEAN C. PHILLIPS (www.hobartbrothers.com) is manager of welding engineering, Hobart Brothers Co., Troy, Ohio.

As a general rule, most applications require “matching” the filler metal tensile or yield strength to that of the base material as applicable to the design requirements. The term “match” here is in quotations because the two strengths are not exact. For example, A36 steel has a minimum yield strength of 36 ksi, but there are no such low-strength filler metals available in the marketplace. Instead, this material would be matched with a filler metal that offered the closest tensile and yield strength, such as an AWS A5.XX 70 ksi tensile class filler metal, which provides a weld deposit of 70 ksi minimum tensile strength and 58 ksi minimum yield strength.

In some cases, it may be desirable to “undermatch” the strength of the filler metal to the base material, especially when making certain fillet welds or for an application requiring only partial joint penetration (PJP). “Undermatching” can be more economical and may help minimize the residual stresses in the weldment. “Overmatching” filler metal strength to a base material’s strength is more controversial and generally discouraged, except in some instances where yielding in the base material is more desirable. An example is spooled piping.

Next, consider the base material’s shape, thickness, and general condition to help determine the appropriate filler metal. For instance, a pipe-to-pipe application usually has a saddle joint design (found in ‘TYK’) and would require a different diameter of filler metal and/or one with different weld position capabilities than a plate application, due to the location and the depth of the joint design. A heavy plate weldment, on the other hand, typically has a T-joint or butt joint and requires complete joint penetration (CJP) and backing. It may use a larger diameter electrode at higher currents to increase penetration and production compared to TKY pipe joints.

Another factor to consider is the thickness of the material to be welded, as some material thicknesses directly affect the material’s strength. Consider the strength of quenched and tempered steel (Q&T), such as A514/A514M-05. This material has a tensile strength of 110 to 130 ksi, 100 ksi minimum yield strength, and 18% elongation when it is 2½ in. thick or less. When it is greater than this thickness (2½ to 6 in. thick), its mechanical properties change to approximately 100 to 130 ksi tensile strength, 90 ksi minimum yield strength, and 16% elongation. The quench and tempering process is responsible for this change, as the thicker material has a slower quench rate that results in lower minimum yield and tensile strengths. As a result, this thicker material may require a lower-strength filler metal.



The condition of the material being welded, plus its postweld requirements, both contribute to filler metal selection.

Similar differences in mechanical properties occur with hot or cold rolled materials, such as mild steel, and those that are postweld heat treated (PWHT), case or through hardened, or normalized. In each instance, these material conditions need to be considered when making a filler metal selection. As an example, AISI 1040 hot rolled, normalized, annealed, and quenched and tempered approximate mechanical properties are in Table 1.

Another manufacturing process, cold rolling, creates a different material condition with higher strengths than as-rolled AISI 1040, and therefore requires higher-strength filler metal for welding it. Cold rolled material will also, because of its higher strength and lower elongation properties, be more sensitive to cracking; the chosen filler metal and welding procedure will need to accommodate for such vulnerability.

Table 1 — Mechanical Properties of AISI 1040 Hot Rolled, Normalized, Annealed, and Quenched and Tempered

Material Condition	Tensile Strength, lb/in. ²	Yield Strength, lb/in. ²	Elongation, %	Reduction of Area, %
As-rolled(HR)	90,000	60,000	25	50
Normalized	85,000	54,000	28	55
Annealed	75,000	51,000	30	57
Q&T	130,000	96,000	16	45

As a rule, choosing filler metals with low diffusible hydrogen levels offer the least amount of potential for cracking in these higher strength and less ductile materials. Also, less ductile harder materials may require higher preheat and interpass temperatures during welding.

What Are the Requirements?

For certain applications, welding codes and specifications may determine filler metal selection, including the type, diameter, and strength. Under these codes and specifications, filler metals must provide specific chemical and/or mechanical properties, CVN toughness, temper embrittlement conditions, hardness, or other similar requirements.

The type of application, specifically whether it is for production or repair, factors into the filler metal (and welding process) decision, as does the desired finished condition of the weld. In a repair situation, base materials that have been in service and need repair often have dirt, oil, rust, or other contaminants on their surface. Additionally, the weld repair area may be or become highly restrained, requiring a filler metal with maximum ductility,

along with unique welding techniques to prevent weld and base metal failure after the repair.

In addition, the physical location of a repair application dictates the welding process and the filler metal capable of the welding positions needed to repair the base material. Take, for instance, a company that needs to make a weld repair on a machine tool base, but does not want (or cannot) move it from its position on the facility floor. Such repairs may require careful attention to preheat and interpass temperatures to prevent the base material from expanding in its current location. Specifically, these temperatures must remain extremely low and the filler metal must be capable of providing adequate strength and ductility under these conditions.

Conversely, in a production situation this same type of material may require elevated preheat and interpass temperatures, a different welding position and process — and a completely different filler metal. For example, whereas the repair of a large hydraulic press fabricated from heavy sections of low-strength carbon steel, such as ASTM A36, may require a carbon steel SMAW electrode, the production of that same press could use FCAW, GMAW, and SAW filler metals. This is because the repair application may

not allow for localized preheating, but the production of the press does; it will also allow for different interpass temperatures.

Next, filler metal selection will depend on whether a material will be welded to itself or another type or strength of material. Similar strength and type materials require a filler metal that has the same matching tensile and/or yield strength. As an example, to weld two pieces of A514 steel together, a 110-ksi tensile strength filler metal would be appropriate.

However, when welding dissimilar strength base materials, such as a piece of A514 steel to a piece of A36, the variables dictating filler metal selection change. That is because when welding a higher strength base material to one that has lower strength properties, the filler metal strength only needs to meet the mechanical requirements of the lower-strength material. For example, a 70 ksi tensile strength filler metal with 58 ksi yield that “matches” the A36 material mechanical requirements (36 ksi yield strength) would provide adequate strength when joined to A514 base material.

Many structural steel applications weldments are used in the as-welded condition, meaning the final weld is acceptable for service after passing inspection; no further postweld heat treatment is necessary. In this situation, matching the filler metal to the base metal via strength and/or chemistry requirements will suffice.

In more critical applications, however, PWHT may be required and this directly affects filler metal selection. Such a situation is common in pressure vessel and pressure tanker rail car welding applications. When welding on certain vessel materials for these applications, the final weld may require PWHT to improve impact or toughness properties and/or reduce any residual stresses in the weldment that could lead to premature failure. AWS A5.XX filler metals for these applications are appropriate and readily available in the marketplace.

Applications requiring welds that need to be quenched and tempered, case hardened or normalized and tempered, will use filler metals capable of maintaining their chemical and mechanical properties after such postweld treatments. These products, however, may be more difficult to obtain, as they must be specially alloyed with additional elements to provide properties compatible to the base material.

Ultimately, if considering each of these criteria still leaves doubt as to matching a filler metal to a particular base material, contact a trusted welding distributor or filler metal manufacturer for assistance. Filler metal selection is absolutely critical to assure the integrity of the weldment regardless of how simple or complex the application. ♦

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Addressing the Future Shortage of Welding and Joining Technicians

How the foundation was laid for the development of a national center for welding education and training

The American industrial landscape and, indeed, the industrialized world owe much of its structural integrity to welding and materials joining. Today's welding and joining technician is a highly skilled worker with an almost unlimited array of economic sectors in which to enjoy a successful career. President Obama's American Recovery and Reinvestment Act and the aggressive energy and infrastructure objectives aimed at putting America back to work significantly rely on the engineering, manufacturing, construction, production, and distribution of products made possible through ever more sophisticated welding and joining techniques and applications.

Rebuilding a Skilled Workforce

In the 20th century, the United States led the world in productivity and innovation in large part because it supported a diverse pool of talented, highly educated workers exemplified in its welding and joining professions. But more recently, evidence of a skilled workforce decline has surfaced — precipitated by increasingly ill-prepared new workers, steadily depleting stock of highly skilled and educated

workers, and the decrease in domestic manufacturing. This erosion of talent, training, and opportunity weakens our competitiveness and lowers our standard of living.

Today, advanced welding and materials-joining applications are at work in virtually every economic sector in America. From aerospace to agriculture, defense and infrastructure, highly skilled welding and joining technicians are making it happen. With so much to support the importance of welding and joining across such a broad spectrum of American enterprise and output, it is estimated over the course of the next six years we will have to address the need for 200,000 skilled welders and technicians to get the job done.

Addressing the Crisis

Starting in 2004, several key people and organizations came together in a focused effort to address the looming workforce crisis for highly skilled welding and materials-joining technicians. These soon-to-be-partners also agreed that technical education and training for future workers needed to be enhanced with state-of-the-art instructional resources both in the classroom/lab, and also on site in the workplace.

One of the leaders in this initiative was James Key, former AWS president and a nationally recognized advocate for higher technical education and training across several manufacturing and engineering fields.

Key knew that the National Science Foundation funded centers of excellence around the country that brought together business, industry, and education partners around specific economic sectors to better prepare high-skilled workers and to keep America competitive in a global marketplace.

In 1994, the National Science Foundation (NSF) created a special division, Advanced Technological Education (ATE), to solicit, review, and award multiyear grants to support industry-driven advances in technical education, professional development of educators, recruitment and retention of workers, advancing diversity in the workplace, and keeping pace with the evolving and challenging workforce development needs in America.

ATE Centers

The Advanced Technological Education (ATE) program supports efforts to improve the knowledge and skills of technicians who work in high-technology fields

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ATECENTERS MAP

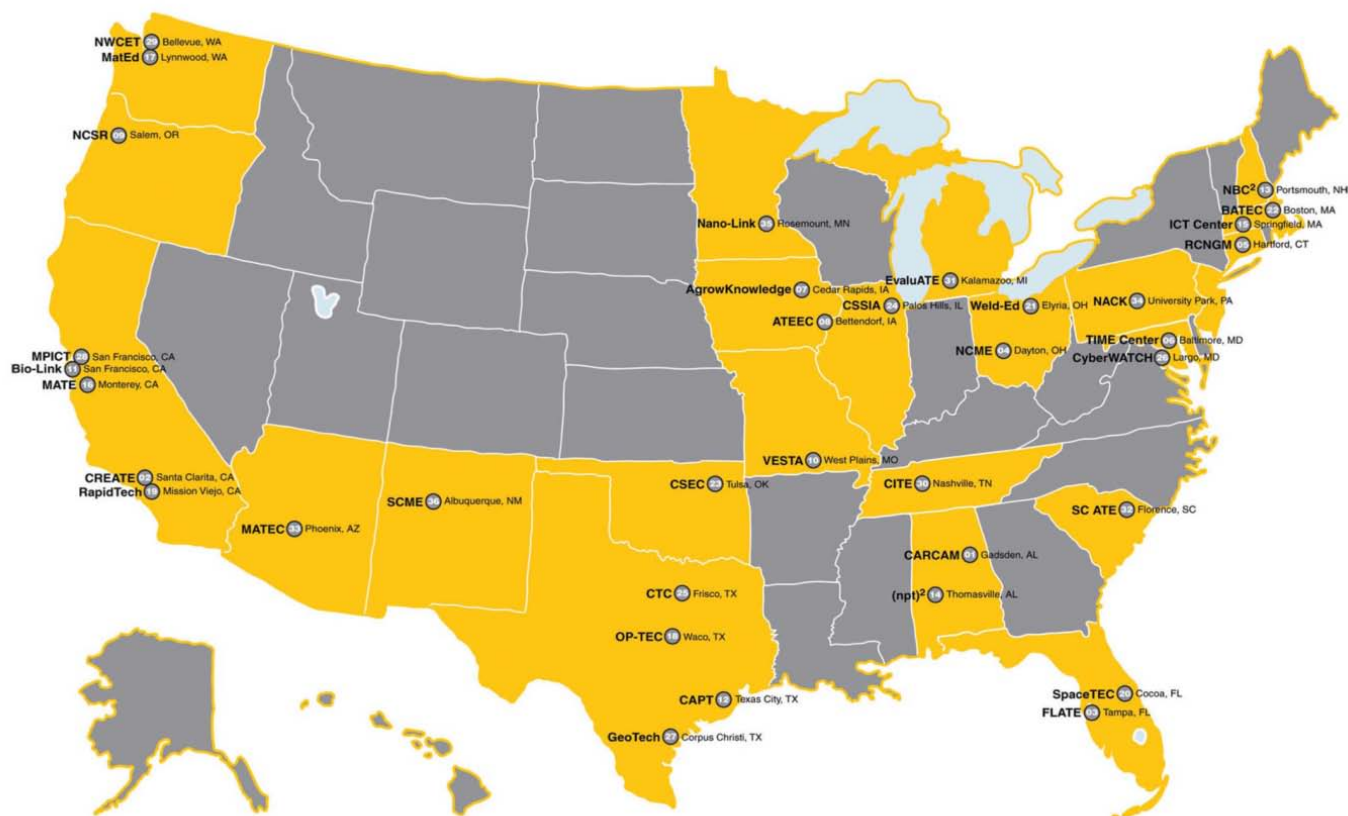


Fig. 1 — There are 36 Advanced Technological Education Centers across the country that promote skills and education in a variety of technologies.

that drive the nation's economy. This National Science Foundation program focuses on undergraduates, secondary school students, incumbent technicians, as well as the educators who teach them.

The ATE Centers, now 36 strong across the country (Fig. 1), focus their education and training goals on the two-year community and technical college network, counting on strong academic partnerships with university, business, and industry leaders. All of the ATE centers serve as leaders in their fields. Additional information about the centers can be found at www.atecenters.org.

Partners in Workforce Development

It was realized that to meet the projected workforce shortage for high-skilled welding and joining technicians, a significant partner would be the American Welding Society (AWS). Executive Director Ray Shook and the AWS board had made it a

priority to get behind an effort to engage education and industry leaders in a national center for welding and materials joining.

"My job, on behalf of AWS, was to connect the dots and to see what we could get going," recalled Jim Key. Meanwhile, The Ohio State University, School of Welding Engineering, a recognized leader in emerging technologies and applications, had approached Lorain County Community College (LCCC) to partner on a grant proposal to enhance welding technician education. They made the case that both the timing and need for a national center for welding and joining presented itself as a real possibility.

The NSF often encourages qualified two-year college applicants to submit a planning grant before taking on the scope and vision of a more significant center proposal. In 2004, an NSF planning grant was awarded to LCCC for an 18-month period. The NSF encouraged the submission of an NSF/ATE national center proposal and subsequently conducted a site visit to LCCC in 2007.

A National Center Is Established for Welding Education and Training

The National Science Foundation awarded Lorain County Community College (LCCC) funding for the creation of a National Center of Excellence in Welding Education and Training (Weld-Ed).

"When we got the news that a National Center for Welding Education and Training had been awarded by the NSF, we were both pleased and proud. Five million dollars would do a lot to address the welding and joining workforce needs across the industry, and we felt very good about the partners who had come together to make this happen," recalled Ray Shook. The founding partners for the Weld-Ed Center are LCCC, which is also fiscal agent for the grant; Pennsylvania College of Technology; Texas State Technical College; North Dakota State College of Science; The Ohio State University; and the American Welding Society.



Fig. 2 — The three legs of Weld-Ed's goals (design by Roger Miller).

In addition to the initial partners, the grant proposal was endorsed by industry groups such as Resistance Welding Manufacturing Alliance (RWMA); Welding Equipment Manufacturers Committee (WEMCO); Gases and Welding Distributors Association (GAWDA); and enjoys the industry goodwill of the National Council for Advanced Manufacturing (NACFAM), the National Association of Manufacturers (NAM), the Manufacturing Skills Standards Council (MSSC), and the National Coalition of Advanced Technology Centers (NCATC).

Elizabeth J. Teles, lead program director for the NSF Advanced Technological Education (ATE) program, said this about the Weld-Ed grant award:

"The welding industry is economically large, technically diverse, and has well-documented needs. This industry considers education and training methods and techniques for welding technicians essential to the United States' competitiveness in advanced manufacturing. Lorain County Community College is well positioned to lead this national effort in welding education. The Lorain project team and partners have the expertise needed to develop and enhance education and training programs that address the workforce needs for the welding jobs of the future."

The Weld-Ed's Mission and Goals

The Weld-Ed Center, located on the LCCC campus in Elyria, Ohio (www.weld-ed.org), is committed to the following:

Vision — Weld-Ed is a national partnership of colleges, universities, profes-

sional societies, government, and private industry committed to increasing the number and quality of welding and materials-joining technicians to meet industry demand. For purposes of scope and clarity, welding includes all areas of materials joining other than mechanical fastening.

Mission — Weld-Ed strives to improve the quality of education and training services to address the hiring and professional development needs of the welding industry.

Goals — The center's goals (Fig. 2) are the following:

- Increase the number of welding technicians to meet the ongoing workforce needs;
- Impact recruitment of women, minorities, and special needs workers;
- Foster and enhance faculty professional development and continuing education for welding educators.

The accomplishment of these goals will be a driver in the future of the welding and materials-joining industry in the U.S. Working together, the educational partners, business partners, and AWS are identifying the new and emerging technologies and methods that will be keys to America's competitiveness in a global marketplace. That information will be the foundation in building new state-of-the-art curricula and services to meet the needs of current and future welders, welding technicians, and welding engineers.

"As a partner in the Weld-Ed Center, one of the things that the American Welding Society believes is very important is the professional development of educators. We need to make sure that educators are not only prepared in the latest



Fig. 3 — Welding student Jessica Johnson is taking advantage of the training offered by North Dakota State College of Science, a Weld-Ed center partner (photo by J. Ondov).

technologies, but also have effective teaching strategies and know how to teach young people using these technologies," said Monica Pfarr from the AWS Foundation and a representative on the Weld-Ed Partners Committee.

Quantifying the Workforce

One of the early and critically important tasks the Weld-Ed Center undertook was to quantify the workforce needs for high-skilled welding and joining technicians. Robert Visdos, president of Workforce Institute, Inc., was retained by the center to conduct a national skills panel project to capture forward-looking data from experts across the country about the nature and scope of what today's welding technician needs to be able to do.

Mr. Visdos states that, "the overall purpose of convening skill panels is part of a real-time and market-driven strategy for the Weld-Ed Center to establish career pathways from high school through community colleges and universities, assist in the recruitment and preparation of welders, welding technicians, welding engineers; address immediate workforce needs; and to provide long-term guidance to the Weld-Ed National Center and to the entire welding industry."

The Weld-Ed National Skills Panel is comprised of leaders who represent business, education, chambers of commerce, workforce organizations, economic development agencies, labor, and industry associations. The AWS recommended the industry panelists. Other panelists were recommended by the American Association of Community Colleges. All of the

recommended panelists have extensive knowledge of the industry or extensive educational experience coupled with knowledge of the industry.

The panel is facilitated by Jerry Uttrachi, an AWS past president. Ken Smith, the principal investigator/project director for the Weld-Ed National Center is also the skills panel manager. The panel will be actively engaged in addressing the needs of the industry through three in-person panel meetings and conference calls/webinars that will be conducted every 6 to 8 weeks over a period of 12 to 18 months.

The results of the skills panel project to date are listed below.

- Identification of the short term (1–3 years), mid-term (4–6 years), and long-term (7+ years) employment needs of the industry;
- Identification of the impact of projected retirements on the welding industry;
- Development of strategies to positively impact turnover and job retention;
- Development of recruitment strategies to increase the pipeline of minorities, women (Fig. 3), and other targeted groups into the welding industry, especially in the area of the welding technicians;
- Development of a career pathway to

move employees from entry-level welding positions through employment as welding technicians and eventually welding engineers;

- Identification of new technologies and emerging technologies that will impact the welding industry and develop strategies to address those needs;
- Development of an outreach campaign to encourage more youth and/or job seekers to consider educational credentials and degrees specific to the high-demand welding and materials joining industry;
- Exploring ways to expand apprenticeship opportunities;
- Creating defined career pathways for specific high-growth jobs within the industry; and
- Providing input on the development of customized training and/or curricula for a specific high-growth area within the industry (e.g. welding technician to welding engineer).

Perhaps the most significant and continuously updated outcome is that information collected and verified provides a true snapshot of today's needs, leading to a "demand-driven" response through education, training, workforce, and economic development.

Progress and the Future

Weld-Ed Center Director Ken Smith summarized both progress to-date and projected products and services being offered in the near future this way.

"The actual work of becoming a national center for welding and materials-joining education and training is a significant undertaking by itself. We have made good progress because we have talented and committed partners at the table with us. Our presence at and participation in the annual AWS Show is growing and guided by the great staff at AWS. A participant in the 2008 Education Day sent me this note."

I attended the AWS Weld-Ed class in Las Vegas (site of the 2008 AWS Welding Show), and I was so inspired by everything that Weld-Ed is doing, and it has motivated me to do a lot more in my welding field of education. I plan to start taking the distance learning programs from Ohio State to work on a welding engineering degree and hopefully bring that back to my own classroom for my high school students.

John Paul Gable, teacher
C & T Education Welding
Jefferson High School
El Paso, Tex.

Smith continued, "The national skills panel project has provided more focus and definition about the complex nature of a day in the life of a welding and joining technician in today's industry. Recruitment of traditional, minority, underserved, and physically challenged students is underway on several fronts. Professional development of faculty and the creation and availability of enhanced education and training resources is the next big challenge facing the center.

We all agree that pursuing a degree as a welding and joining technician requires time in both the classroom and the lab; it's theory and practice; it's being able to multitask and manage other workers to do what it takes to get the job done right — and right now. The innovative and emerging trends in the field today will require regular tune-ups for a good employee to stay current and remain a real asset to the employer. It's our job to connect the dots and match the need with a quality resource. As America gets back to work, the task of putting it together across the manufacturing spectrum will require skilled technicians. That puts the Weld-Ed Center at the right place and at the right time." ♦

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BRAZING & SOLDERING TODAY

Brazing: An Important Joining Option

Brazing provides engineers with a versatile form of joining similar and dissimilar base materials that is adaptable to varying production volumes

BY CREED DARLING

To meet the constantly changing product design and economic requirements of today's industries, engineers need to be able to modify or change many of the materials and processes used to manufacture a product. Metal joining is one of those processes that is commonly used in industry and is often affected by material changeover. Among the many joining techniques that are available, engineers most commonly will choose one of four methods (Fig 1): mechanical fastening, adhesives, welding, or brazing. Brazing provides design and manufacturing engineers with a versatile and cost-effective method of joining similar and dissimilar metals and nonmetallic materials. This article discusses many of the criteria that engineers have to consider when choosing a joining method and how brazing compares to the other primary methods.

What to Consider when Choosing a Joining Method

One of the primary characteristics that engineers consider when designing a component is the strength and durability of that component when in use. Products need to stand up to normal wear and tear and to any excessive force that may occur. Joints that hold components together can be exposed to various forces depending on the application and environment.

Aesthetics can also be an important consideration when designing consumer products. Joints between two components can affect the overall appearance and uniformity of an assembly. Engineers and designers look for joining methods that can provide a smooth, clean joint that makes

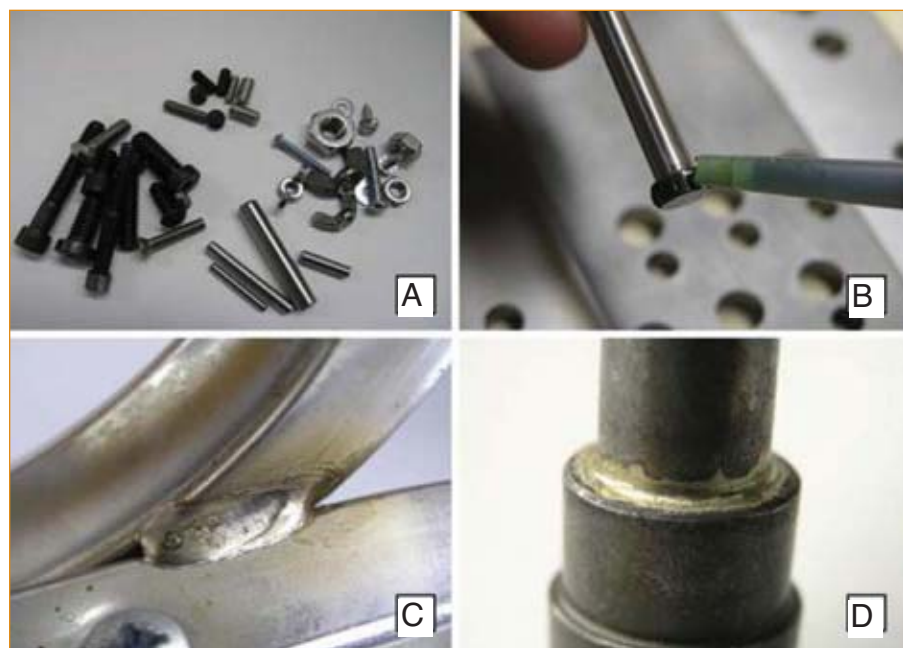


Fig. 1 — Examples of the four primary joining methods: A — Mechanical fasteners; B — adhesives; C — welding; D — brazing.

the consumer product appear like one component vs. an assembly of parts. A clean, uniform joint also provides a surface that is readily plated or painted during postjoining processes.

In many of today's industries, engineers design assemblies that are used to transfer, contain, or transport various types of media. Some of these applications include heat exchangers, fuel lines, refrigeration lines, etc. The joints that are used to connect these components must be leaktight to ensure that none of the media escapes from the assembly.

In the aerospace and automotive industries, among others, temperature and cor-

rosion resistance are critical aspects of products that engineers consider. If a component fails due to high-temperature exposure or corrosion, severe damage of an entire product can occur. The corrosion resistance and temperature resistance of the material used to make the joint needs to be appropriate for each application.

Manufacturing and design engineers are constantly looking for ways to simplify production, reduce cycle time, and lower process costs. Joining methods can vary in cost due to the many different types and the consumables that are used for each method. Automating a process that is currently manual can reduce a lot of time and

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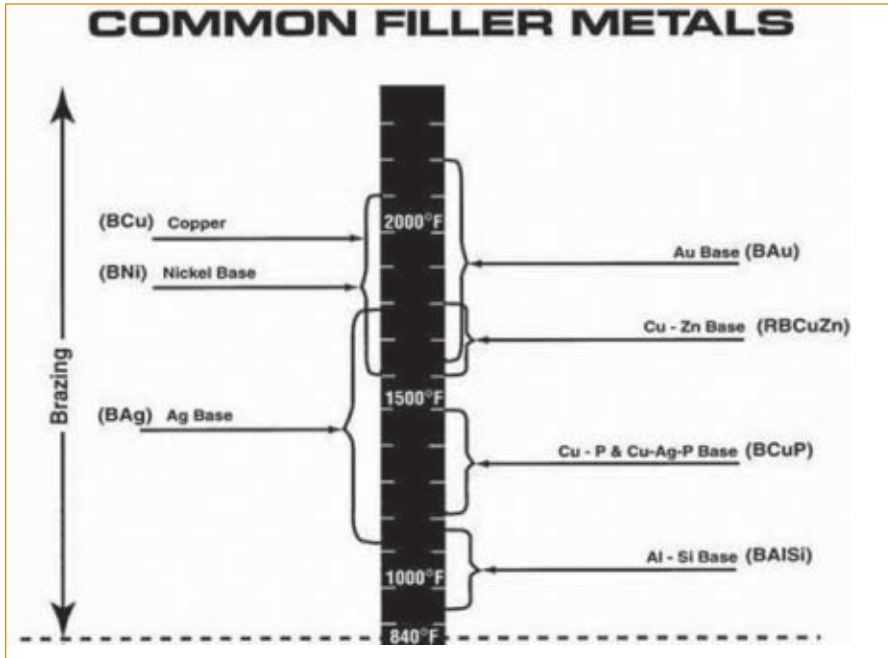


Fig. 2 — Common filler material families.

cost on the manufacturing floor. Automation options can range from semiautomatic processes that still require some operator input, or full automation that does not require operator interaction. Depending on the application and type of method, joining processes can often be automated, lending toward high production and lower processing costs.

Primary Joining Methods

Taking the criteria discussed previously into consideration, the following section discusses the four primary methods of joining that engineers can choose from and how each method meets those particular requirements.

Mechanical Joining

Mechanical joining is commonly used to join structural components by fixing similar and dissimilar base materials together by the use of fasteners. The fasteners that are commonly used in today's industries include tension fasteners, compression fasteners, and shear fasteners. Examples of fasteners used in industry are shown in Fig. 1A. Joining by mechanical means can provide very strong and rigid joints that are suitable for applications ranging from car frames to building trusses. Fasteners can withstand high temperatures and if chosen properly can with-

stand various types of corrosive media. Although joints made with this method can withstand very high forces, mechanical fasteners do not distribute stress well and can create stress concentration sites. In most cases, mechanical joining does not provide a leaktight component unless used in conjunction with an adhesive. Automation of mechanical fastening may be applied in some cases. Fasteners can be expensive and add significant mass and bulk to an assembly, which reduces the aesthetic appeal of the assembly.

Adhesives

Adhesives offer a versatile and economical means of joining various base materials. Adhesives hold the base materials together by surface attachment. Common types of adhesives include reactive, nonreactive, and hot melt adhesives. These adhesives are used to provide leaktight joints across a wide application base. Aesthetically pleasing joints are often produced with adhesives without adding significant weight to an assembly. Figure 1B shows a common application of adhesives. If strength is of concern, adhesives are usually not the best option. Most adhesives will not withstand tensile forces much greater than 5000 lb/in.² and cannot be exposed to operating temperatures above 500°F. Adhesive joining can be automated but may require extensive curing times.

Welding

Welding is the most common method of joining metals in industry today. Welding is the joining of metal substrates by applying heat to the base metal surfaces and fusing the base materials together. Figure 1C illustrates a weld bead that is produced between two base materials during welding. While there are a vast variety of welding methods available, which allow for wide application use, the most common methods include gas tungsten arc, gas metal arc, shielded metal arc, flux cored arc, resistance, laser beam, and electron beam welding. A welded joint is a very high strength joint that can often reach tensile strengths in excess of 100,000 lb/in.². Weld joints can withstand high-temperature and corrosive environments. Welding can also produce a leaktight joint that will withstand high pressures. Welding is suitable for joining similar metals but typically cannot join dissimilar metals as easily. In order to join dissimilar base metals more specialized and costly welding methods may be required. The high amount of heat that is applied to the base materials during welding can cause distortion of the welded assembly. While being widely used, welding does require highly trained operators and some methods are not easily automated. When aesthetics are a concern, welded joints may require grinding and polishing to smooth out the weld bead that is formed on the base materials.

Brazing

Brazing is one of the more flexible methods of joining similar and dissimilar materials. Brazing produces a metallic bond between the base materials by using a molten filler material that melts above 840°F but does not melt the base materials. The molten filler material is dispersed between the base material interfaces by capillary attraction. Figure 1D shows an example of a brazed joint. Like welding, there are many different types of brazing methods used in today's industries. Torch, induction, resistance, and furnace brazing are some of the most frequently used methods.

If designed properly, brazed joints can meet the majority of the joint design criteria discussed in this article. Brazing produces high-strength, leaktight joints that are often as strong as the base materials in the assembly. Joint tensile strengths of up to 140,000 lb/in.² can be achieved with braze joints depending on the application, base materials, and filler materials used.

BRAZING & SOLDERING TODAY

Brazing is commonly used for joining heat exchanger assemblies, fuel lines, and many other transfer assemblies requiring hermetic seals. Many products such as metal furniture, musical instruments, and jewelry require smooth, strong, and uniform joints that only brazing can provide.

A properly brazed joint provides a surface that is aesthetically pleasing and easily painted or plated if needed. Many brazing alloys exhibit high temperature resistance and resist corrosion, lending themselves toward many aerospace and automotive applications. The variety and flexibility of brazing lends itself to automation and can reduce costs in many ways. Methods like torch, induction, and resistance brazing can be automated at several different levels in order to produce high production quantities. Many furnace brazing options can also produce high volumes.

One concern of engineers when choosing brazing as a joining method is the cost of the filler metals that are used due to the fact that many of the filler metals are precious metal based alloys. However, if the joint and the brazing process are designed properly, brazing can be an economical means of joining. Brazing typically does not require as highly skilled operator as welding demands. Using preform rings and shapes will control the amount of alloy applied in the joint area guaranteeing that an excessive amount of alloy is not used. Choosing the appropriate filler material for the application will also ensure that the most economical alloy is used. Joining of nonmetallics like ceramics, diamonds, and glasses is also possible with active metal brazing while welding does not present any readily available options.

Brazing Tips

In order to achieve optimum braze joint quality as discussed in the preceding section, several important steps and design factors are important to keep in mind. All braze joint designs should follow what is known as the “six fundamentals of brazing.” If the six fundamentals are properly followed, brazing will provide a suitable joint for many assemblies. The fundamentals are as follows:

1. Proper fit and clearance
2. Clean metals
3. Proper flux/atmosphere
4. Fixturing
5. Heating
6. Final cleaning.

Engineers also need to choose the appropriate brazing filler material for the application that they are designing



Fig. 3 — The main brazing heating methods are (clockwise from top-left) torch, induction, furnace, and resistance.

around. There are several filler metal families that can be chosen as shown in Fig. 2. Each filler family has different characteristics and properties that lend themselves to particular applications. The Ag-based, Au-based, Ni-based alloys have wide application bases that are suitable for many industries ranging the aerospace to mining and cutting tools. Other alloys are used for brazing specific base materials like Ag-Cu-P alloys for copper-based materials and Al-Si or Zn-Al alloys for aluminum-based materials. Filler metals are available in various forms depending on the family of alloy that is used. Typical forms available include wire, strip, preforms, powder, and paste. To ensure that the proper brazing alloy and form is used for the specific application, engineers should consult their filler metal supplier for the appropriate alloy choice.

Another factor that is important to consider is the type of heating method to use for brazing. Choosing the appropriate heating method can affect braze quality, filler metal choice, production output, costs, and base metal distortion. Examples of the four main heating methods are

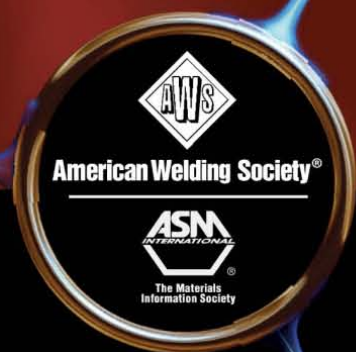
shown in Fig. 3. Torch heating is the most flexible form of heating and is suitable for a wide variety of applications and base materials. Fast, localized heating methods like induction and resistance heating minimize base metal distortion and heat effects. Furnace brazing provides a broad uniform heat that is suitable for small and large assemblies. All of these methods can accommodate both low and high production quantity volumes.

Conclusion

Designers and engineers face many options when choosing a proper joining method for their particular application. Brazing can provide engineers with a versatile method for joining similar and dissimilar base materials that is adaptable to varying production volumes. When designed correctly, brazing can provide similar joint characteristics to welding while being a more flexible production process. With the increasing demand for streamlined products and processes, brazing is an important option to consider when joining of components is required. ♦

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BRAZING & SOLDERING TODAY

The Effects of Adding Silver and Indium to Lead-Free Solders

Even small additions of silver and indium produced improvements in the wettability, microstructure, and microhardness of lead-free solder

BY I G. B. BUDI DHARMA, M. HAMDI, AND T. ARIGA

Tin-lead (Sn-Pb) solder alloys have been used for many years in the assembly of electronic devices. This alloy has many desirable characteristics, including low cost, low melting temperature, good manufacturability, and excellent wetting on copper (Cu) substrates and its alloys. However, the toxicity of Pb to human health and the environment has stimulated substantial research to discover a Pb-free solder suitable for electronic assemblies. Many Pb-free solder alloys have been proposed as a replacement for Sn-Pb solder, but few meet the required material properties, solderability, and cost criteria.

Pb-Free Material Selection

A number of elements can be considered to replace Pb in solder. Table 1 provides a comparison of the elements most likely to be used as the Pb replacement. Note that any substitute for Pb will increase solder cost, because Pb is a relatively inexpensive metal. Tin remains the best choice for the base metal because its melting point is lower than Cu and Ni, and it's priced lower than gold (Au), silver (Ag), and indium (In), which are too expensive to use in the quantities required as a solder base. If either In or Ag is added, its content must small to keep the cost down. Zinc (Zn) used as a base alloy or an addition has been reported to have several drawbacks, especially its poor corrosion resistance (Ref. 1).

Clearly, the toxic metallic elements such as cadmium, thallium, and mercury can be eliminated immediately as solder element candidates (Ref. 2). Japan and Scandinavia also regard antimony as a toxic element (Ref. 3).

Table 1 — Melting Temperatures of Metals Used in Electronic Assemblies

Metal	Melting point (°C)
Bismuth (Bi)	271
Copper (Cu)	1083
Gold (Au)	1063
Indium (In)	157
Lead (Pb)	327
Nickel (Ni)	1453
Silver (Ag)	960
Tin (Sn)	232
Zinc (Zn)	419

Improving Sn-Cu Eutectic Solder

The Sn-Cu binary alloy, which has a eutectic composition of Sn-0.7 wt-%Cu, has been considered for use in wave soldering applications because it is the least expensive of the lead-free alloy candidates (Ref. 4). Solder cost is a key consideration in wave soldering because of the need to periodically replace the entire solder bath to control contamination buildup. However, Sn-Cu eutectic solder also has poor mechanical properties compared with Sn-Ag and Sn-Ag-Cu eutectic solders (Refs. 3, 5).

The Sn-0.7Cu eutectic solder melts at a rather high temperature — 227°C. An attractive approach to lowering its melting temperature is to use an additive such as In. Indium-containing solders also have been confirmed to have good wetting characteristics, and increased alloy strength and fatigue resistance (Ref. 6).

Silver is widely used in electronics for its superior electrical conductivity and good solder wetting characteristics. Unfortunately, the price of silver has risen

steeply, increasing the cost of solder to where its price is a major manufacturing issue (Ref. 7). However, variations in the amount of silver can significantly affect the reliability and the mechanical properties of the alloy since the concentration of this element in a solder matrix is relatively small (Ref. 8).

In this study, small additions of Ag (0.1, 0.3, 0.5 wt-%) and 1.0 wt-% of In were added to Sn-0.7Cu eutectic alloy to improve the alloy's wettability and mechanical properties.

Experiment Details

The solder alloys were provided by Nihon Almit Co. Ltd. Japan in bar form. The solder alloys used for this study were Sn-0.7Cu-1.0In-xAg (where x = 0, 0.1, 0.3, and 0.5). Thermal analysis of the solder alloys was performed using a DSC-50 Shimadzu differential scanning calorimeter (DSC). Small specimens, about 20 mg, were used for the DSC analysis. The heating rate was 5°C/min from room temperature to 350°C in 50 mL/min argon gas flow.

The wetting balance test was conducted using a SAT5100 Rhesca. The parameters used for wetting balance test were 5 mm/s of dipping speed with a dipping depth of 10 mm. The dipping time was 20 s, and the testing temperature was 250°C. Oxygen-free, high-conductivity (OFHC) copper sheet, 10 × 30 × 0.3 mm, was used as the substrate metal. The flux used in the experiments was RC-15SH, a commercial rosin mildly activated (RMA) from Nihon Almit Co. Ltd., Japan.

The Vickers hardness number (H_V) of the solder alloy was determined by conducting a microhardness test. The parameters were 0.025 g-f of loading weight and 20 s loading time.

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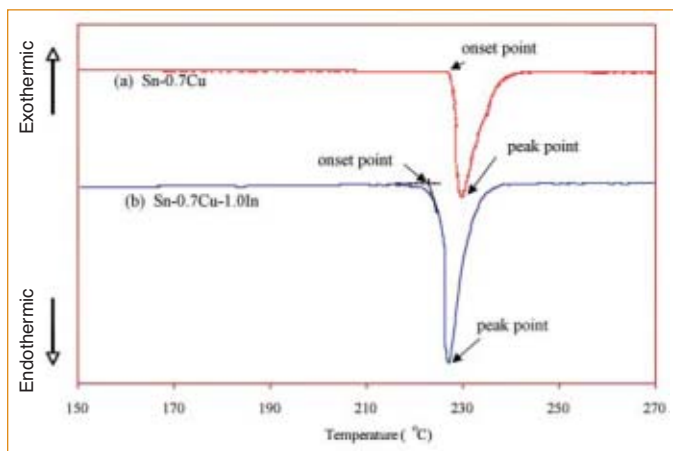


Fig. 1 — Differential scanning calorimeter (DSC) curve of lead-free solders.

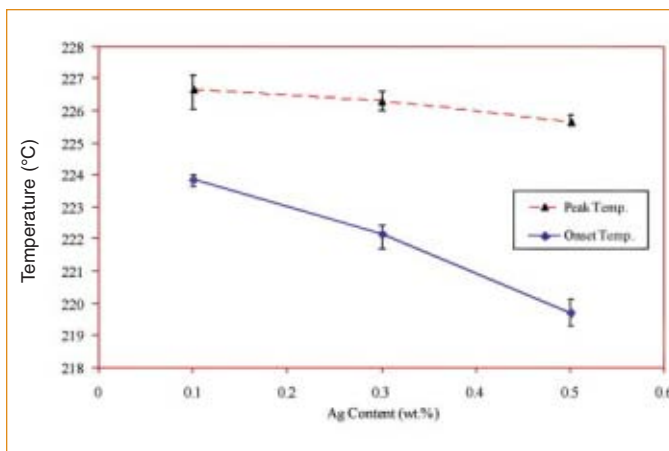


Fig. 2 — Effect of silver (Ag) addition on the peak and onset temperatures (°C) in differential scanning calorimeter (DSC) curves of the solders.

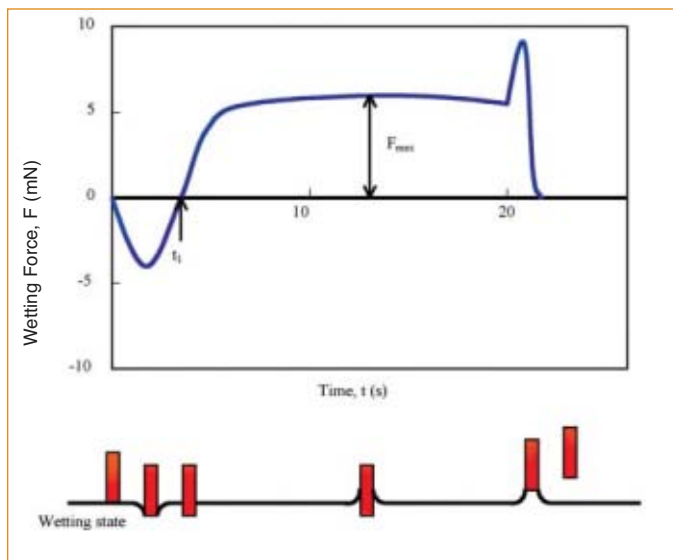


Fig. 3 — Typical wetting balance curve and wetting state.

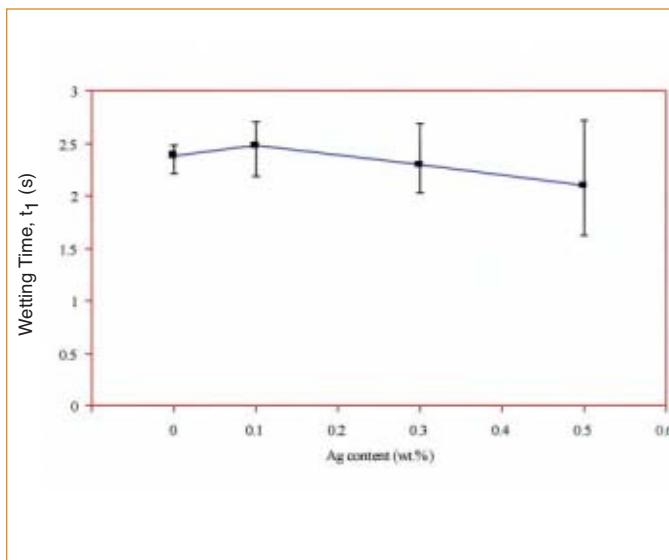


Fig. 4 — Effect of Ag content on wetting time t_1 (seconds), of the solders.

Results of the Investigation

DSC Analysis

The curve obtained from DSC analysis is shown in Fig. 1. Figure 1A shows the onset temperature of Sn-0.7Cu is 227.4°C. The onset temperature of the DSC heating curve is the temperature at which the solder starts to melt, or it can be marked as a solidus temperature of the solders or the eutectic temperature of a eutectic solder alloy. The addition of 1.0 wt-% In into the Sn-Cu eutectic solder lowered the onset temperature from 227.4° to 224.4°C — Fig. 1B.

The onset and peak temperatures can

be further lowered by small additions of Ag to the Sn-0.7Cu-1.0In-xAg solders. Figure 2 shows the onset and peak temperatures in the DSC curve as a function of Ag additions. The addition of 0.1 wt-% Ag slightly lowered the onset temperature from 224.4° to 223.8°C. The addition of 0.3 wt-% Ag lowered the onset temperature to 222.1°C, and adding 0.5 wt-% Ag lowered it to 219.7°C. The peak temperatures also decreased with increasing Ag content. The DSC analysis showed that small amounts of Ag and In can effectively lower the onset and peak temperatures.

Wetting Balance Test

Figure 3 shows a typical wetting curve.

In this force-time curve, the two most common values are used as the wettability parameters: the wetting time (t_1) and the maximum wetting force (F_{max}) (Refs. 9, 10). The times at which the solder contact angle to the specimen is 90 deg, or for the measured wetting force to return to zero are widely used as the wetting time (Ref. 11). The F_{max} is obtained when the meniscus is stabilized after immersion and the measured force remains constant.

The t_1 and F_{max} of Sn-0.7Cu-1.0In-xAg ($x = 0, 0.1, 0.3$, and 0.5) solders obtained from wetting balance test are displayed in Figs. 4 and 5, respectively. In Fig. 4, the addition of 0.1 wt-% Ag slightly increased t_1 from 2.3 to 2.5 s. However, with the addition 0.3 wt-% Ag, t_1 decreased to 2.2 s and

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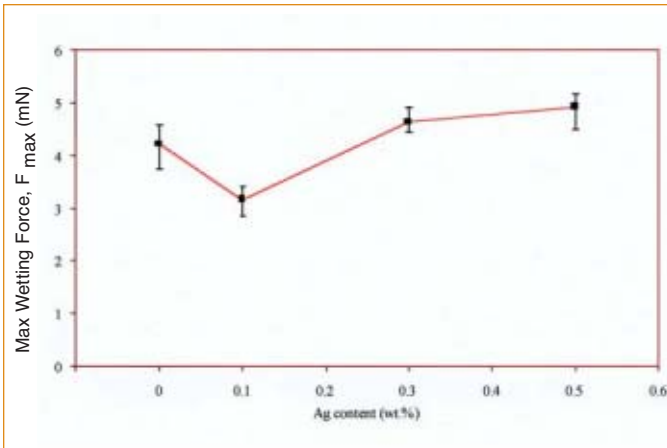


Fig. 5 — Effect of silver (Ag) content vs. maximum wetting force (F_{max} in mN) of the solders.

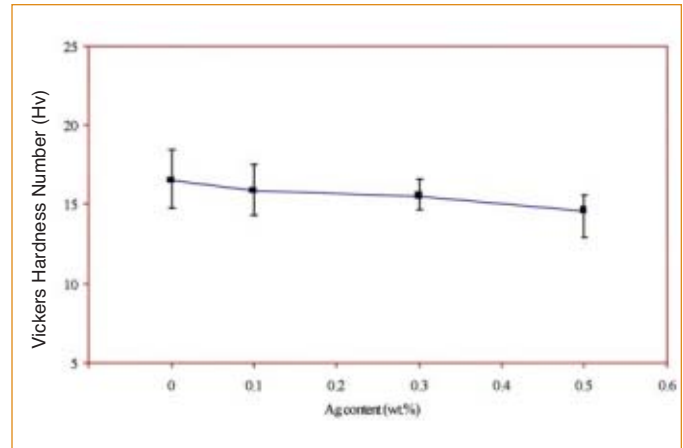


Fig. 6 — Effect of silver (Ag) addition on microhardness of the solders (Vickers hardness number (H_v)).

further decreased to 2 s with the addition 0.5 wt-% Ag.

As shown in Fig. 5, the addition of 0.1 wt-% Ag reduced the F_{max} of the solder from 4.2 to 3.2 mN. The F_{max} started to increase with the addition of 0.3 and 0.5 wt-% of Ag, which increased to 4.6 and 4.9 mN, respectively. This proved that the addition of small amounts of Ag can improve the solder's wettability.

Microhardness

The microhardness of the solders with varying Ag content is displayed in Fig. 6. Additional Ag content up to 0.5 wt-% slightly reduced the Vickers hardness (H_v) of solders from 16.5 to 14.6 H_v . The result indicates that increasing the Ag content can improve ductility of the solders. Ductility of the solder is very important to insure the reliability of the joint structure. It has been reported that small additions of Ag improve the elongation by about 50% (Ref. 12).

EPMA Result

Figure 7 shows the electron probe microanalysis (EPMA) results of solder alloys with various Ag contents in the Sn-0.7Cu-1.0In-xAg solders. The results indicate that with increasing Ag content, the bright Sn-rich grain size becomes finer surrounded by Cu-Sn and Ag-Sn intermetallic compounds. It has been reported that the bright grains correspond to primary β -Sn phase and it is surrounded by Cu_6Sn_5 and Ag_3Sn intermetallic compound phases (Refs. 12, 13). Indium was observed distributed in primary grain because of its similar atomic size.

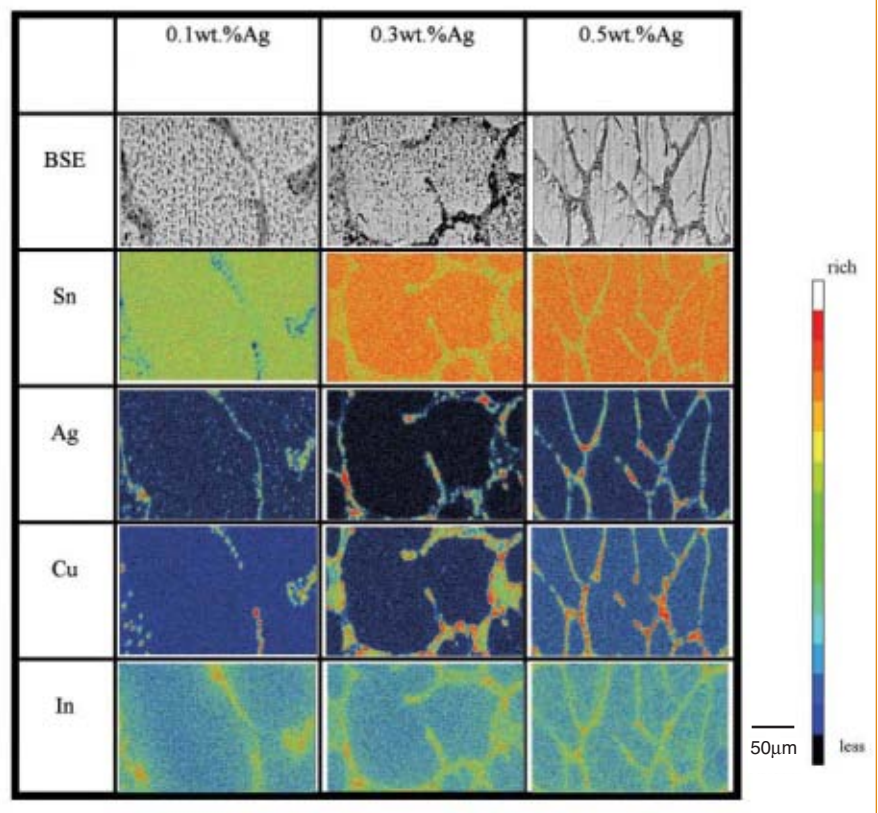
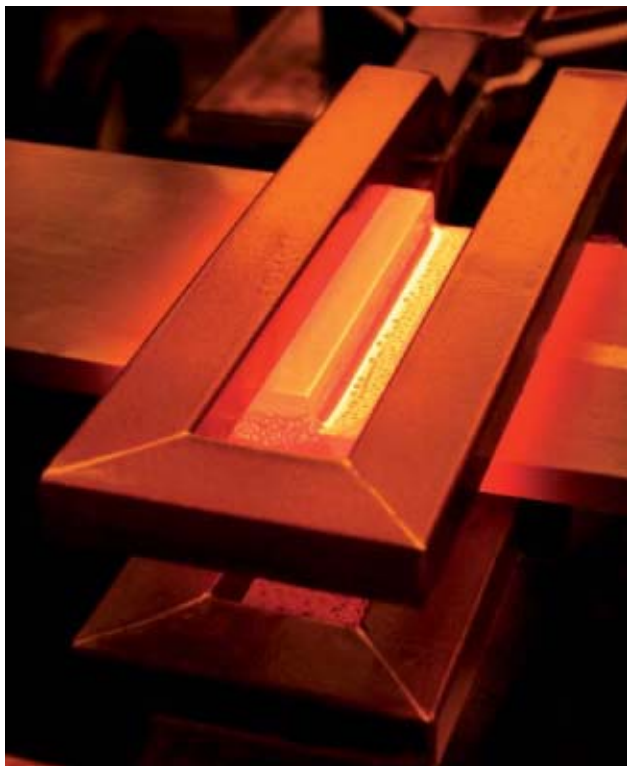


Fig. 7 — Electron probe microanalysis results for the solders.

Conclusions

Improving the Sn-Cu eutectic solder with small amounts of Ag and In displayed promising results as a lead-free solder candidate. The onset temperature in DSC curve of Sn-Cu eutectic solder was low-

ered by the addition 1.0 wt-% In. Further lowering of the onset and peak temperatures was obtained by the addition of Ag. Small additions of Ag affect the wettability of solders. Higher Ag contents produced better wettability by lowering wetting time (t_1) and increasing maximum



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wetting force ($F_{\max}$). Increasing the Ag content from 0.1 to 0.5 wt-% in Sn-0.7Cu-1.0In-xAg solders, slightly decreases its hardness. The addition of Ag makes the primary grain size of β -Sn become smaller. Based on the EPMA results, Cu-Sn and Ag-Sn intermetallic phases were observed and In atoms were distributed on the β -Sn matrix.

Acknowledgments

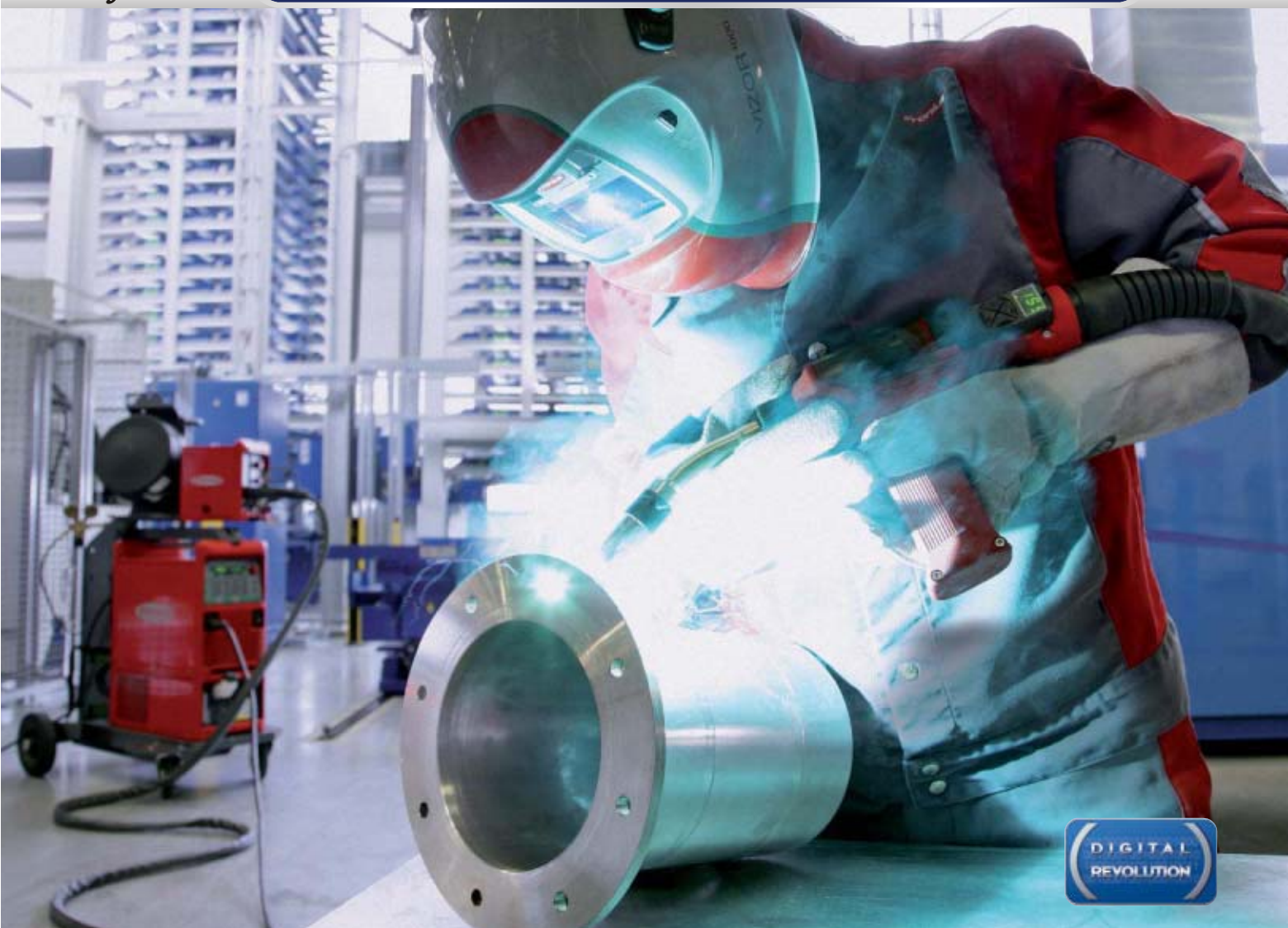
The authors would like to acknowledge the support from Japan International Cooperation Agency (JICA) under AUN/SEED-Net (ASEAN University Network, Southeast Asia Engineering Education Development Network) program. We also acknowledge Nihon Almit Co. Ltd., Japan, for supplying the solders and fluxes. Our thanks also to Messrs. Kanaya, Sawano, and Sakurai for their assistance in performing the experiments, and to Mr. Miyamoto for his assistance in the EPMA analyses.

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BRAZING & SOLDERING TODAY

Exploring Different Brazing and Soldering Methods

Here's a look at various ways — using furnace, dip, resistance, and torch techniques — to complete a job

BY JERRY ARNOLD, EARL MILLER, AND GREG MITCHELL

Brazing and soldering processes offer professionals strong, long-lasting joints, but when it comes to performing the action, different applications can utilize different methods. Some of the most common methods of heating include furnace, dip, resistance, and torch. So the question is, which method should you use on your next job?

Furnace

In both brazing and soldering, the furnace method of heating can be profitable for processing many parts at a time or for making many joints at once in a large and complex part. For instance, this method is used to make dental equipment as well as tools used in the aerospace industry.

This method comes in handy when the brazing material can be in contact with the joint, and the part can survive uniform heating. However, there are several disadvantages to using furnace methods. Furnace heating can be costly using high power consumption and requiring a significant amount of maintenance. Typically, furnaces are heated by electric elements, gas, or flame — provided the flame does not impinge directly on the work load.

Dip

The most effective way to apply heat uniformly and rapidly by direct contact is the dip method. Used especially for aluminum parts, the filler metal may be provided as a thin layer clad on the brazing sheet from which parts are formed. Dip consists of applying heat through

the immersion of the solid parts either in a molten flux or metal. A metallic bath, covered with a flux, provides the molten filler metal. The cleaned parts should be covered with flux at the joint locations.

A critical advantage of using the dip method is that an entire unit comprised of any number of joints can be brazed and/or soldered in one operation, thus increasing production volume at a minimum cost of equipment. On the other hand, only alloys containing high-melting metals can be used in this method. There is a chance low-melting metals may vaporize from the bath. In addition, this method lacks portability to on-site applications. Likewise, safety should always take first priority during the dipping process due to the risk of explosion when wet parts are dipped into the bath.

Resistance

Resistance brazing and soldering is a process using resistance heating to heat a workpiece while melting a braze or solder filler alloy. Contact tips or horns clamp onto the part and pass a current through at a point adjacent to the joint causing internal and contact resistance heating. The molten alloy wets and flows across the heated work surface. Temperatures are normally high so that a metallurgical bond can be formed, but fusion of the workpiece does not normally occur.

Resistance brazing is normally used for low-volume production, where heat is localized at the area to be brazed. According to brazing experts, this method is essential to the electro-mechanical equipment production industry, which relies on resistance braz-

ing to join dispersion-strengthened, ceramic composites to metals with high electrical conductivity. Both resistance brazing and soldering are commonly used in the automotive, electronic, and plumbing industries. Used for soldering various joints, resistance soldering can fuse everything from components on a circuit board to copper tubing.

Although the resistance method has many advantages, it still has its limitations. One problem with this method is its distortion of joints. Additionally, brazing and soldering cannot be done simultaneously, resulting in less efficiency.

Torch

One of the most versatile methods of heating is torch brazing and soldering. Due to its practicality, the torch method is used in almost every industry from fabrication to repair work. This method joins relatively small assemblies made from materials that do not oxidize or can be protected from oxidation with a flux. The most commonly used filler metals include aluminum-silicon alloys, silver-base alloys, and copper-zinc alloys. Flux is required with these fillers unless protective atmosphere is used. Self-fluxing copper-phosphorus alloys are also available.

Torch brazing and soldering are accomplished with hand-held oxyfuel gas torches using various fuels; and both processes are similar in the fact that the source of oxygen used can be from bottled/pressurized oxygen cylinders or oxygen from atmospheric air.

Historically, the preferred method of heating was the use of a torch that used an oxygen acetylene mixture to create the flame and heat. The oxygen and acetylene

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Tips for Proper Torch Usage

Torch brazing and soldering utilize the most common method of heating, and it is crucial to practice proper torch usage when using those processes. According to Thermadyne, following the correct procedures in soldering and brazing can be the determining factor between a durable joint and failure.

Don'ts

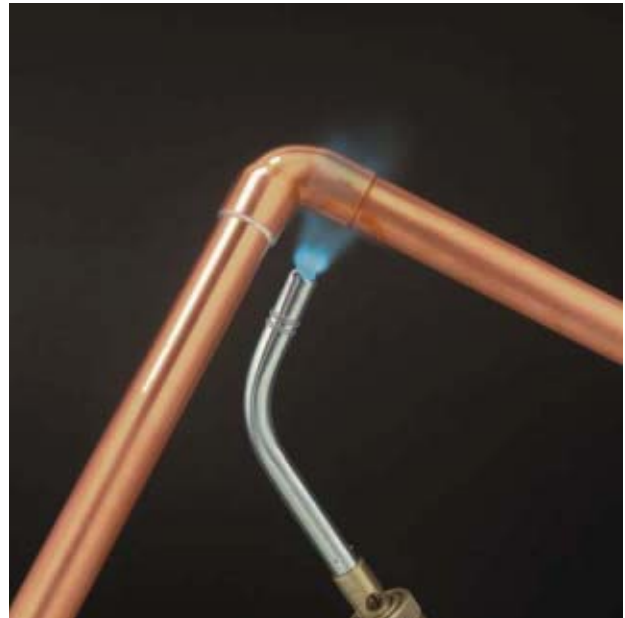
- Don't reduce the flame, which could overheat the tip, ruin the tip end, or loosen the helical rotor.
- Don't use partial flame with self-lighting tips, which could cause ignition wire to burn as well as loosen the rotor.
- Don't rotate the torch flame.

Dos

- Remember the acetylene regulator should always be turned full on.
- Always run torch with a full flame.
- Keep the flame on copper with as little movement as possible; instead move the filler.
- Bear in mind that the regulators on hand torches are adjustable for MAPP®. Replace with MAP//PRO™ or propane.



A worker demonstrates the correct flame using a TurboTorch® TX540.



Another example of a correct flame during a torch brazing operation.

were provided from pressurized cylinders each containing one of these gases. With the invention of TurboTorch® “swirl” technology, it became possible to create enough temperature and heat energy by combining a fuel gas with oxygen taken from the atmosphere through a venturi and then using a mixer to facilitate a flame, which allows you to complete a solder or braze connection. The most common fuel gases used for this process are MAP//PRO™, propane, and acetylene. Each offers its own unique combination of temperature and energy (BTUs). It is important that you choose the right combination of these along with the proper

tip size selection in order to complete your solder or braze connection properly.

Using a TurboTorch, the following applies:

- Oxyacetylene, 5800°F, 1470 BTU/ft³
- Swirl air acetylene, 2800°F, 1470 BTU/ft³
- Swirl air propylene (called MAP//PRO), 2200°F, 2200 BTU/ft³
- Swirl air propane, 1700°F, 1700 BTU/ft³

Swirl technology continues to be developed through continuous engineering improvements. It is easy to make a swirl torch, but it is the right combination of regulator flow, venturi, flame tube, and mixer that allows the professional to make a safe and effective connection.

Conclusion

While there are many methods of heating for brazing and soldering purposes, the deciding factor in a professional's application will depend on the technical, production, and economical means and requirements. Selecting the most appropriate heating methods will provide the best possible connections in brazing and soldering. The fact is the welding industry is continually advancing and changing technology while simultaneously promoting the safety and superior welding capabilities of our industry. ♦

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Induction Soldering Gets Maglev Vehicle on Track

All design and operational requirements were met during the construction of more than 700 ft of track for an urban magnetic levitation vehicle

BY KENNETH H. HOLKO

A unique approach to an urban magnetic levitation vehicle (Refs. 1–3) was developed by a multiorganizational team led by General Atomics. Powerful NdFeB magnets arranged in a “Halbach” array were coupled with more than 700 ft of Litz wire ladder track to produce levitation and control. The conceptual vehicle, demonstration vehicle, and details of track and magnet relationship are shown in Fig. 1. The Federal Transit Administration sponsored the Urban Maglev program and the Litz ladder track was fabricated for General Atomics, San Diego, Calif.

The vehicle is propelled by a fixed linear synchronous motor reacting with permanent propulsion magnets attached to the vehicle — Fig. 1. Two other sets of NdFeB magnets with poles aligned in a specific pattern provide levitation. As these magnets pass over the fixed Litz ladder track, opposing magnetic field loops are generated. This sequential interaction or repulsion is responsible for levitation and path control. Successful operation of the vehicle depends on copper wires inside the Litz ladder bars being metallurgically bonded to the copper extrusions shown in Fig. 1.

The track also has a structural function. As seen in Fig. 1, the Litz track is cantilevered off a fixed guideway foundation weldment. This means the track must be able to support the weight of the vehicle through magnetic force levitation reaction.

Although this vehicle has a maximum speed of about 100 mph and normal operational speed of about 35 mph, magnetic levitation vehicles in operation today have attained speeds in excess of 300 mph. Advan-

tages of these vehicles include pollution-free operation, adaptability to existing roadways, no vehicle/track friction, and good acceleration and ride characteristics.

Tract Construction Details

A finished Litz bar track is shown in Fig. 2. The individual Litz track bars consisted of ~144 insulated oxygen-free high-conductivity (OFHC) copper wires encased in 1-in.-square Type 304/304L tubes. The wires are originally installed in oversized round tubes and then both are extruded to the square shape. The wires have a spiral contour within the tubing that is important for proper magnetic performance. It was also important to maintain the integrity of insulation on each Litz wire due to the skin effect present at the high operational frequencies. Shorting from wire to wire had to be avoided. Details of the Litz bar construction are seen in Fig. 3.

The OFHC copper extrusions had to be designed and purchased. This was a critical part of the project since the ends of the Litz bars had to closely nest in the extrusions so that the ends of the wires could be soldered. Since 201 bars had to be soldered into both extrusions, some tolerance for out of straightness and twist had to be considered. At the same time, clearance of the stainless steel tube with the extrusion “trough” could not be excessive or joint strength would suffer. One important extrusion detail was to provide undercuts in the interior corners so interference with the stainless steel bars was avoided. An extrusion and joint cross section are shown in Fig. 4.



Fig. 1 — Conceptual and demonstration vehicles and track/magnet relationship.

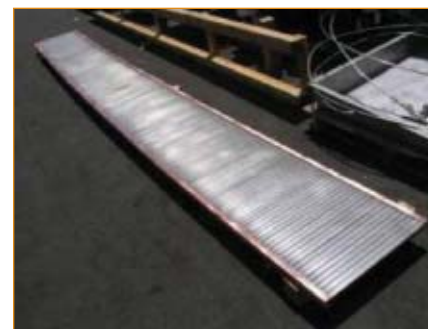


Fig. 2 — Litz bars soldered transverse to the pair of copper extrusions for the finished track.



Fig. 3 — Litz wire (top) removed from bar and stainless steel bar enclosure (bottom).

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Based on a paper to be presented at the International Brazing & Soldering Conference, Orlando, Fla., April 26–29, 2009.

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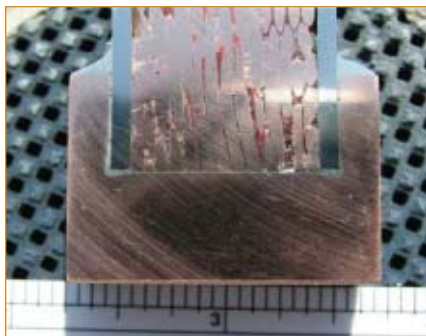


Fig. 4 — Litz bar, solder joint, and copper extrusion cross section.

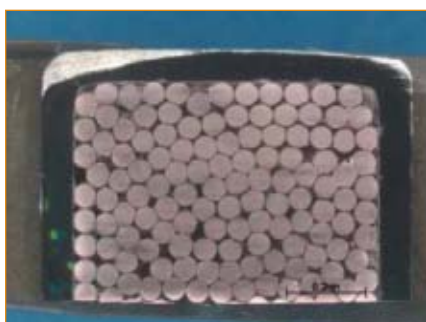


Fig. 5 — Low (top) and higher (bottom) magnification cross-sectional views through the Litz wire inside bar.

A cross section through the Litz wires and bars is shown in Fig. 5 to illustrate the tight spacing and insulation coating.

It was essential for the ends of each wire to be soldered to the copper extrusions, so the magnetic loops necessary for levitation could be developed. The low and repeatable interface resistance was necessary for adequate lifting force to be generated and to provide a smooth ride.

Track Requirements

Track requirements were stringent in that 17-ft track sections were required to be flat within 0.08 in. and within drawing contour to 0.04 in. About half of the 42

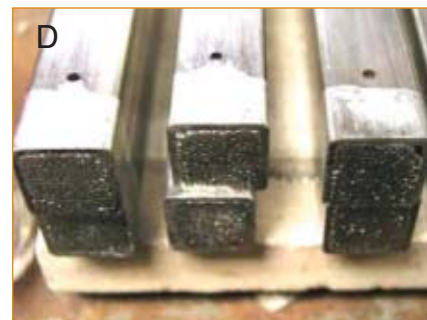


Fig. 6 — A — Preheat; B — fluxing, solder; C — pot immersion; and D — final tinned appearance.



Fig. 7 — Untwisting the Litz bars.



Fig. 8 — Fixture used to set up Litz bars and extrusions.

sections fabricated had unique, nonlinear designs. These various track curvatures were necessary so the final test track could include a 165-ft radius turn. Total test tract length was about 360 ft. Also, bar-to-bar spacing had to be held to 0.04 in. to ensure optimum vehicle performance.

Each joint in each track was tested by applying high amperage and measuring resistance. Each joint was required to have less than 40- $\mu\Omega$ electrical resistance.

Since measurement for contour and resistance was done at the customer's facility, each completed track section had to be shipped on a custom strongback to avoid damage. Since each track section weighed in excess of 1500 lb, this also enabled safe handling.

Development

After the copper extrusions were received they were solvent cleaned and lightly etched to remove surface oxide. The Litz bars were also solvent cleaned. One-ft-long qualification samples were soldered and provided to the customer for electrical testing. Initial samples did not pass the resistance test. It was learned that a pretinning step the customer suggested for the bar ends and the method of solder application were critical to successful soldering. This was learned through metallurgical sectioning and examination. The problem was largely related to removal of the electrical insulation around each Litz

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Fig. 9 — Vellum used to fit tubes and extrusions.



Fig. 10 — Moving assembly into position for induction soldering.

wire at the solder joint.

So, the first challenge was to develop a repeatable tinning technique for both ends of the 8400 Litz bars that needed to be soldered. The solder material the customer selected was 95 wt-% Sn-5 wt-% Ag. This alloy was used for tinning and fabrication.

A necessary step was to preheat the bars in an air furnace before fluxing and tinning in a solder pot. The preheat and solder pot temperatures were critical. (See the boxed item to review the actual parameters and procedures for soldering the track.) The function of these steps was to burn off the insulation, but only from the ends of the wires, and simultaneously wet the copper wires and stainless steel tubing.



Fig. 11 — Induction soldering equipment.

Time in the solder pot was also critical as too much or too little solder could be drawn up between the wire ends. Figure 6 shows the preheat, flux, solder pot immersion steps, and final appearance after wiping off excess solder.

Harris Stay Clean liquid flux (Fed. Spec. OF506, Type 1, Form B) was used to facilitate wetting. The small holes near the ends of the Litz tubes are vent tubes to allow insulation vapor to escape. Reliable wetting could not be achieved without these vents. It was also critical to remove excess solder from the tube ends while the solder was still molten. A combination of snapping each tube and wiping with a wet rag was used. Both tube ends had to be kept above the solder liquidus for this to work. Excess solder on even one tube end would prevent proper fit, later, in the copper extrusion.

Another challenge remained in Litz



Fig. 12 — Coil providing heat for soldering.



Fig. 13 — Dam used to control solder flow.

bar preparation for fitting later in the extrusions. About half the bars contained an unacceptable amount of twist and/or bend. Therefore, each bar had to be untwisted or straightened in a hydraulic press. Care had to be taken not to over-twist or overstraighten the bars. This operation was done both before and during fitting into the extrusions. The untwisting operation is shown in Fig. 7.

After the bars were prepared they were set up on an aluminum fixture with proper spacing controlled by stainless steel shims. As seen in Fig. 8, the aluminum fixture was built in two halves to clamp and hold the Litz bars.

After light clamping to hold position, the copper extrusions were sequentially drawn into tight contact with bar ends through the use of clamps as shown in Fig. 8.

During assembly and before soldering could begin, the position of each tube and extrusion location and profile had to be checked against each unique drawing. Since a coordinate measuring machine was not available, a number of full-size vellums were created from the CAD files for the track segments. By laying the vellums on the assembled tubes and extrusions, position could be corrected and fit into tolerance. Figure 9 shows the use of vellum.

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Induction Soldering Procedure

The final procedure developed and used on most of the maglev tracks was as follows.

1. Check Litz bars for straightness and twist. Straighten bars as necessary.
2. Degrease Litz bars and copper extrusions with acetone. Lightly etch copper extrusions in Citrinex at RT. Rinse in DI water and dry.
3. Preheat Litz bars in air at 275°–300°F metal temperature for 30 min minimum.
4. Fill solder pot with 95 wt-% Sn–5 wt-% Ag solder and heat to 650°–700°F.
5. Remove bars from preheat furnace and briefly immerse ends in Harris Stay-Clean liquid flux.
6. Immediately tin ends of Litz bars by immersing in solder pot to a depth of 1 in. for a minimum time of 3 min and a maximum time of 6 min.
7. Remove from pot and use a combination of snapping bar and wiping with a wet rag to remove excess solder.
8. Inspect Litz wire ends for untinned areas and re-tin if necessary.
9. Install bars in extrusions, apply fixtures and clamps. Located bars per applicable customer drawing using tape, precision scale, and vellum. Install solder dams at both ends of extrusion.
10. Rotate track into position for soldering.
11. Setup traveling Tocco 25-kW induction unit, custom two-turn saddle coil, and track. Check coil spacing ($\sim\frac{1}{4}$ in.) and travel along extrusion bar. Set travel speed for 3 in./min.

12. Starting with coil stationary and centered about 3 in. from one end, squirt Harris Stay Clean liquid flux into joint, and begin heating at $\sim 50\%$ power setting.

13. When melting temperature is reached, begin pushing the $\frac{1}{8}$ -in.-diameter 95 wt-% Sn–5 wt-% Ag solder rod into joint. Note: Best results were achieved with an operator on both sides of the track.

14. When molten solder reaches dam, start coil travel away from dam while continuing to feed solder into joint.

15. Maintain $\sim\frac{1}{4}$ -in. coil to extrusion gap, feed solder rod, add flux as necessary for good wetting, and adjust power for control of melting and solidification in front and behind coil position. A uniform solder fillet should form behind the coil position as the solder solidifies.

16. Turn off induction power and stop travel ~ 3 in. from end of extrusion. Continue to add flux and feed solder until joint is filled and solidified.

17. Inspect entire length of extrusion, both sides, for joint fill and uniform fillet formation. Go back and repair questionable locations while track is still in fixture.

18. Rotate track and solder other side in same manner.

19. After both sides are finished and inspected, remove track. Check with appropriate vellum and correct/resolve any discrepancies with customer representative.

20. Use solvent to remove excess flux. Use sanding discs with fine grit to touch up areas with excess solder.

21. Strap to strongback and prepare shipping documents.

Induction Soldering the Tracks

Once the bars and extrusions were set and clamped into correct position, the same setup fixtures were used to hold and manipulate the tracks during induction soldering. Rotating the fixtured assembly into position for soldering is shown in Fig. 10.

Induction soldering was performed with a 25-kW Tocco variable-frequency induction unit, remote station, and custom water-cooled coil as seen in Fig. 11.

As seen in Fig. 11, the power supply, remote station, and coil were mounted on an adjustable stand and track so the coil could travel under the extrusion/Litz bars to provide heating. The coil in position during soldering is shown in Fig. 12.

Solder was manually introduced to the joint from $\frac{1}{8}$ -in. straight lengths. The joint was fed simultaneously from both sides. Liquid flux was also added to the joint during soldering to aid wetting. Shims were left in place (top of Fig. 12) during soldering to hold the required bar-to-bar gap.

Controlling the soldering operation was a careful balance between coil design,

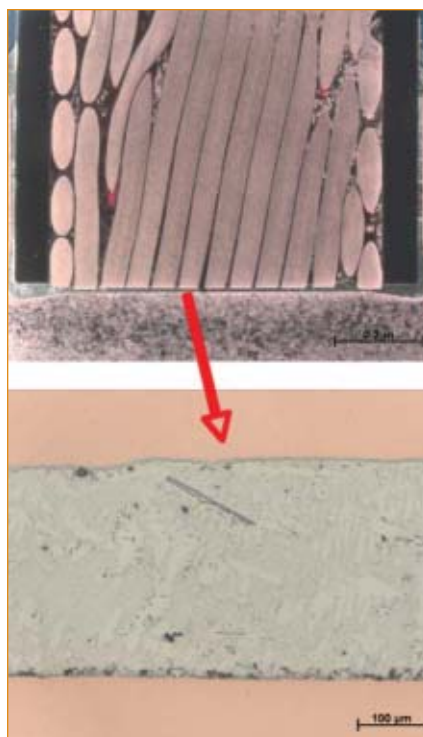


Fig. 14 — Metallurgical section through induction soldered joint, unetched.

power input to the joint, localization of heating, and travel speed. If heating was too spread out over the extrusion, solder would run away from the joint and fill and solidification control would be lost. This was particularly a problem at the beginning and end of each track where physical “dams” had to be used as seen in Fig. 13.

Several coil designs were tried and used for production. Best results were obtained with the two-turn “saddle” coil design shown in Fig. 11. To obtain a tight coil geometry for heat concentration and provide for water cooling, $\frac{1}{4}$ -in.-square OFHC copper tubing with a round hole was used. The coil was made from cut and mitered segments silver brazed together to avoid bend problems. Insulation tape was used to minimize coil shorting to the extrusions.

When proper balance was achieved, induction soldering could be done at 3 in./min without overdriving the coil or power supply. The induction soldering operation went smoothly after the lessons described here were learned. Occasional low fill areas or small fillets could be repaired by reheating with the induction coil and adding more solder. Cleanup of excess solder, as seen in Fig. 13, was eventu-

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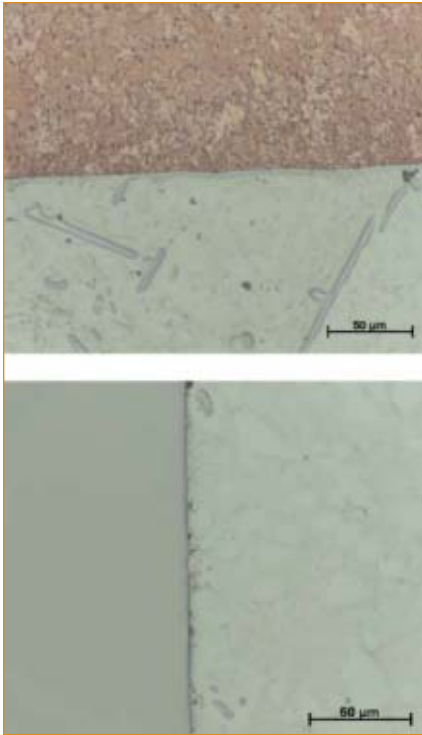


Fig. 15 — Metallurgical sections at wire to solder (top) and stainless steel tube to solder (bottom) interfaces, etched.

ally minimized and good cosmetic appearance was achieved as seen in Fig. 2. No rejects for high resistance were reported for the 42 segments fabricated.

Metallography was used to determine interior quality by sectioning small samples during the program. Examples of sections through the Litz bar to copper extrusion joints are shown in Figs. 14 and 15.

Good fill, fillet, and joint formation were observed. Occasional oxide-type inclusions can be seen that are probably a result of residual wire insulation. However, overall quality is good.

The vellum approach previously described was used for final inspection as seen in Fig. 16. On rare occasions, the track was reinstalled in the fixture, reheated, and a dimension restored, such as bar-to-bar spacing.

Track flatness was checked on the assembly table shown in Figs. 8 and 10, which had been ground flat prior to the beginning of this program. Conventional height and feeler gauges were used.

Preparation for shipment is shown in Fig. 17.

Conclusions

This was a very successful program and



Fig. 16 — Full-size vellum used to check finished track dimensions.



Fig. 17 — Finished track prepared for shipment.

fabrication experience as proven by the tracks meeting all design and operational requirements. The track was installed in 2004 and is still being operated today. In fact, new interest in this system has developed for moving cargo containers at port locations as seen in Fig. 18. ♦

Acknowledgments

This work was conducted at Bodycote



Fig. 18 — World's first cargo move using a magnetically levitated vehicle in 2006.

Thermal Processing, San Diego. Thanks are due to Charles Gee, then general manager, for his participation. Also, thanks to Chuck Ball of GCE Industries (now Doncasters) for preparing the vellums and Frauke Houge for the fine metallographic work shown here. Technical support from Dr. Sam Gurol and others at General Atomics is also appreciated.

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How to Choose Nickel-Based Filler Metals for Vacuum Brazing

Selection of the right filler metal can lead to more economical and functional brazements

BY MICHAEL WEINSTEIN, ROBERT L. PEASLEE, AND FORBES M. MILLER

Nickel-based filler metals can braze any type of high-melting-point base metal. They find use primarily with heat- and corrosion-resistant alloys, most commonly the AISI 300 and 400 series stainless steels and nickel- and cobalt-based alloys. Provided the right filler metal is selected, the brazed joint will retain its properties up to 1800°F (980°C). The nickel-based fillers are not generally used on mild steel because other, less costly, filler metals will do. In some special cases, however, the nickel series is used on steel.

What to Consider

Selection of filler metal for a brazed joint depends on five main points: properties of the filler metal, joint design, service requirements, base metal composition, and cost and availability.

1. Properties of the filler metal.

Melting point or melting range. Eutectic compositions melt at a specific temperature; other compositions melt within a range of temperatures. This fact determines whether the material flows all at once or over a range of temperatures.

Fluidity. Poor or good fitup of the braze joint determines whether the job needs sluggish or rapid-flowing filler. Knowing the fluidity of the filler metal lets the designer prescribe proper joint clearance.

Joint remelt temperature. Filler material alloys with the base material at rates depending on the compositions of both materials and temperature. This interaction determines the composition and the melting temperature of the brazed joint,

the temperature at which it will fail by fusion.

Vapor pressure. In vacuum brazing the filler metal should have a vapor pressure lower than the vacuum pressure to prevent outgassing of filler metal elements. Such outgassing results in a braze of poor quality.

2. Joint design. For the reasons listed previously, the designer needs to know joint geometry and clearance in order to

choose the filler metal with the right flow properties.

3. Service requirements. These include joint strength, ductility, and heat and corrosion resistance. The chemistry, flow characteristics, and mechanical properties of the final braze metal determine which filler should be used.

4. Base metal composition. The base metal alloys with the braze filler. The properties of the alloyed braze metal

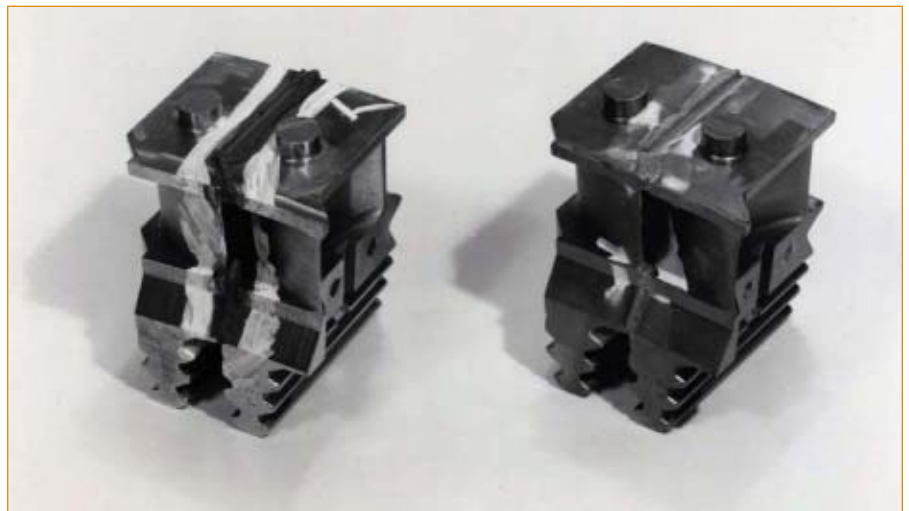


Fig. 1 — BNi-1 was the best choice for brazing these turbine vanes because when the filler diffuses into the base metal, it does not form austenite and reduce hardness.

Table 1 — Comparison of Raw Material Prices for Brazing Filler Metals

Metal	2nd Quarter 2003	6/2/2008	Price Increase
Gold (troy oz)	\$300.00	\$896.00	199%
Silver (troy oz)	\$5.00	\$16.87	237%
Nickel (troy oz)	\$0.33	\$0.68	106%

MICHAEL WEINSTEIN is technical services manager, Alloy Products Group, prior to his recent death, ROBERT L. PEASLEE was a brazing consultant with Wall Colmonoy Corp. and FORBES M. MILLER is former director, Brazing Engineering Center, Wall Colmonoy Corp., Madison Heights, Mich. (www.wallcolmonoy.com).

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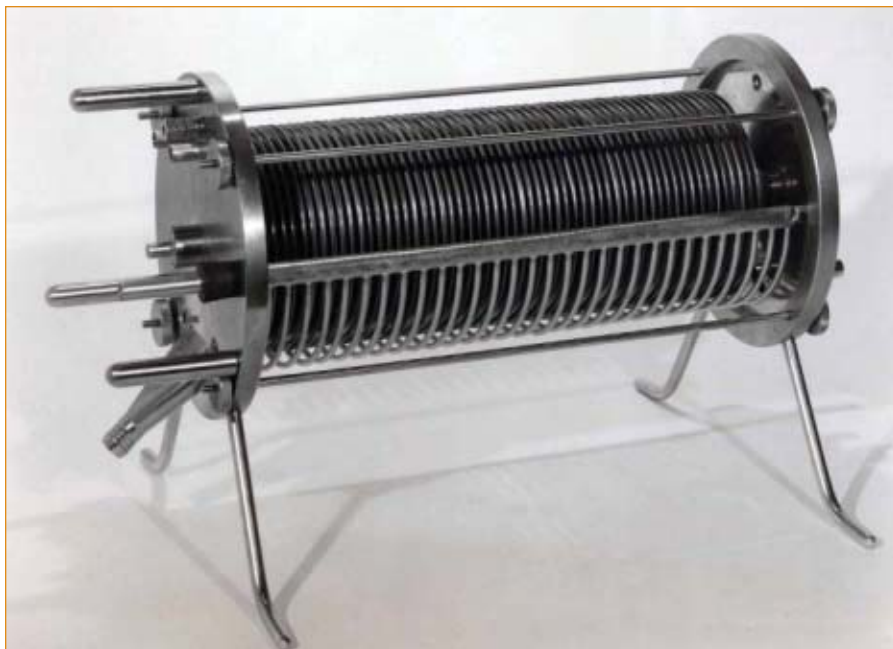


Fig. 2 — A brazing filler metal with a high chromium content was needed for brazing this part from an artificial heart used during major surgery because it resists corrosion caused by human body fluids.

ultimately determine the properties of the joint.

5. Cost and availability. Cost of raw materials in today's market have a significant impact on the cost of a brazed assembly. Volatile and unpredictable fluctuations in both precious metals and strategic metals markets greatly affect the cost of brazing. The effect of this unpredictability can be controlled to a degree by engineering and designing parts that utilize brazing filler metals that are less sensitive to fluctuations in

the metals markets. Table 1 compares gold, silver, and nickel as primary ingredients in brazing filler metals over the past five years.

Traditionally, certain designs have specified precious metals brazing for certain applications. Today the technology exists to design assemblies that can take advantage of relatively lower cost nickel brazing filler metals such as those described by both AMS and AWS specifications.

The true material cost of a braze joint is a function not only of the metals market price but also of the metal content in the alloy and its density. That is to say, the same volume of filler metal must be used independent of the composition. Gold is more than two times more dense than nickel and will take correspondingly more weight to fill the same volume. Table 2 illustrates this relationship based only on the gold, silver, and nickel content and market value as of June 2, 2008. This cost is shown for comparison purposes — by filler metal for a braze joint thickness of 0.001 in. over areas of 1 in.² and 1 ft². The table illustrates the magnitude of how material costs of brazing alloys will be affected by fluctuations in the metals market, and that the most significant opportunity for savings is where a gold or silver brazing filler metal can be replaced in the design by a nickel-

Table 2 — Material Costs of Brazing Alloys Based on Their Gold, Silver, and Nickel Content

Brazing Filler	\$/in. ² at 0.001-in. joint clearance	\$/ft ² at 0.001-in. joint clearance
AWS BAu-1 (38% Gold)	\$2.27	\$326.88
AWS BAu-2 (80% Gold)	\$6.45	\$928.80
AWS BAg-7 (56% Silver)	\$0.05	\$7.20
AWS BNi-5 (71% Nickel)	\$0.002	\$0.29
AWS BNi-7 (76% Nickel)	\$0.0022	\$0.32
AWS BNi-6 (90% Nickel)	\$0.0028	\$0.40



Fig. 3 — The interior of this part, the housing for a jet engine starter, experiences high temperatures and high stresses and the joint has tight fitup, which necessitates the use of a free-flowing alloy such as BNi-2 or BNi-3.

based brazing filler metal.

AWS A5.8:2004, *Specification for Filler Metals for Brazing and Braze Welding*, is the most recent and most complete specification system for nickel-based brazing filler metals. It should be referenced wherever possible. It includes 15 nickel-based brazing filler metals and describes the properties and primary applications, as follows:

- BNi-1 finds use for high-strength, heat-resistant joints in assemblies like turbine blades and jet engine parts.
- BNi-2, similar to BNi-1, allows good flow properties at lower brazing temperatures.
- BNi-3 flows well in less-than-perfect vacuum conditions. Ideal for tight-fitting joints and for wide-area joints.
- BNi-4 forms large, relatively ductile fillets, making it a choice for large joint clearance fitup.
- BNi-5, for high-strength and corrosion-resistant joints, finds use in nuclear and other applications where boron cannot be tolerated.
- BNi-6 is a free-flowing filler that offers only minimal alloying with nickel- or iron-based substrates.
- BNi-7 produces strong leak-proof joints with heat-resistant base metals at low brazing temperatures. Erosion is low because it has low solubility in iron- and nickel-based alloys. It is used for honeycomb structures and thin-wall tube assemblies.
- BNi-8 is also used in honeycomb brazements and on stainless steels and other corrosion-resistant base metals.
- BNi-9 is excellent for jet engine parts

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and similar highly stressed components. It offers good strength at lower brazing temperatures.

- BNi-10 provides extra-high strength at high temperatures. It is good for brazing base metals containing cobalt, tungsten, and molybdenum.
- BNi-11 can be used for applications that are similar to those of BNi-10 except it offers better flow.
- BNi-12 is similar to BNi-7 except it has greater strength, and heat and corrosion resistance.
- BNi-13 offers brazing characteristics similar to those of BNi-2 but with enhanced corrosion resistance and high joint strength.

How Designers Fit the Filler Metal to the Brazement

The following short case studies illustrate how selection of the right filler metal leads to economical and functional brazements.

Turbine vanes. After brazing, $2 \times 2 \times 3$ -in. ($65 \times 51 \times 76$ -mm) turbine vanes (Fig. 1) of 422 stainless steel were heat treated to rigid hardness, tensile strength, and impact strength requirements. However, the joint needed good strength as well. Most importantly, the filler metal could not reduce the hardenability of the base metal. BNi-1, which contains 0.7% carbon, was the best choice for this job because when the filler diffuses into the base metal, it will not form austenite and reduce hardness. For this job, filler metal was preplaced, so that high fluidity was not necessary.

Heat exchanger. This 304 stainless steel component is part of an artificial heart used in a life support system for major surgery — Fig. 2. Leak tightness and resistance to corrosion from human body fluids were the main requirements. Joint fitups were tight, so the braze filler metal had to be free flowing. High chromium content handled the corrosion requirement. The designer's choice: BNi-2 or a proprietary nickel-16 chromium-3½ boron filler metal.

Housing for a jet engine starter. This assembly (Fig. 3), about 8 in. (203-mm) OD, had close-tolerance, sleeve-type joints that joined the top and bottom fixtures to the main section. The part sees high temperatures and high stresses in its interior, but the joints on its exterior are exposed to less severe temperatures and lower stresses. The determining factors, close fitup and the great length of



Fig. 4 — Because fitup for the joint edges on these gas engine turbines was not well controlled, a sluggish filler metal such as BNi-1 was needed.

the joints, dictated a free-flowing alloy such as BNi-2 or BNi-3.

Diffusers for a gas turbine engine. Even though these 16-in. (406-mm) OD assemblies (Fig. 4) are well supported, they require high strength to withstand considerable vibration in service. Fitup of the joint edges is not well controlled and may vary from contact to a 0.010-in. (0.254-mm) joint clearance. This situation called for a sluggish filler metal that gives good strength in the braze. BNi-1, the filler metal first used for this job, gave good results. BNi-1a, the low-carbon version of the same alloy, can also do the job. A nickel-chromium, boron-silicon filler that contains 17% tungsten gives strength to braze metal in joints with wide joint clearances. It is also sluggish at brazing temperatures, making it ideal for wide joint clearances. Some users mix filler metals to get two melting ranges for this kind of job.

Fuel meter. This 410 stainless steel brazement contained 200 joints in 347 stainless steel thin-wall tubing. In service, the meter heats up to about 200°F (90°C). Corrosive fuel mixtures flow through the meter, which must be leak-tight. Imposed pressure and stress are low, but braze joints between dissimilar metals must stand up under stresses introduced by differences in the coefficient of expansion between the base metals. With close fitup, a nickel-phosphorus-chromium alloy like BNi-7 will stand up to the stress and give a leak-tight joint. BNi-7 offers enough fluidity to fill close fitting joints of 0.001 in. (0.025 mm) or less.

Cooling cylinder with wide joint clearances. The best way to fill wide joint clearances (10 mils, 0.25 mm, or greater) with braze metal is a two-step

procedure that uses a joint clearance filler. A high-melting-point metal powder was laid into the joint clearance, held in place by a binder, and heated in a furnace. This procedure sintered the metal into place without melting it. After brazing filler metal was applied to the joint, the part was heated again. The sintered material prevented the filler metal from running out of the joint. It also offered capillaries for flow. The brazed joint was ½ in. (13 mm) deep with a ⅛-in. (1.6-mm) joint clearance. The joint clearance filler metal was a Ni-Cr-Si mixture, melting point 2400°F (1316°C). Filler was Ni-16Cr-3.5B, a eutectic composition, melting point 1900°F (1038°C).

This stainless steel cooling cylinder, about 7 ft (2 m) long, was wound with stainless steel tubing that will carry a coolant. The gap between the cylinder and the tube windings was irregular. Designers required heavy fillets to promote cooling. First, a high-melting metal powder was laid on the joint and sintered at 2000°F (1093°C) in a protective atmosphere. The sintered metal acted as a sink for the braze metal to be added. The sintered sink required a filler that was fluid enough to fill the pores formed by sintering, but viscous enough that it would not run off the joint. Filler metal should be a nickel-chromium-boron type such as BNi-2 or Ni-Cr-3.5B.

On condensers of plain carbon steel for refrigeration equipment, a nickel-based filler metal, BNi-2 (Ni-Cr-B-Si-Fe), works well. The corrosive refrigerant — wet, hot ammonia — makes use of silver or copper filler metals inadvisable. The same applies to methylacetylene-propadiene bottles used for hand soldering torches. Here, BNi-06, a nickel-phosphorus filler metal, handled the job. ♦



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TECHNOLOGY NEWS

Engineered Solder-Directed Self-Assembly of Discrete Semiconductor Components

The construction of cell phones and computers relies on robotic assembly lines that place, package, and interconnect a variety of devices having macroscopic >1-mm dimensions. The problem is not the fabrication of smaller parts but their assembly into an interconnecting system. Adhesive capillary forces dominate over gravitational forces for components with dimensions less than 100 μm , making it difficult to release these components from a robotic manipulator. Recent progress in directed self-assembly of inorganic semiconductor components was reported by scientists of the Dept. of Electrical and Computer Engineering, University of Minnesota, Minneapolis, Minn. (Ref. 1).

The goal was the integration of small dies while supporting unique-angle orientation and contact pad registration. The process is based on the reduction of surface-free energy between liquid solder coated areas of the substrate and metal-coated binding sites on the semiconductor dies.

A low-melting Bi-22.6Pb-19.1In-8.3Sn-5.3Cd solder (Y-LMA-117) having a melting point at 47°C (117°F) and medium-melting eutectic Bi-42Sn solder with a melting point at 138°C (280°F) (LMA-281, Small Parts, Inc., Miami Lakes, Fla.) were used in experiments. The assembly was performed in a glass vial filled with ethylene glycol at 150°C (302°F) so the solder was molten. A notable difference between two solders was not observed. Component transport and mixing were provided by hand agitation of the vial to provide a tumbling motion across the surface.

A number of different components such as GaAlAs-LEDs, glass, SU-8 blocks with different pad layouts (e.g., 1500 Silicon chiplets having 300 μm on a side) were tested. With ~5000 components inside the vial, the assembly took about 90 s to reach steady state and was completed in 3 min. The lateral and angular precision was ~15 μm and ~3 deg, and limited by nonuniformity of the components that were made by dicing using a dicing saw.

It was also demonstrated that the solder-directed self-assembly can be scaled down to smaller dimensions, e.g., 20 μm . The surface-free energy of liquid solders dominates thermal energy and Brownian motion down

to sub-1 mm scale. However, scaling has been challenging in practice. The problem was a surface oxide that was formed due to residual oxygen, blocking the self-assembly. In order to resolve this problem, small amounts of hydrochloric acid were added (pH 2–4) to the ethylene glycol.

Bonding Ni-Based Heat-Resistant Alloy Material and Fe-Based Steel Material

An alloy suitable for liquid-phase diffusion bonding (TLP process) of dissimilar base metals such as Ni-based superalloy and steel was developed in Nippon Steel Corp., Tokyo, Japan (Ref. 2).

In determining the insert material, which is to comprise the foil or powder between assembled parts in liquid-phase diffusion bonding, the maximizing of high-temperature creep strength when joining nickel-based heat-resistant alloy Incoloy® 600 and steel STK-400 was achieved via an alloy comprising of 22–60 at.-% nickel,

7–18 at.-% boron, 4–11 at.-% carbon, and the balance being iron. One specific example tested contained 32 at.-% Ni, 13 at.-% B, 1 at.-% C, and 54 at.-% Fe. This sample had a melting point of 1076°C (1969°F). The Inconel® and steel rods were brazed under compression of 2 MPa to make a perfect contact.

The ratio of joint strength to the strength of base metals is in the range of 1–1.04. Molybdenum and/or tungsten in amounts up to 5 at.-% can be added to the brazing filler metal composition in order to improve creep characteristics of brazed joints.

Mechanical Behavior of Brazed EUROFER-Tungsten Joints

The strength and stress distributions in tungsten-to-steel brazed joints have been evaluated by the Institute fuer Materialforschung II and Karlsruhe University within the scope of the European fusion power plant study (Ref. 3). Brazed joints of tungsten alloy WL10 (W-1% La₂O₃)



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with ferritic-martensitic steel EUROFER 97 were studied using two brazing filler metals: (a) amorphous foil Stemet@1309 (Ni-15Cr-7.5Si-4Fe-4Mo-1.5B) and (b) paste BrazeTec@1135 (Ni-19Cr-10.1Si-0.06C). The actual brazing temperatures were 1150°C (2102°F) for the amorphous foil and 1180°C (2156°F) for the paste, holding time 720 s.

Finite element modeling was carried out to calculate stress distributions and study their evolution at operational thermal loads. Bending strength of the joint made with the BrazeTec paste is a linear function of the test temperature with values from 180 MPa (26.1 ksi) at room temperature to 240 MPa (34.8 ksi) at 300°C (572°F) and 320 MPa (46.4 ksi) at 700°C (1292°F).

Charpy-impact energy also depends on the test temperature, but the curve is linear. The impact strength is in the range of 0.02–0.04 J below 600°C, and then drastically goes up above this temperature to reach 0.11 J at 700°C (1292°F).

The combined thermal and mechanical operational loads lead to local plastic deformation of the joint. The highest stresses are concentrated in the braze zone of the joint. The plasticity of the braze metal partially reduces the high stresses. However, the brazed joints may be subject to fatigue and spalling under cyclic loading conditions.

Study of Metallurgical Reactions during Brazing of AlN to SiC Using Praseodymium Silicide as a Filler Material

Thermodynamic calculations of the standard Gibbs energy of reaction in the system PrSi₂-Si and wetting experiments were carried out in SiMAP Lab of National Research Center and Grenoble-Institut National Polytechnique, France, to evaluate a compatibility of SiC ceramic with praseodymium silicide used as the brazing filler material (Refs. 4, 5). The molten alloy Pr-83Si (at.-%) is expected to be nonreactive with silicon carbide, meaning that the interaction at the eutectic temperature 1212°C (2214°F) does not result in graphite precipitates. However, some dissolution of SiC into the Pr-83Si melt will occur.

Two types of experiments were performed with a Pr-83Si at.-% eutectic alloy: (a) sessile drop experiments to determine a contact angle and (b) vacu-

um brazing of AlN and SiC plates to evaluate gap filling. AlN was chosen as an interlayer material for brazing SiC to superalloys. Interfacial reactivity, joint microstructure, and type of failure occurring during cooling were examined by optical and SEM.

The Pr-83Si at.-% eutectic powder alloy is suitable for successful brazing AlN to SiC at 1250°C (2282°F) without a significant reactivity with both ceramics. The average contact angles are 38 deg for wetting SiC and 58 deg for wetting AlN. The spreading kinetics of the braze on ceramics are controlled by substrate deoxidation accompanied by formation of gaseous species of SiO and its removal from the ceramic surface. Therefore, the geometry of brazed joints is critical: The capillary gap design is better for the braze flow than that of so called “sandwich” design.

Modification of SiC and AlN ceramic surfaces by a carbon coating ~1 micron thick allowed to braze these materials in the confined “sandwich” configuration. The carbon coating decreased contact angles by about 15 deg and increased spreading time by a factor of 10.

Flux-Free Brazing of Al-5Mg Alloy Using Ultrasonic Vibration and Pure Silver Filler Metal

Usually brazing of Al-Mg alloys of 5xxx series with traditional Al-12Si eutectic filler metals is characterized by inadequate wetting and poor joint quality due to the magnesium spinel-type oxide film on the surface of the base metal. In order to produce high-strength brazed joints of A5056 aluminum alloy containing about 5 wt-% magnesium, the flux-free brazing method with the aid of ultrasonic vibrations applied to the base metal was tested at Niigata University, Japan. The authors (Ref. 6) selected pure silver foil as the brazing filler metal and examined the effect of brazing parameters on quality, microstructure, and strength of joints.

Ultrasonic vibrations of 19 kHz and 600 W were applied to the base metal. The maximal tensile strength of joints (215 MPa) at the brazing temperature 570°C (1050°F) was reached for 4 s of brazing time; however, the strength went down to about 180 MPa with increasing holding time to 8 s. When the brazing temperature was varied in the range of 550–580°C, the maximal strength of brazed joints (about

270 MPa) was also reached at 4 s of holding time, and then went down to 180 MPa for 8 s of holding time. The optimal thickness of silver foil was 100–200 microns, which met the previously mentioned best strength values, while a small thickness of 50 microns resulted in decreasing the joint strength to 200 MPa. Fracture of brazed joints occurred along the (Al₃Mg₂ + Al) solid-solution phase, which caused high microhardness at the grain boundaries of the base metal near the base-joint interface. The amount of (Al₃Mg₂ + Al) solid-solution phase increased with the increase of ultrasonic applying time and the brazing temperature.

Transient Liquid Phase (TLP) Diffusion Brazing of Carbon-Carbon Composite to Niobium Plates

Plates of C/C composite and niobium alloy C-103 (Nb-10Hf-1Ti wt-%) were successfully brazed using Ti/Cu interlayers by the TLP process in Northwestern Polytechnic University (Xi'an, PR China). Both plates had the following dimensions: 35 × 20 × 5 mm, and titanium and copper foils were placed between C/C and niobium plates. The thickness of the Ti foil was 0.1 mm, while the thickness of the Cu foil was varied as 0.1, 0.4, 0.6, 0.8, 1.0, and 1.1 mm in order to find out the effect of the interlayer thickness on the joint strength (Ref. 7).

The joining process was carried out in a vacuum 3.2×10^{-3} Pa and included two steps: (a) diffusion bonding of copper to niobium at 780°C (1436°F) for 30 min under the pressure of 4 MPa and (b) TLP brazing at 1050°C (1922°F) for 30 min under the pressure varied from 0 to 0.03 MPa. Titanium and copper foils were contact-melted into the eutectic liquid, which served as a brazing filler metal. The Ti-Cu eutectic, which melted at 955°C (1751°F), actively brazed the C/C composite surface and infiltrated into the C/C matrix to take “nail effect.”

The thick copper layer served as a stress relief buffer to absorb the thermal stresses that appear in the joint due to big difference in the coefficient of thermal expansion between niobium and C/C material. The thickness of copper foil 0.9–1.1 mm resulted in maximal shear strength 28.6 MPa of the brazed joint, while the joint strength was only 15–18 MPa at the thickness of copper foil 0.4

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mm. No microcracks were found in the joint brazed with the copper foil 1 mm thick, while multiple cracks were found in the joints made with the copper foil of 0.4 mm thick and lower.

Au-Ni-Cu-Ti Alloys for Brazing WC-Co Pads to Titanium Parts in Gas Turbine Engines

Gas turbine engines derive energy from the flow of combustion gases through multiple turbine stages; the fan or compressor blades often have WC-Co wear-resistant pads brazed onto their contact faces. These blades also often comprise of titanium alloys Ti-6Al-4V or Ti-8Al-1V-1Mo having a beta-transus temperatures $\geq 982^{\circ}\text{C}$ (1800°F), and the wear-resistant pads are usually brazed onto them with Ti-Ni-Cu braze foils. But titanium forms brittle compounds with the alloying elements of the wear-resistant pad due to diffusion, reducing the joint's ductility to the point that it is unfit for even low impacts of as little as 0.30 J (the wear-resistant pads are reported to separate from the blade at impact energies of ≥ 0.60 J). A new brazing filler metal with postbrazing hardness of ~ 450 – 600 KHN ductile enough to withstand impacts ≥ 0.60 J was developed and tested at GE Aviation, Cincinnati, Ohio (Ref. 8).

The said brazing material is comprised of (20–60) wt-% Au, (6–16) wt-% Ni, (16–60) wt-% Cu, and (6–16) wt-% Ti, wherein the material is delivered in either a homogenous powdered form or by layering a Cu-Ni foil between Au foil and Ti foil. The brazing assembly is recommended to be heated by induction under vacuum (10^{-5} torr is enough) for $1 \text{ min} < t < 10 \text{ min}$, at temperatures $\leq 982^{\circ}\text{C}$. In exemplary circumstances, brazing time approaches 1–3 min. For example, the brazing filler metal contains (a) 29 wt-% Au, 8 wt-% Ni, 55 wt-% Cu, and 8 wt-% Ti and has the brazing temperature about 968°C (1775°F), or (b) 49 wt-% Au, 14 wt-% Ni, 25 wt-% Cu, and 11 wt-% Ti and has the brazing temperature about 979°C (1795°F).

Solder Composition with Optimal Electromigration Resistance for Use in Integrated Circuits

Electromigration, the movement of

the atoms comprising a conductor in the direction of electron flow during device operation, causes defects such as fracturing, voids, and interconnect solder joint separation in integrated circuit devices

having increasing current densities due to the miniaturization of transistors; hence, electromigration resistance (IMAX) is a necessary component of useful C4 solder bumping technologies (evaporation of

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solder onto the wafer). Incorporation into the solder of what is termed a barrier component, which is an element reacting sufficiently more quickly with Sn than Sn with Ni or Cu such that it significantly reduces the reactivity of Sn with Ni and Cu, is suggested as a solution to increasing electromigration resistance in near-future high density interconnects (Ref. 9).

The suggested solder composition disclosed by Intel Corp., Phoenix, Ariz., is Sn-containing base material, being either Sn-Ag, Sn-Pb, Sn-Ag-Cu, Sn-In, Sn-In-Cu, and Sn-In-Ag, with the barrier component Pd ≤ 3 wt-%, usually between 0.01 and 1.0 wt-%.

Embodiments of this invention present a solder alloy to fundamentally improve C4 soldered joint IMAX performance by doping C4 solder with trace amount of a barrier component, such as palladium metal. The presence of a barrier component in a tin-based solder may impede a relatively fast diffusion into Sn/reaction with Sn of Cu from the die copper bumps, and thus delay an intrinsic IMAX failure based on tin consumption. In particular, the presence of palladium barrier in Sn-based solder may prevent the growth rate of Ni_3Sn_4 and Cu_3Sn_6 intermetallics during IMAX testing.

Braze Material for Joining Parts of Beta-Titanium Alloy Timet®21S

Titanium alloys have a high utility in applications wherein low material density is desired, but not at the expense of high strength, fatigue, and corrosion resistance or temperature resistance; there is great demand in many industries, such as in aerospace, for lower-weight designs of this sort. More formable titanium alloys such as Beta-alloy 21S, Ti-15Mo-3Nb-3Al-0.2Si, which has substantial oxidation resistance, are most desirable. Nevertheless, Timet®21S titanium alloy is difficult to use primarily because during the joining of parts excessive alloying, erosion of base material, and degradation of mechanical properties are observed.

During previous attempts at brazing Timet®21S titanium alloy parts, alpha-phase precipitated on grain boundaries during higher temperature aging and within grain boundaries during lower temperature aging. A new brazing material disclosed by Honeywell International Inc., Morristown, N.J., is comprised of a

mixture of Ti, Ni, and Cu powders with a particle size ≤ 60 μm , and repeatable method wherein temperature is reduced initially and during every subsequent brazing is suggested to overcome this issue (Ref. 10). Second and third brazing materials comprising of Ti, Ni, Cu, and Zr or Ag (PM), with similar particle size, with sometimes 1–20% of Fe, V, Cr, Co, Mo, Nb, Mn, Si, Sn, Al, B, Gd, and/or Ge, are suggested in rebrazing any joint that did not braze effectively in the initial brazing. The primary benefit is that even in this circumstance lesser amounts of Zr are necessarily required than in other similarly intending brazing materials. Hence, cost of production is thereby reduced, and alternatively, the listed supplementary elements improve corrosion and oxidation resistance by reducing necessary Cu content of the brazing material; both increase the material's utility.

For example, the first brazing temperature may be about 900°C (1652°F) and at a heating rate in the range of 1.1–11°C/min. If the second braze is desired, a second braze material may be mixed with the additions of Zr and Ag, such as Ti-20Ni-15Cu-15Ag-15Zr (wt-%) and at the brazing temperature 840°C (1544°F) and the heating rate in the range of 1.1–7.7°C/min.

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BRAZING Q&A

BY TIM P. HIRTHE

Q: We currently braze a variety of 300 series stainless steel assemblies in our vacuum furnace. The filler metal we use is primarily AWS A5.8 BNi-2. We have an application that calls for the use of a silver filler metal. We have some leeway in the selection of the filler metal but we are concerned about the use of silver in a vacuum furnace. We hear it can cause contamination of assemblies subsequently Ni brazed in this furnace. What do you recommend?

A: In an ideal world you would have furnaces designed to perform a process and have that equipment dedicated to that process. Things don't always work out that way. While it is tempting to use furnaces for more than one process, most manufacturing people I talk to shy away from using silver in vacuum. They are concerned not only about contamination of workpieces but also damage to the furnace. However, there are some applications using certain techniques where brazing with silver filler metals in vacuum have been successful. The consensus, though, is that you should do everything possible to design the assembly and process to avoid using high vacuum.

When brazing stainless steel, regardless of the filler metal selected, a certain vacuum level and temperature need to be reached to achieve a successful braze. This is required to ensure the chromium oxide is reduced sufficiently for the proper wetting of the filler metal. Other oxides such as those of aluminum or titanium may also be present. Typically this involves temperatures above 1800°F (982°C) and at vacuum levels of 1×10^{-4} torr or below. This would be considered a high-vacuum situation. This combination of pressure and temperature is a problem for silver filler metals.

The issue is the vapor pressure of sil-

ver. Vapor pressure is the pressure, at a given temperature, at which an element is in equilibrium with its own vapor. The vapor pressure of a metal is fixed at a certain value at a given temperature. At atmospheric pressure, silver will not vaporize until 4014°F (2212°C). However, the temperature at which the metal is in equilibrium with its own vapor decreases as the pressure at which it is exposed decreases. Therefore, a material's tendency to vaporize increases as you decrease the pressure and increase the temperature. At a pressure of 1×10^{-4} torr, silver will begin to vaporize below 1600°F (871°C). This vaporization, then, begins well before the conditions necessary for successful brazing of stainless steel are reached.

Vaporized silver condenses on the cold sections of the furnace, typically the shielding and ceramic insulators at the power feed throughs. The shielding is usually fabricated from molybdenum and interaction between the silver and molybdenum may occur. More dangerous is the possibility of short circuiting the incoming power at the ceramic insulators. From a process perspective, if subsequent furnace cycles are run at higher temperatures and lower pressures, the condensed silver can revaporize and deposit on brazed assemblies. Depending on the parts and their intended use, this can be very detrimental.

The problem is most severe when you use high vacuum, i.e., pressures of 1×10^{-4} or below, and run cycles at high temperatures. A common approach in attempting to overcome this is to add a partial pressure of an inert gas such as argon. Partial pressures between 200 and 500 microns (2.0 or 5.0×10^{-1} torr) can suppress silver vaporization. The argon must be extremely dry or oxygen can be introduced along with it, causing the chromium to oxidize. Because the high vacuum and high temperature are required to reduce the chromium oxide, in order to achieve good filler metal wetting, the timing of argon introduction will not be successful in suppressing all silver vaporization.

Another approach is to plate the stainless steel with Ni. Recommendations for this plating can be found in the AWS *Brazing Handbook* and AWS C3.6M, *Specification for Furnace Brazing*. The plating eliminates the need to reduce chromium oxide during brazing, allowing for the cycle to be run at lower temperature and higher pressure. Partial pressure of argon may still be required but the potential for vaporization and its associated problems will be significantly less.

By doing this, you can take advantage of one of the major benefits of using a silver filler metal. They are available in chemistries that allow you to braze at temperatures lower than those of BNi, BCu, and other high-temperature options. For example, BNi-2, probably the most commonly used Ni filler metal, has a melt range of 1780° to 1830°F (971° to 999°C). In comparison, BAg-8 has a melt point of 1435°F (779°C).

If you are brazing directly to stainless steel, i.e., without plating, the BAg-8 is not the best selection. Alloy additions are available that provide improved wetting over that of the BAg-8. Most common are additions of nickel or lithium. Filler metals with nickel additions are more common as they are less expensive and lithium vaporizes more readily than silver.

The most common silver filler metals, with their AWS A5.8 classifications, recommended for stainless steels brazed in a furnace are shown below.

BAg-13a	56Ag/42Cu/2Ni
BAg-21	63Ag/28.5Cu/2.5Ni/6Sn
BAg-8a	72Ag/27.6Cu/0.4Li
BAg-19	92.5Ag/7.3Cu/0.2Li

The melting ranges of these filler metals fall between 1275° and 1635°F (691° and 891°C). The BAg-13, for example, has a melt range of 1325° to 1360°F (718° to 738°C). These temperatures are very attractive if the assembly can benefit from a low-temperature brazing cycle. We would normally recommend using a dry hydrogen atmosphere to allow the brazing of these filler metals to be done at temperatures closer to their melt ranges. The hydrogen, if its dew point is below -40°F (-40°C), is capable of reducing the chromium oxide and providing a pressure in the furnace that suppresses silver vaporization. Furnaces that are capable of using hydrogen are designed with safety features for that purpose. Hydrogen should never be used in a furnace without these features.

While acceptable brazing of stainless steels with silver filler metals can be achieved in vacuum, it can be problematic for the furnace and long-term braze quality if done in great quantity and in high vacuum. I would recommend that alternatives such as dry hydrogen brazing be considered if appropriate equipment is available. If vacuum must be used, whatever steps that are possible should be taken to allow the brazing to occur at as low a temperature and as high a pressure as possible.

TIM P. HIRTHE has been a member of the C3 Committee on Brazing and Soldering since 1982, and a member of its Subcommittees on Brazing Handbook, Education and Safety, Soldering, Brazing Specifications, and Brazing Conferences; and the A5H Subcommittee on Filler Metals and Fluxes for Brazing. He has spent his entire career doing brazing applications engineering and owns his own consulting business.

Readers are requested to post their questions for Mr. Hirthe on the Brazing Forum section of the Brazing and Soldering Manufacturers Committee Web site www.brazingandsoldering.com.

Mr. Hirthe thanks the following for reviewing the content of this column: Toshi Oyama and Tom Sandin of Wesgo Metals, Div. of Morgan Advanced Ceramics; and Robert Heath with Thermal Technology, Inc.



American Welding Society

Friends and Colleagues:

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

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For specifics on the nomination requirements, please contact Wendy Sue Reeve at AWS headquarters in Miami, or simply follow the instructions on the Counselor nomination form in this issue of the *Welding Journal*. The deadline for submission is July 1, 2009. The committee looks forward to receiving these nominations for 2010 consideration.

Sincerely,

Alfred F. Fleury
Chair, Counselor Selection Committee



CLASS OF 2010 COUNSELOR NOMINATION FORM

(please type or print in black ink)

DATE _____ NAME OF CANDIDATE _____

AWS MEMBER NO. _____ YEARS OF AWS MEMBERSHIP _____

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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 _____

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SUBMISSION DEADLINE JULY 1, 2009



American Welding Society

Nomination of AWS Counselor

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II. RULES

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

III. NUMBER OF COUNSELORS TO BE SELECTED

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Fluxes for Brazing and Braze Welding

Brazing fluxes are classified according to the filler metal, form, and activity temperature range for which they are applicable, as specified in Table 1.

Description and Intended Use of Brazing Fluxes

Brazing fluxes are mixtures of chemical compounds that may include inorganic salts and mild acids selected for their ability to provide chemical cleaning or protection of the faying surfaces and the filler metal during brazing. They must perform their protective, cleaning, and fluxing action with the specific filler metals being used, in conjunction with the other brazing variables; such as base metal, brazing process, mass of the workpieces, and method of flux application. A description of the brazing fluxes and their intended use follows:

FB1-A comes in powder form and is intended for torch and furnace brazing of aluminum and its brazeable alloys. It consists primarily of fluorides and chlorides of some of the alkali metals. Water or alcohol may be used for thinning.

FB1-B is intended for furnace brazing of aluminum and its brazeable alloys. The lower end of its activity temperature range is slightly lower than that of FB1-A. It consists primarily of fluorides and chlorides of some of the alkali metals. Water or alcohol may be used for thinning.

FB1-C is intended for salt-bath dip brazing of aluminum and its brazeable alloys. The lower end of its activity temperature range is much lower than that of FB1-A and FB1-B. It consists primarily of fluorides and chlorides of some of the alkali metals. Water should be avoided in the flux or removed prior to immersion of the brazement in the salt bath.

FB2-A is intended for salt-bath dip brazing of magnesium alloys whose designators start with AZ. It consists primarily of fluorides and chlorides of some of the alkali metals. Water should be avoided in the flux or removed prior to immersion of the brazement in the salt bath.

FB3-A is a general-purpose brazing flux intended for use with most brazing processes in the brazing of steels, copper, copper alloys, nickel, and nickel alloys. It is not suitable for aluminum bronze or other base metals containing alloying elements that form refractory oxides. It consists primarily of boric acid, borates, and complex fluorine compounds. Water is used for thinning.

FB3-C is similar to FB3-A but its activity temperature range extends to a higher temperature, and it may contain elemental boron. Water is used for thinning.

FB3-D is intended for torch, furnace, and induction brazing of steels, nickel and its alloys, and carbides using high-temperature filler metals. It consists primarily of boric acid, borates, and complex fluorine compounds. It may contain elemental boron. Water is used for thinning.

FB3-E is a low-activity liquid brazing flux used for torch brazing of jewelry or to augment borderline furnace brazing atmospheric conditions. It is usually applied by dipping or by the use of semi- or fully automatic spray dispensing equipment.

FB3-F is somewhat similar to FB3-A, except that no vehicle is added to the powder during manufacture. Water may be used as a thinning vehicle.

FB3-G is used with automatic spray dispensing equipment. The general areas of application are similar to those of FB3-A. Water may be used as a thinning vehicle.

FB3-H is also used with automatic spray dispensing equipment. Its general areas of application are similar to those of FB3-C. It typically contains complex borates and fluoride compounds plus powdered boron. Water may be used as a thinning vehicle.

FB3-I is used with automatic spray dispensing equipment. Its areas of application are similar to those of FB3-D. It typically contains complex borates and fluoride compounds plus powdered boron. Water may be used as a thinning vehicle.

FB3-J has areas of application similar to those of FB3-D. It typically contains complex borates and fluoride compounds plus powdered boron. Water may be used as the thinning vehicle.

FB3-K is used almost exclusively in torch brazing. The fuel gas is passed through the container of liquid flux entraining flux in the fuel gas. The flux is applied by the flame where needed on base metals such as carbon steels, low-alloy steels, cast iron, copper and copper alloys, nickel and nickel alloys, and precious metals. The flux consists primarily of liquid borates.

FB4-A is intended for brazing of copper alloys and other base metals containing up to 9% aluminum, e.g., aluminum bronze. It may also be suitable for base metals containing up to 3% titanium or other metals that form refractory oxides. It consists primarily of borates, complex fluorine compounds, and complex chlorine compounds. Water is used for thinning.

Table 1 — Classification of Brazing Fluxes with Brazing or Braze Welding Filler Materials

AWS Classification*	Form	Filler Metal Type	Activity Temperature Range	
			°F	°C
FB1-A	Powder	BAISi	1080–1140	580–615
FB1-B	Powder	BAISi	1040–1140	560–615
FB1-C	Powder	BAISi	1000–1140	540–615
FB2-A	Powder	BMg	900–1150	480–620
FB3-A	Paste	BAg & BCuP	1050–1600	565–870
FB3-C	Paste	BAg & BCuP	1050–1700	565–925
FB3-D	Paste	BAg, BCu, BNi, BAu, & RBCuZn	1400–2200	760–1205
FB3-E	Liquid	BAg, & BCuP	1050–1600	565–870
FB3-F	Powder	BAg, & BCuP	1200–1600	650–870
FB3-G	Slurry	BAg, & BCuP	1050–1600	565–870
FB3-H	Slurry	BAg	1050–1700	565–925
FB3-I	Slurry	BAg, BCu, BNi, BAu, RBCuZn	1400–2200	760–1205
FB3-J	Powder	BAg, BCu, BNi, BAu, & RBCuZn	1400–2200	760–1205
FB3-K	Liquid	BAg & RBCuZn	1400–2200	760–1205
FB4-A	Paste	BAg & BCuP	1100–1600	595–870

*Flux 3B in the *Brazing Manual*, 3rd Edition, 1976, has been discontinued. Type 3B has been divided into types FB3-C and FB3-D.

Notes:

a. The selection of a flux designation for a specific type of work may be based on the form, the filler metal type, and the classification above, but the information here is generally not adequate for flux selection. Refer to Section A6 and the latest issue of the *Brazing Handbook* for further assistance.

b. See 11.2 and 11.3 for the difference between paste flux and slurry flux.

Excerpted from AWS A5.31:2003, Specification for Fluxes for Brazing and Braze Welding.



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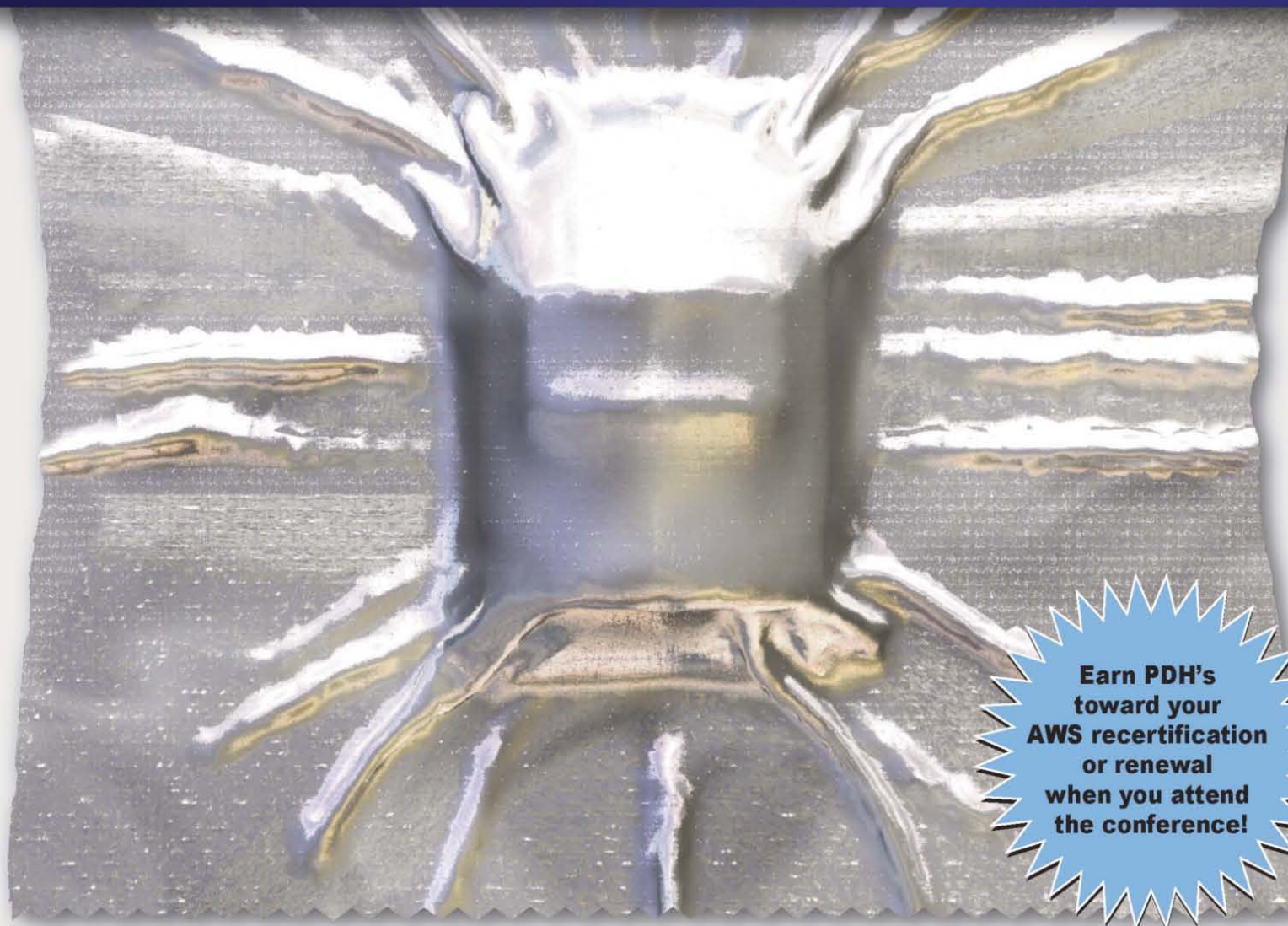
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NOTE: A DIAMOND (♦) DENOTES AN AWS-SPONSORED EVENT.

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2nd Annual Global Marine Renewable Energy Conf. April 15, 16, The Carnegie Institution for Science, Washington, D.C. Contacts (877) 463-3846; info@globalmarinerenewable.com.

The Aluminum Assn. Spring Meeting. April 20-22, Omni La Mansion del Rio, San Antonio, Tex. Visit www.aluminum.org.

♦ **IBSC, 4th Int'l Brazing and Soldering Conf.** April 26-29, Hilton Hotel in the Walt Disney World Resort, Orlando, Fla. Cosponsored by AWS and ASM International. Contact American Welding Society, (800/305) 443-9353, ext. 229; visit www.aws.org.

JOM-15, 15th Int'l Conf. on the Joining of Materials, and 6th Int'l Conf. on Education in Welding. May 3-6, Helsingør, Denmark. Organized by JOM Institute, supported by Dansk Metal, Danish Welding Society, DSL.FORCE Technology. Send e-mail inquiries to jom_aws@post10.tele.dk.

AISTech 2009, The Iron & Steel Technology Conf. and Expo and Asia-Pacific Partnership Technology Showcase 2009. May 4-7, St. Louis, Mo. Contact Association for Iron & Steel Technology www.iss.org.

Int'l Thermal Spray Conf. and Expo (ITSC). May 4-7, Flamingo Las Vegas Hotel, Las Vegas, Nev. Sponsored by ASM Int'l Ther-

mal Spray Society, German Welding Society, and Int'l Institute of Welding. Visit www.asminternational.org/itsc.

Offshore Technology Conf. May 4-7, Reliant Center, Houston, Tex. Visit www.otcnet.org/2009.

♦ **12th Aluminum Welding Conf. and Expo.** May 5, 6, Toronto, Ont., Canada. Cosponsored by AWS and The Aluminum Assn. Contact American Welding Society, (800/305) 443-9353, ext. 229; visit www.aws.org.

Del Mar Electronics Show. May 6, 7, Del Mar Fairgrounds, San Diego, Calif. Visit www.vts.com.

♦ **Robotic Arc Welding Conf. and Expo.** May 11-13, Milwaukee Area Technical College, Milwaukee, Wis. Cosponsored by the AWS Milwaukee Section and D16 Committee on Robotic and Automatic Welding. Includes tour of Caterpillar's facility in Aurora, Ill. Contact Karen Gilgenbach at karen.gilgenbach@airgas.com, or call (262) 613-3790.

RAPID 2009. May 12-14, Renaissance Schaumburg Convention Center, Schaumburg, Ill. Contact Society of Mfg. Engineers, (800) 733-4763, www.sme.org/rapid.

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Advanced Manuf. Expo. and Plant Maintenance & Design Engineering Show. May 19–21, Place Bonaventure, Montreal, Que., Canada. Contact Society of Mfg. Engineers, (800) 733-4763, www.sme.org.

EASTEC. May 19–21, Eastern States Exposition Grounds, W. Springfield, Mass. Contact Society of Mfg. Engineers, (800) 733-4763; or visit www.sme.org/eastec.

◆ **AWS/Weldmex.** June 2–4, Monterrey, Mexico. Contact American Welding Society, (800/305) 443-9353, ext. 229; or visit www.aws.org.

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

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

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

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

◆ **Shipbuilding Conf.** June 16, 17, New Orleans, La. Contact American Welding Society, (800/305) 443-9353, ext. 229; or visit www.aws.org.

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

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

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

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

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

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

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

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

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

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

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

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

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

ICALEO, 28th Int'l Congress on Applications of Lasers & Electro-Optics. Nov. 2–5, Hilton in the Walt Disney World Resort®, Orlando, Fla. E-mail Laser Institute of America at conferences@laserinstitute.org; or visit www.icaleo.org.

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

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◆ **Power-Gen Int'l.** Dec. 8–10, Las Vegas, Nev. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.

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ASME Section IX Course. June 1–3, Houston, Tex. Presented by Walter J. Sperko. Call ASME InfoCentral (800) 843-2763, or visit http://catalog.asme.org/Education/ShortCourse/BPV_Code_Section_IX_Welding.cfm.

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Laser Safety Online Courses. Courses include Medical Laser Safety Officer, Laser Safety Training for Physicians, Industrial Laser Safety, and Laser Safety in Educational Institutions. Contact Laser Institute of America, (800) 345-3737, www.laserinstitute.org.

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, www.laserinstitute.org.

Machine Safeguarding Seminars. Contact Rockford Systems, Inc., (800) 922-7533, www.rockfordsystems.com.

Machining and Grinding Courses. Contact TechSolve, www.TechSolve.org.

Motorsports Welding School Advanced Materials Courses. Cleveland, Ohio. April 27–May 1, June 15–19, Sept. 14–18, Oct. 12–16, Dec. 7–11. Contact The Lincoln Electric Co., www.lincolnelectric.com.

Motorsports Welding School Basic Materials Courses. Cleveland, Ohio. April 20–24, May 11–15, June 8–12, July 27–31, Sept. 8–11, Sept. 21–25, Oct. 5–9, Nov. 9–13, Nov. 30–Dec. 4. Contact The Lincoln Electric Co., www.lincolnelectric.com.

NACE Int'l Training and Certification Courses. Contact National Assoc. of Corrosion Engineers, (281) 228-6223, www.nace.org.

NDE and CWI/CWE Courses and Exams. Allentown, Pa., and at customers' locations. Contact Welder Training and Testing Institute, (800) 223-9884, www.wtti.edu.

Pipe Welding. Cleveland, Ohio. Three-week-long courses beginning May 11, June 22, Aug. 3, Sept. 14, and Oct. 26. Contact The Lincoln Electric Co., www.lincolnelectric.com.

Plastics Welding School. A two-day, hands-on course for certification to European DVS-approved plastics welding standards for hot gas and extrusion techniques. Contact Malcom Hot Air Systems, www.plasticweldingtools.com.

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Structural Welding: Design and Specification Seminars and AWS D1.1, Structural Welding Code — Steel. Contact Steel Structures Technology Center, www.steelstructures.com, (248) 893-0132.

Tool and Die Welding Courses. Troy, Ohio. Contact Hobart Institute of Welding Technology, (800) 332-9448, www.welding.org.

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Certified Welding Inspector (CWI)

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San Francisco, CA	Apr. 26-May 1	May 2
Portland, ME	Apr. 26-May 1	May 2
Las Vegas, NV	Apr. 26-May 1	May 2
Waco, TX	EXAM ONLY	May 2
St. Louis, MO	EXAM ONLY	May 9
Miami, FL	EXAM ONLY	May 14
Nashville, TN	May 10-15	May 16
Jacksonville, FL	May 10-15	May 16
Baltimore, MD	May 10-15	May 16
Long Beach, CA	EXAM ONLY	May 30
Detroit, MI	May 31-Jun. 5	Jun. 6
Miami, FL	May 31-Jun. 5	Jun. 6
Albuquerque, NM	May 31-Jun. 5	Jun. 6
Spokane, WA	Jun. 7-12	Jun. 13
Oklahoma City, OK	Jun. 7-12	Jun. 13
Birmingham, AL	Jun. 7-12	Jun. 13
Hartford, CT	Jun. 14-19	Jun. 20
Pittsburgh, PA	Jun. 14-19	Jun. 20
Beaumont, TX	Jun. 14-19	Jun. 20
Corpus Christi, TX	EXAM ONLY	Jun. 20
Kansas City, MO	Jun. 21-26	Jun. 27
Miami, FL	EXAM ONLY	Jul. 16
Fargo, ND	Jul. 12-17	Jul. 18
New Orleans, LA	Jul. 12-17	Jul. 18
Sacramento, CA	Jul. 12-17	Jul. 18
Phoenix, AZ	Jul. 19-24	Jul. 25
Orlando, FL	Jul. 19-24	Jul. 25
Milwaukee, WI	Jul. 19-24	Jul. 25
Cleveland, OH	Jul. 26-31	Aug. 1
Los Angeles, CA	Jul. 26-31	Aug. 1
Louisville, KY	Jul. 26-31	Aug. 1
Denver, CO	Aug. 2-7	Aug. 8
Philadelphia, PA	Aug. 2-7	Aug. 8
San Diego, CA	Aug. 9-14	Aug. 15
Miami, FL	Aug. 9-14	Aug. 15
Charlotte, NC	Aug. 16-21	Aug. 22
San Antonio, TX	Aug. 16-21	Aug. 22
Bakersfield, CA	Aug. 16-21	Aug. 22
Rochester, NY	EXAM ONLY	Aug. 22
Portland, ME	Aug. 23-28	Aug. 29
Salt Lake City, UT	Aug. 23-28	Aug. 29
Seattle, WA	Aug. 23-28	Aug. 29
Corpus Christi, TX	EXAM ONLY	Aug. 29
Pittsburgh, PA	Aug. 30-Sept. 4	Sept. 5
Houston, TX	Aug. 30-Sept. 4	Sept. 5
Minneapolis, MN	Aug. 30-Sept. 4	Sept. 5
St. Louis, MO	Sept. 20-25	Sept. 26
Miami, FL	Sept. 20-25	Sept. 26
New Orleans, LA	Sept. 20-25	Sept. 26
Anchorage, AK	EXAM ONLY	Sept. 26
Tulsa, OK	Oct. 4-9	Oct. 10
Long Beach, CA	Oct. 4-9	Oct. 10
Newark, NJ	Oct. 4-9	Oct. 10
Miami, FL	EXAM ONLY	Oct. 15
Portland, OR	Oct. 18-23	Oct. 24
Roanoke, VA	Oct. 18-23	Oct. 24
Cleveland, OH	Oct. 18-23	Oct. 24

9-Year Recertification Seminar for CWI/SCWI

LOCATION	SEMINAR DATES	EXAM DATE
Sacramento, CA	May 4-9	NO EXAM
Pittsburgh, PA	Jun. 1-6	NO EXAM
San Diego, CA	Jul. 13-18	NO EXAM
Orlando, FL	Aug. 24-29	NO EXAM
Dallas, TX	Oct. 5-10	NO EXAM
Miami, FL	Nov. 30-Dec. 5	NO EXAM

For current CWIs and SCWIs needing to meet education requirements without taking the exam. If needed, recertification exam can be taken at any site listed under Certified Welding Inspector.

Certified Welding Supervisor (CWS)

LOCATION	SEMINAR DATES	EXAM DATE
New Orleans, LA	Apr. 20-24	Apr. 25
Columbus, OH	Jun. 1-5	Jun. 6
Minneapolis, MN	Jul. 20-24	Jul. 25
Philadelphia, PA	Aug. 31- Sep. 4	Sept. 5
Tulsa, OK	Oct. 5-9	Oct. 10
Long Beach, CA	Nov. 30-Dec. 4	Dec. 5

CWS exams are also given at all CWI exam sites.

Certified Radiographic Interpreter (CRI)

LOCATION	SEMINAR DATES	EXAM DATE
Indianapolis, IN	Apr. 20-24	Apr. 25
Miami, FL	Jun. 22-26	Jun. 27
Houston, TX	Jul. 27-31	Aug. 1
Miami, FL	Oct. 19-23	Oct. 24

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

Certified Welding Sales Representative (CWSR)

LOCATION	SEMINAR DATES	EXAM DATE
Miami, FL	Oct. 21-23	Oct. 23
Chicago, IL	Nov. 16-18	Nov. 18

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

Certified Welding Educator (CWE)

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

Senior Certified Welding Inspector (SCWI)

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

Code Clinics & Individual Prep Courses

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

On-site Training and Examination

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

International CWI Courses and Exams

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

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

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American Welding Society®

SOCIETY NEWS

BY HOWARD M. WOODWARD

National Officers Transition at HQ Event

BY KRISTIN CAMPBELL

President **Victor Y. Matthews** defined success as a pyramid that must have adequate blocks at the bottom base in order to build the next layers. He was speaking at the officers' transition ceremony held February 6 at AWS headquarters in Miami, Fla. Matthews recalled his inaugural address where he instructed AWS volunteers to set a priority for enhancing welding education and improving career expansion for individuals. He also pushed the volunteers on improving our technology support. He said, "In today's environment, the materials are changing, and the way we weld them is changing. For example, the automotive industry seeks better gas mileage and to accomplish this, cars must be made lighter and welds stronger; new materials and technology have to be developed.

"And to that extent, I thank our technical committees. We have more than 200 committees, and we have about 75 new standards and specifications being published in the years 2008 and 2009, which is an unprecedented number."

Matthews concluded, "I'm very proud to say that I am a member of the American Welding Society. I have to say that fifteen years ago if you would have told me I would be an AWS president I would not have believed you — I did not see that in my success pyramid."

Gene E. Lawson reflected on his experiences serving as the 2008 AWS president with his wife, **Bette**, at his side. "When we visited foreign countries we were wonderfully accepted, and we were humbled by the respect that they have for the American Welding Society and for us coming to visit them. It was a rewarding experience."

Later, Lawson presented Matthews with his AWS president's pin and ring. On accepting the ring, Matthews said, "I want to thank you for all your contributions, Gene. You have set a fantastic course for me to follow."

Ray Shook, AWS executive director, then read a proclamation from the Mayor of Miami declaring February 6 as American Welding Society Day in the city.

Introduced were first-term Vice President **William A. Rice Jr.** and his wife, **Cherry**, and Vice President-Elect **Nancy Cole**. Others participating in the event included **Sally Matthews**; Foundation Chairman **Gerald Uttrachi** and wife, **Christine**; Treasurer **Earl Lipphardt**; Vice President **John Bruskotter** and wife, **Donna**; Vice President **John Mendoza** and wife, **Nora**; District 12 Director **Sean Moran**; District 16 Director **Dave Landon**; Director-at-Large **Dave McQuaid**; and the AWS staff.

AWS Employee of the Year Award

Andrew Davis, managing director, technical services, was chosen by his peers to receive the prestigious Michael A. Rowland Employee of the Year Award.

This honor recognizes an AWS employee who has provided exemplary service and made notable contributions over and above the scope of normal duties, plus possesses an attitude and behavior contributing to teamwork and positive treatment of others in ways that exceeded job expectations.

Shook said during the presentation, "Andrew has been instrumental in shifting and managing the change of publications sales responsibilities from IHS to WEX over the past three years," He also recounted that Davis renegotiated a contract with ASME for reproduction rights to the Society's A5 standards, and worked closely with WEX to renegotiate more favorable vendor contracts on several fronts. Shook noted that, "He has also been vigilant in protecting AWS copyright material by assisting in the establishment of PDF security features for downloadable publications, and by investigating and following up on possible copyright infringements. Andrew was also instrumental in establishing the ISO delegate fund. Davis," Shook added, "sets a great example by coming in early and leaving late; stays active with his e-mails while traveling for work and during weekends; actively directs his staff members to keep travel and work expenses to a reasonable



Andrew Davis (left), AWS technical director, receives the Michael A. Rowland Employee of the Year Award from Ray Shook, AWS executive director.



Victor Y. Matthews (right) accepts his AWS president's pin and ring from Gene E. Lawson, 2008 president.

minimum without sacrificing quality or productivity; assists several of his employees with personal issues outside of the office; and is aware of the work being done in most other departments and provides assistance, advice, and support to them frequently."

Among the gifts presented as a part of the award, Davis received \$1000 cash, a gift certificate for dinner at a local restaurant, a designated parking space for one year, and an engraved clock. ♦

KRISTIN CAMPBELL (kcampbell@aws.org) is associate editor of the Welding Journal.

Tech Topics

New Standard Project

Development work has begun on the revision of the following standard. Concerned individuals are invited to contribute to its development. Participation on AWS Technical Committees and Subcommittees is open to all persons.

D18.2:200X, *Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube*.

This standard addresses factors that affect weld discoloration on the inside of austenitic stainless steel tubing. The document contains a color illustration relating the discoloration to the oxygen content of the backing shielding gas. **Stakeholders:** Designers, engineers, welders, inspectors, and manufacturers of medical, food service, and environmental services equipment. Contact Reino Starks, staff engineer, ext. 304, rstarks@aws.org.

Standards Approved by ANSI

G2.3M/G2.3:2009, *Guide for the Joining of Wrought Solid Solution Austenitic Stainless Steels*. New standard. 2/2/09.

B5.14:2009, *Specification for the Qualification of Welding Sales Representative*. Revised standard. 2/2/09.

Standards for ANSI Public Review

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

D17.3/D17.3M:200X, *Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications*. New standard — \$30. Public review expires 4/6/09.

The ANSI public review period for the following ten reaffirmed standards expired 3/30/09. Draft copies may be obtained for \$25 each.

B2.1-4-217:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Chromium-Molybdenum Steel (M-4/P-4, Group 1 or 2), ER80S-B2, 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 3/4 in. Thick, PWHT Condition, Primarily Pipe Applications*

B2.1-4-218:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Chromium-Molybdenum Steel (M-4/P-4, Group 1 or 2), E8018-B2, 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 1 1/2 in. Thick, PWHT Condition, Primarily Pipe Applications*

B2.1-4-219:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding Followed by Shielded Metal Arc Welding of Chromium-Molybdenum Steel (M-4/P-4, Group 1 or 2), 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 1 1/2 in. Thick, PWHT Condition, ER80S-B2 and E8018-B2, Primarily Pipe Applications*

B2.1-4-220:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding (Consumable Insert Root) of Chromium-Molybdenum Steel (M-4/P-4, Group 1 or 2), E8018-B2, 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 3/4 in. Thick, PWHT Condition, IN515 and ER80S-B2, Primarily Pipe Applications*

B2.1-4-221:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding (Consumable Insert Root) Followed by Shielded Metal Arc Welding of Chromium-Molybdenum Steel (M-4/P-4, Group 1 or 2), 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 1 1/2 in. Thick, PWHT Condition, IN515, ER80S-B2, and E8018-B2, Primarily Pipe Applications*

B2.1-5A-222:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Chromium-Molybdenum Steel (M-5A/P-5A), ER90S-B3, 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 3/4 in. Thick, PWHT Condition, Primarily Pipe Applications*

B2.1-5A-223:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Chromium-Molybdenum Steel (M-5A/P-5A), E9018-B3, 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 1 1/2 in. Thick, PWHT Condition, Primarily Pipe Applications*

B2.1-5A-224:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding Followed by Shielded Metal Arc Welding of Chromium-Molybdenum Steel (M-5A/P-5A), E9018-B3, 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 1 1/2 in. Thick, PWHT Condition, ER90S-B3 and E9018-B3, Primarily Pipe Applications*

B2.1-5A-225:1999 (R200X), *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding (Consumable Insert Root) of Chromium-Molybdenum Steel (M-5A/P-5A), 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 3/4 in. Thick, PWHT Condition, IN521 and ER90S-B3, Primarily Pipe Applications*

B2.1-5A-226:1999 (R200X), *Standard Welding Procedure Specification*

(WPS) for Gas Tungsten Arc Welding (Consumable Insert Root) Followed by Shielded Metal Arc Welding of Chromium-Molybdenum Steel (M-5A/P-5A), 1/8 through 1/2 in. Thick, As-Welded Condition, 1/8 through 1 1/2 in. Thick, PWHT Condition, IN521, ER90S-B3, and E9018-B3, Primarily Pipe Applications

ISO Standard for Public Review

ISO/DIS 9606-1.3, *Qualification testing of welders — Fusion welding — Part 1: Steels*

Copies of this draft standard are available for review and comment through your national standards body, which in the United States is ANSI, 25 W. 43rd St., 4th Fl., New York, NY 10036; (212) 642-4900. Any comments regarding ISO documents should be sent to your national standards body.

In the United States, if you wish to participate in the development of International Standards for welding, contact Andrew Davis, ext. 466, adavis@aws.org.

Technical Committee Meetings

April 1, A5M Subcommittee on Carbon and Low-Alloy Steel Electrodes for Flux Cored Arc Welding. Orlando, Fla. Call Rakesh Gupta, ext. 301, gupta@aws.org.

April 9, D3 Committee on Welding in Marine Construction. Hanover, Pa. Call Brian McGrath, ext. 311, bmcgrath@aws.org.

April 27, D15C Subcommittee on Track Welding. Skokie, Ill. Call Reino Starks, ext. 304, rstarks@aws.org.

April 29, A5H Subcommittee on Filler Metals and Fluxes for Brazing. Orlando, Fla. Call Stephen Borrero, ext. 334, sborrero@aws.org.

April 30, C3 Committee and Subcommittees on Brazing and Soldering. Orlando, Fla. Call Stephen Borrero, ext. 334.

April 30, J1 Committee on Resistance Welding Equipment. Dayton, Ohio. Call Annette Alonso, ext. 299, aalonso@aws.org.

May 5-7, D17 Committee and Subcommittees on Welding in the Aircraft and Aerospace Industries. Cincinnati, Ohio. Call Matthew Rubin, ext. 215, mrubin@aws.org.

May 6, 7, A2 Committee and Subcommittees on Definitions and Symbols. Myrtle Beach, S.C. Call Annette Alonso, ext. 299, aalonso@aws.org.

May 14, D16 Committee on Robotic and Automatic Welding. Milwaukee, Wis. Call Matthew Rubin, ext. 215, mrubin@aws.org.

Member-Get-A-Member Campaign

Listed are the February 17 tallies. For rules and prize list see page 87 of this *Welding Journal* or visit www.aws.org/mgm. Call the Membership Dept., (800) 443-9353, ext. 480, regarding your proposer point status.

Winner's Circle

Sponsored 20+ new members.

The superscript indicates the number of times the member has achieved Winner's Circle status since June 1, 1999.

J. Compton, San Fernando Valley⁷
E. Ezell, Mobile⁶
J. Merzthal, Peru²
G. Taylor, Pascagoula²
L. Taylor, Pascagoula²
B. Mikeska, Houston¹
R. Peaslee, Detroit¹
W. Shreve, Fox Valley¹
M. Karagoulis, Detroit¹
S. McGill, NE Tennessee¹
T. Weaver, Johnstown/Altoona¹
G. Woomer, Johnstown/Altoona¹
R. Wray, Nebraska¹
M. Haggard, Inland Empire¹

President's Roundtable

Sponsored 9-19 new members.

E. Ezell, Mobile — 16
P. Betts, Mobile — 12

President's Club

Sponsored 3-8 new members.

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

President's Honor Roll

C. Alfaro, San Diego — 2
M. Boggs, Stark Central — 2

M. Boyer, Detroit — 2
R. Boyer, Nevada — 2
B. Donaldson, British Columbia — 2
E. Dupree, Tidewater — 2
T. Ferri, Boston — 2
F. Hendrix, New Jersey — 2
T. Johnson, Pittsburgh — 2
G. Lawrence, N. Central Florida — 2
J. Livesay, Nashville — 2
J. Padilla, Cuautitlan Izcalli — 2
S. Luke, Acadiana — 2
J. Nash, Atlanta — 2
R. Pitt, Tidewater — 2
J. Polson, L.A./Inland Empire — 2
D. Roland, Upper Peninsula — 2
J. Rule, Cleveland — 2
J. Sisson, Niagara Frontier — 2
K. Smith, North Texas — 2
A. Stute, Madison-Beloit — 2
J. Svatos, Siouxland — 2
D. Thomason, Chicago — 2
B. Whatley, Albuquerque — 2
M. Yung, Portland — 2
P. Zammit, Spokane — 2

Student Member Sponsors

Sponsored 3 or more students.

D. Berger, New Orleans — 110
B. Benyon, Pittsburgh — 41
A. Baughman, Stark Central — 36
M. Boggs, Stark Central — 36
R. Jones, Puget Sound — 36
A. Rowe, Philadelphia — 36
A. Zinn, Eastern Iowa — 34
T. Moore, New Orleans — 32
J. Carney, Western Michigan — 26
E. Norman, Ozark — 26
S. Siviski, Maine — 26
J. Roberts, Sacramento — 25
T. Geisler, Pittsburgh — 24
J. Kline, Northern New York — 24
D. Newman, Ozark — 24
R. Newman, Maine — 24
R. Cook, Utah — 23
D. Howard, Johnstown-Altoona — 23
B. Suckow, Northern Plains — 23
L. Clark, Milwaukee — 22
H. Hughes, Mahoning Valley — 22
D. Schnalzer, Lehigh Valley — 22
J. Rule, Cleveland — 21
R. Munns, Utah — 20
A. Duron, New Orleans — 19
J. Fox, NW Ohio — 19
D. Zabel, SE Nebraska — 19
D. Pickering, Central Arkansas — 18
R. Schmidt, Philadelphia — 18
J. Boyer, Lancaster — 17

R. Boyer, Nevada — 17
J. Ciaramitaro, N. Central Florida — 17
T. Strickland, Arizona — 17
C. Donnell, NW Ohio — 16
B. Hallila, New Orleans — 16
M. Arand, Louisville — 14
W. Harris, Pascagoula — 14
R. Hutchinson, Long Bch./Or. Cty. — 14
G. Smith, Lehigh Valley — 14
A. Mattox, Lexington — 13
R. Rummel, Central Texas — 13
D. Saunders, Lakeshore — 13
A. Stute, Madison-Beloit — 13
D. Taylor, Kern — 13
J. Daugherty, Louisville — 12
J. Marshall, Siouxland — 12
R. Evans, Siouxland — 11
J. Theberge, Boston — 11
C. Kipp, Lehigh Valley — 10
D. Kowalski, Pittsburgh — 10
D. Vranich, N. Florida — 10
C. Abram, Columbus — 9
A. Badeaux, Washington, D.C. — 9
S. Colton, San Diego — 9
R. Ledford Jr., Birmingham — 9
R. Norris, Maine — 9
V. Facchiano, Lehigh Valley — 9
D. Kearns, Northern Michigan — 8
M. Rabo, Sacramento — 8
G. Saari, Inland Empire — 8
N. Carlson, Idaho/Montana — 7
L. Caughron, Kansas City — 7
W. Galvery Jr., Long Bch./Or. Cty. — 7
J. Geesey, Pittsburgh — 7
S. MacKenzie, Northern Michigan — 7
D. Roskiewich, Philadelphia — 7
J. Fitzpatrick, Arizona — 6
C. Schiner, Wyoming — 6
K. Caliva, New Orleans — 5
M. Hayes, Puget Sound — 5
R. Olesky, Pittsburgh — 5
J. Reed, Ozark — 5
T. Buckler Sr., Columbus — 4
H. Evans, Portland — 4
W. Geiger, N. Central Florida — 4
C. Hobson, Olympic Section — 4
T. Hopper, Mobile — 4
S. Robeson, Cumberland Valley — 4
G. Rolla, L.A./Inland Empire — 4
F. Gorglione, Connecticut — 3
D. Hamilton, Chattanooga — 3
S. Hansen, SE Nebraska — 3
J. Hayes, Oklahoma City — 3
R. Huston, Olympic Section — 3
D. Saunders, Holston — 3
M. Shelton, Sabine — 3
S. Tennant, Fox Valley — 3

Nominees Sought to Receive Prof. Masubuchi Award

November 2 is the deadline for submitting nominations for the 2010 Prof. Koichi Masubuchi Award, sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology. This award includes an honorarium of \$5000. It is presented each year to one person who has made significant contributions to the advancement of materials joining through

research and development.

The candidate must be 40 years old or younger, may live anywhere in the world, and need not be an AWS member. The nomination package should be prepared by someone familiar with the research background of the candidate. It should include the candidate's résumé listing background, experience, publications, honors, and awards, plus at

least three letters of recommendation from fellow researchers.

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

New AWS Supporters

Sustaining Companies

Duron Systems, Inc.

9110 Taub Rd.

Houston, TX 77065

Representative: Phillip Lower

www.duronsystems.com

Duron Systems, Inc., has been serving the offshore oil and gas industry since 1980. It provides turnkey structural fabrication for both subsea and surface projects, offers design and engineering services to its customers, and follows an ISO-based QA/QC program that maintains complete traceability.

Dynamic Laboratories, Inc.

3650 Underwood Rd.

La Porte, TX 77571

Representative: Rick Shepherd

www.dynamictesting.com

Dynamic Laboratories, Inc., was established in 1995. Since its inception, it has become a leading welder accreditation facility in North America. The company offers superior service provided by experienced personnel. Contact the company for all your needs in welder testing, welding procedures (qualified or written), materials testing, or weld coupons. The company will soon be accredited as an ISO-17025 laboratory.

Flame Technologies, Inc.

703 Cypress Creek

Cedar Park, TX 78613

Representative: Shawn Toops

www.flametechnologies.com

Flame Technologies, Inc., is a manufacturer of gas apparatus products including cutting kits, torches, regulators, and heating products. The company produces and sells products under the Flame Tech brand name to welding distributors and wholesalers predominantly in North America. Its in-house engineering and design capabilities support custom designing products to its customers' requirements.

Affiliate Companies

B & B Steel Fabrication

1785 E. Washington Dam Rd.

Washington, UT 84780

Base, Inc.

1020 Ashford Ave.

Ste. 105 La Rada

San Juan, PR 00907

Belsinger Group, LLC

1300 Bayard St.

Baltimore, MD 21230

Crimson Fire

907 7th Ave. N.

Brandon, SD 57005

Dakota Pump, Inc.

PO Box 947. 25524 413th Ave.

Mitchell, SD 57301

Gammax S.A. de C.V.

Nueva York #4054

Fracc. Industrial Lincoln

Monterrey Nuevo Leon 64310

Mexico

H P Piping Solutions

6611 Lindbergh St.

Houston, TX 77087

Jolomi Engineering Services, Ltd.

Ste. 22 Mabiaku Rd., PO Box 890

Warri Delta, 332008, Nigeria

Max-Weld, LLC

315 Cokesbury Rd.

Lebanon, NJ 08833

Precision Metal Fabrication, Inc.

6295 S. Pearl St.

Las Vegas, NV 89120

P S Doors

1150 S. 48th St.

Grand Forks, ND 58201

Reeves & Woodland Industries

24475 Grandera Rd.

Homeland, CA 92548

SBI Metal Buildings

114 Trooper Dr.

Hot Springs, AR 71913

Support Points, LLC

136 Main St., Box 290

Anita, PA 15711

TRIMMASTER

4860 5th St. Hwy.

Temple, PA 19560

Supporting Companies

C.O.W. Industries, Inc.

1875 Progress Ave.

Columbus, OH 43207

E & E Manufacturing

201 Industrial Dr.

Plymouth, MI 48170

Fronius Mexico, SA de CV

Carretera Monterrey Saltillo 3279E

Santa Catarina

Nuevo Leon 66367, Mexico

JETS NDT

101 Medical Ct., Ste. 206

Martinsburg, WV 25401

Omaha Standard

3501 S. 11th St.

Council Bluffs, IA 51501

Pickwick Manufacturing Services

4200 Thomas Dr. SW

Cedar Rapids, IA 52404

Reis Robotics USA, Inc.

1320 Holmes Rd.

Elgin, IL 60123

Stahl Y Hagane

Los Cipreses 165

La Molina, Lima 12, Peru

Educational Institutions

Arian Gostaresh Etesal Engineering &

Technical Consulting Co.

3rd Fl., No. 24 Kooh-e-Noor

Montahari Ave., Tehran, Iran

Ivy Tech Community College

2357 Chester Blvd.

Richmond, IN 47374

Sierra Nevada Job Corps

14179 Mt. Charleston St.

Reno, NV 89506

Membership Counts

Member Grades	As of 3/01/09
Sustaining.....	517
Supporting.....	314
Educational.....	491
Affiliate.....	473
Welding distributor.....	48
Total corporate members.....	1,843
Individual members.....	50,202
Student + transitional members.....	5,384
Total members.....	55,586

SECTION NEWS

District 1

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

BOSTON

DECEMBER 1

Activity: The Section members toured the welding facilities at Plymouth Regional Vocational High School in Plymouth, N.H. **John Morash**, lead instructor of welding technology, conducted the program. The District Educator of the Year Award was presented to **John Morash**. **Geoff Durant** received the District CWI of the Year Award. The school's culinary arts students prepared the four-course dinner for the attendees. **Russ Norris**, District 1 director, attended the event.



Shown at the Boston Section program are (from left) District 1 Director Russ Norris, John Morash, Geoff Durant, and Tom Ferri, vice chairman.

GREEN & WHITE MOUNTAINS

JANUARY 8

Activity: The Section hosted its second annual vendors' night program at River Valley Technical High School in Springfield, Vt. **Rich Fuller**, head instructor, coordinated the event with the help of Lincoln Electric, Miller Electric, Revco Gloves, Smith Cutting Equipment, Steel Max Tools, and Thermadyne Industries representatives. **Jack Paige**, welding department head at Manchester Community College, presented a PowerPoint talk.



Members of the Green & White Mountains Section and guests pose for a group shot.

MAINE

JANUARY 22

Activity: The Section held the initial planning session for the Maine SkillsUSA welding tests. **Joe Champagne**, president and head of training at UA Plumbers and Pipefitters Local #716, conducted the program. Assisting were **Adam Fallon** from Lincoln Electric, **Paul Rice** from Maine Oxy, **John Ware** and **John Napolitano** from Local #716, and District 1 Director **Russ Norris** from Airgas. The meeting was held in Augusta, Maine.



Shown at the Maine Section January 22 meeting are (from left) Adam Fallon, Paul Rice, District 1 Director Russ Norris, Joe Champagne, John Ware, and John Napolitano.

JANUARY 29

Activity: **Mark Legel**, welding department head at Southern Maine C.C., hosted the Maine Section's fifth annual vendors' night program in South Portland, Maine. Assisting were **Chris Mas-eychik**, CWI and welding department



Shown January 29 at the Maine Section vendors' night program are (from left) Chris Mas-eychik, Pat Kein, Mark Legel, and Kevin Conley.



Shown at the Feb. 12 Maine Section meeting are (front, from left) Phil Mee, Fran Piccirillo, Paul Rice, and Joe Champagne; (back, from left) Art Gallant, District 1 Director Russ Norris, speaker John Napolitano, Scott Lee, Adam Fallon, and Erik Miskin.



Shown at the New Jersey Section meeting are (from left) Chair Seann Bradley, Treasurer Al Fleury, and Gus Manz, during the presentation of The Well-Grounded Member Award.



Working the Philadelphia Section welding contest were instructors (from left) Doug Bonner, Jim Rynex, Jay Lloyd, Mel McCullum, Jack McDade, Rich Schmidt, Dan Roskiewich, and Rick Zadroga.



Judging the Philadelphia Section welding contest were (from left) Tom Brown, Pat Thomashefsky, and Jim Korchowsky.



Speaker Greg Slavin (left) is shown with Seann Bradley, New Jersey Section chair.

chairman at Eastern Maine C.C.; **Pat Kein**, CWI and welding department head, U.S. Coast Guard, Portland Group; and **Kevin Conley**, CWI and instructor at Southern Maine C.C.

FEBRUARY 12

Speaker: **John Napolitano**, business agent

Affiliation: UA Local #716

Topic: Maine SkillsUSA testing

Activity: The Maine Section attendees completed plans for the SkillsUSA welding test. Participating were associates from Advantage Gases, Airgas, Maine Oxy, Metso Paper, Quality Assurance Labs, and UA Plumbers and Pipefitters Local #716. The program was held at Bruno's Restaurant in Portland, Maine.

District 2

Kenneth R. Stockton, director

(908) 412-7099

kenneth.stockton@pseg.com

NEW JERSEY

JANUARY 20

Speaker: **Greg Slavin**, vice president

Affiliation: Clean Air Co.

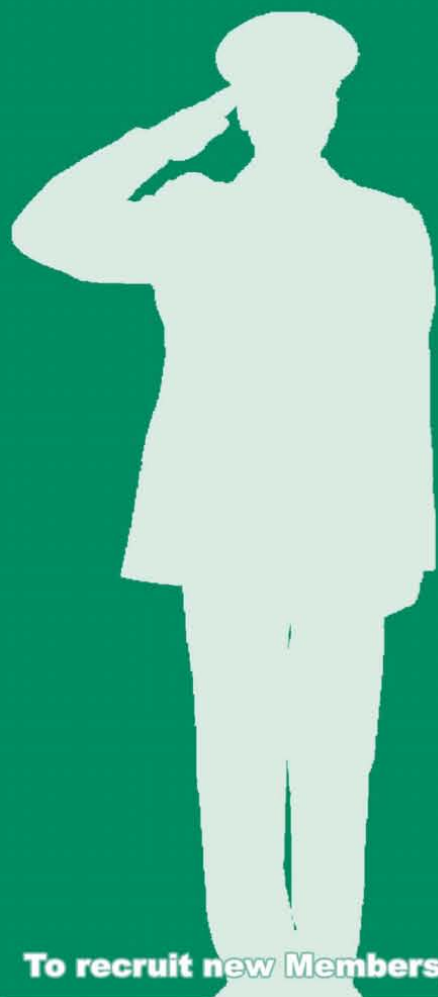
Topic: Welding fume removal

Activity: **August F. (Gus) Manz**, the Section's historian and safety and health expert, received his Gold Membership Certificate for 50 years of service to the Society plus the unique Well-Grounded Member Award for his contributions to furthering welder safety and the importance of proper electrical grounding of welding equipment. The event was held at Pantagis Renaissance Snuffy's Clam-bar in Scotch Plains, N.J.

PHILADELPHIA

FEBRUARY 7

Activity: The Section hosted its annual student welding contest, organized by **Dan Roskiewich**, education chairman.



AWS IS ON A MISSION

Win Great Prizes in the **2007-2008 AWS Member-Get-A-Member Campaign***

MISSION: 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 2007-2008 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 American Welder™ camouflage hat and an AWS key chain.

President's Roundtable: Recruit 9-19 new Individual Members and receive an American Welder™ camouflage t-shirt, hat and an AWS key chain.

President's Guild: Recruit 20 or more new Individual Members and receive a Timex camouflage watch, an American Welder™ camouflage hat, 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 2008).

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 2008 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 American Welder™ camouflage t-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 2007, as well as in February and June 2008.

Prizes Include:

- ★ Complimentary AWS Membership renewal
- ★ American Welder™ camouflage t-shirt
- ★ American Welder™ camouflage hat

SUPER SECTION CHALLENGE

The AWS Section in each District that achieves the highest net percentage increase in new Individual Members before the June 2008 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 2007-2008 MGM Campaign runs from June 1, 2007 to May 31, 2008. Prizes are awarded at the close of the campaign.



American Welding Society

Visit www.aws.org

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

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

AWS MEMBERSHIP APPLICATION

4 Easy Ways to Join or Renew:

- ✉ Mail this form, along with your payment, to AWS
- ☎ Call the Membership Department at (800) 443-9353, ext. 480
- 📠 Fax this completed form to (305) 443-5647
- 💻 Join or renew on our website <www.aws.org/membership>

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

Last Name _____

First Name _____ M.I. _____

Title _____ Birthdate _____

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

Primary Phone () _____ Secondary Phone () _____

FAX () _____ E-Mail _____

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

If "yes," Member's name: _____ Member's # (if known): _____

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

ADDRESS

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

Company (if applicable) _____

Address _____

Address Con't. _____

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

PROFILE DATA

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

- ① Who pays your dues?: ☐ Company ☐ Self-paid ② Sex: ☐ Male ☐ Female
- ③ Education level: ☐ High school diploma ☐ Associate's ☐ Bachelor's ☐ Master's ☐ Doctoral

PAYMENT INFORMATION (Required)

ONE-YEAR AWS INDIVIDUAL MEMBERSHIP\$80
TWO-YEAR AWS INDIVIDUAL MEMBERSHIP†~~\$160~~ \$135



New Member? ☐ Yes ☐ No

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

Domestic Members add \$25 for book selection (\$192 value), and save up to 87%†.....\$ _____ (Optional)
International Members add \$75 for book selection (note: \$50 is for international shipping) ††..\$ _____ (Optional)
(Note: Book Selection applies to new Individual Members only – Book selections on upper-right corner)

TOTAL PAYMENT\$ _____

AWS STUDENT MEMBERSHIP†††

☐ Domestic (Canada & Mexico incl.).....\$15
☐ International\$50
TOTAL PAYMENT.....\$ _____

NOTE: Dues include \$18.70 for *Welding Journal* subscription and \$4.00 for the AWS Foundation.
\$4.00 of membership dues goes to support the AWS Foundation.

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

- ☐ Check ☐ Money Order ☐ Bill Me
☐ American Express ☐ Diners Club ☐ Carte Blanche ☐ MasterCard ☐ Visa ☐ Discover ☐ Other

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

Signature of Applicant: _____ Application Date: _____

Office Use Only
Source Code **WJ** Check # _____ Date _____ Account # _____ Amount _____



American Welding Society

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

Member Services Revised 5/4/06

†Two-year Individual Membership Special Offer: applies only to new AWS Individual Members. ††Discount Publication Offer: applies only to new AWS Individual Members. Select one of the four listed publications for an additional \$25; International Members add \$75 (\$25 for book selection and \$50 for international shipping); Multi-Year Discount: First year is \$80, each additional year is \$75. No limit on years (not available to Student Members). †††Student Member: Any individual who attends a recognized college, university, technical, vocational school or high school is eligible. Domestic Members are those students residing in North America (incl. Canada & Mexico). This membership includes the *Welding Journal* magazine. Student Memberships do not include a discounted publication. **Airmail Postage Option:** International Members may receive their magazines via Airmail by adding \$99 to the annual dues amount.

BOOK/CD-ROM SELECTION

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

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

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

☐ **New Member** ☐ **Renewal**

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

Type of Business (Check ONE only)

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

Job Classification (Check ONE only)

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

Technical Interests (Check all that apply)

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



The 21 students participating at the Philadelphia Section welding contest pose for a group shot.

Twenty-one students and their instructors representing eight schools participated. The students taking top honors were **Matthew DeGeralamo**, **Justin Wigglesworth**, and **Anu Abdul-Whid**. The welding instructors included **Dan Roskiewich**, **Jim Rynex**, **Rick Zadroga**, **Doug Bonner**, **Mel McCullum**, **Jack McDade**, **Jay Lloyd**, and **Rich Schmidt**. The welding contest judges included past chairmen **Jim Korchowsky** and **Pat Tomashefsky**, and **Tom Brown** from Iron Workers Union Local #399. The event was held at Gloucester County Institute of Technology in Sewell, N.J.



Shown during the South Carolina Section tour are (from left) Ben Magrone, vice chair; Chairman Gale Mole; and presenter Josh Ingram.

FEBRUARY 11

Speaker: **Robert Murray**

Affiliation: Divers Academy International

Topic: The variety of career opportunities in commercial diving

Activity: This Philadelphia Section program was held at Villari's Lakeside Inn in Gloucester Township, N.J.

District 3

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(610) 820-9551
mike@welderinstitute.com

District 4

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

District 5

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

SOUTH CAROLINA

JANUARY 29

Activity: The Section members toured Brackett and Cochran Mfg. Co. in Goose Creek, S.C., to study its manufacturing of aircraft parts, relays, molded plastic



Speaker Robert Murray (right) is shown with Gary Atherton, Philadelphia Section chair, at the Feb. 11 meeting.



Underwater welder Kevin Peters (right) is shown with Gilly Burrion, South Florida Section chairman.



Kevin Peters details the fine art of underwater welding for South Florida Section members.



Colonel Richard Graham discussed the SR71 Blackbird's unique features and history for Columbus Section and other area technical societies.

products, hospital beds, and custom machinery. **Josh Ingram**, CNC production manager, conducted the program.

SOUTH FLORIDA

JANUARY 22

Speaker: **Kevin Peters**

Affiliation: Miami Diver Inc.

Topic: Underwater welding procedures

Activity: Following the talk, about 60 members and welding students toured the facility in Miami, Fla.

District 6

Kenneth Phy, director

(315) 218-5297

k.phy@holtec.com

NORTHERN NEW YORK

FEBRUARY 17

Speakers: **Lyle Spiegel**, engineer, GE Energy; and **Marshall Jones**, principal engineer, GE Global Research

Topic: Laser welding technology — Where it came from and where it is headed

Activity: This was a joint meeting with members of the local chapter of ASM International. The program was held at Mill Road Restaurant & Tavern in Latham, N.Y., for 50 attendees.

District 7

Don Howard, director

(814) 269-2895

howard@ctc.com

COLUMBUS

FEBRUARY 11

Speaker: **Richard Graham**, colonel

Affiliation: USAF, ret.

Topic: The SR71 Blackbird

Activity: More than 100 members of var-

ious Columbus area technical societies met at Buckeye Hall of Fame for this lecture about the recently declassified stealth aircraft.

DAYTON

FEBRUARY 16

Activity: This spouses' night wine tasting and wine auction fund-raising event was jointly sponsored by the Section and members of the Dayton Chapter of ASM International and the American Foundry Society, Southwestern Ohio Chapter. The proceeds went to fund student scholarships.

PITTSBURGH

DECEMBER 5

Activity: The Section members hosted their students' day weld-off at the Boilermakers Training Center in Pittsburgh, Pa., organized by **John Foly**, training coordinator at the facility.

Triangle Tech DuBois Campus Student Chapter

SEPTEMBER 18

Activity: The Student Chapter, affiliated with the Johnstown-Altoona Section, held an open house featuring **Melvin Coe**, a Triangle Tech graduate and a welder and blacksmith with Swartfager Welding Inc. The students had the opportunity to learn about metals, basic tools, and participate in hands-on exercises in welding and blacksmithing projects. **Brenda Benyon** is the Student Chapter advisor.

DECEMBER

Activity: The Triangle Tech, DuBois Campus, Student Chapter conducted a month-long drive to collect Christmas toys to donate to the local Toys for Tots Foundation.



Franklin Turner detailed for the Chattanooga Section members in January how his company makes E7018 electrodes.

FEBRUARY 5

Activity: The Triangle Tech, DuBois Campus, Student Chapter held a pizza and wing luncheon to honor its graduating members. The prizes were provided by Valley National Gases.

District 8

Joe Livesay, director

(931) 484-7502, ext. 143

joe.livesay@ttcc.edu

CHATTANOOGA

JANUARY 20

Speaker: **Franklin Turner**, QA manager

Affiliation: Electrode Engineering, partner

Topic: The chemistry and manufacture of E7018 electrodes

Activity: The program was held at Alstrom Power in Chattanooga, Tenn.

FEBRUARY 17

Speaker: **Jeff Defalco**, business manager

Affiliation: ESAB Welding & Cutting Products, Welding Automation

Topic: Friction stir welding of steel

Activity: The program was held at Komatsu America International in Chattanooga, Tenn.

NE MISSISSIPPI

JANUARY 22

Activity: The Section members toured the Babcock and Wilcox facility in West Point, Miss., to study the fabrication of boiler assemblies for the power-generation industry. **Jerry Eaton**, night shift foreman, conducted the program.

District 9

George D. Fairbanks Jr., director

(225) 473-6362

fits@bellsouth.net



Jeff Defalco discussed friction stir welding of steel for Chattanooga Section members at the February program.



Chattanooga Section members learned about friction stir welding at the February program.



Don DeCorte (right) receives the District Meritorious Award from Eftihios Siradakis, District 11 director, at the Detroit Section program.

NEW ORLEANS

JANUARY 20

Speaker: **Mike Davis**

Affiliation: Airgas Southwest

Topic: Gas cylinder safety

Activity: The Section presented its sponsor-apreciation award to Airgas Southwest for its continued support. Accepting the plaque were **Mike Davis**, **Sean Hargis**, **Wil Adams**, and **Chris Petaroria**. District 9 Director **George Fairbanks** welcomed the 86 attendees to the Section's first program of the year. **Chris Fernandez** received the Section's fourth annual Welding Instructor Award.

District 10

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

District 11

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



Airgas Southwest representatives accept a sponsor-appreciation award at the New Orleans Section program. Shown (from left) are Vice Chairman **Donald Berger**, speaker **Mike Davis**, **Sean Hargis**, **Wil Adams**, **Chris Petaroria**, Chairman **Matt Howerton**, and District 9 Director **George Fairbanks**.



Shown at the Detroit Section program are (from left) District 11 Director **Eftihios Siradakis**, **Jeff Weber**, **Richard DuCharme**, and **Phil Temple**.

DETROIT

FEBRUARY 13

Activity: The Section hosted its 69th annual ladies' night celebration at Athenum International Banquet Center in Detroit, Mich. The funds raised from the evening are used to support the Section's scholarship program. Since its inception, the Section has awarded more than \$750,000 in scholarships for students pursuing careers in welding. **Richard C. DuCharme** was recognized for his service as chairman of the Welding Handbook Volume 3 Committee. The District Meritorious Award was presented to **Donald B. DeCorte** of RoMan Manufac-



New Orleans Section Chair **Matt Howerton** (left) and **Tony DeMarco** (right) present **Chris Fernandez** his welding instructor award.



Attending the Madison/Beloit board meeting were (from left) Chair Ben Newcomb, Bill Dawson, District 12 Director Sean Moran, Dan Gibbs, and Dave Diljak.



Madison/Beloit Section members are shown at the January program.



Shown at the Milwaukee Section program are (from left) Chair Gerald Blaski, Gail Beyer II, Craig Wentzel, Robert Schuster, Michael Kersey, John Albanese, John Kozeniecki, and Joseph E. Campbell.



Shown at the Milwaukee January program are (from left) John Albanese, Chuck Gaspar, Gwen Izewski, Christopher Albanese, and Garry Toddish.

turing and an AWS director-at-large. Attending this Detroit Section event were **Eftihios Siradakis**, District 11 director; **Jeff Weber**, AWS senior associate executive director; and **Phil Temple**, Welding Handbook Committee chairman.

District 12

Sean P. Moran, director
(920) 954-3828

sean.moran@hobartbrothers.com

MADISON-BELOIT

JANUARY 14

Activity: The Section held an executive board meeting at Erin's Snug Irish Pub in Madison, Wis. Attending were **Ben Newcomb**, chair; **Bill Dawson**, treasurer; District 12 Director **Sean Moran**; **Dan Gibbs**, publicity; **Dave Diljak**, secretary; **Jim Pfeil**, membership; and **Rob Stinson**, member-at-large.

JANUARY 21

Speakers: **Phil Fish**, **Lonnie Anderson**, and **Bill Hardey**

Affiliation: Fish & Associates

Topic: Requirements for the design, building, and inspection of bridges

Activity: The Madison/Beloit Section held its new members' night program at Coliseum Bar & Grill in Madison, Wis. New members **Dale Krasemann** and **Randy Way** were introduced.

MILWAUKEE

DECEMBER 11

Activity: This past chairmen's night program and holiday party included a tour of Sprecher Brewery in Milwaukee, Wis. Past chairs in attendance included **John Albanese**, **Joe Campbell**, **John Hinrichs**, **Mike Kersey**, and **Craig Wentzel**.

JANUARY 22

Activity: The Section hosted a vendors' expo and hands-on night program at Waukesha County Technical College. Participants included Advanced Welding Supply, Airgas, Computer Weld Technology, Eutectic, Kru Mar, Lincoln Electric, Machinery and Welder, Miller Electric, Norton, Phoenix Int'l, Pferd, Robovent, United Abrasives, and Walter Products.

RACINE-KENOSHA

FEBRUARY 13

Speaker: **Victor Y. Matthews**, AWS president

Affiliation: The Lincoln Electric Co.

Activity: The Section toured the John Deere manufacturing facility in Horicon, Wis. Vice Chair **Kenneth Karwowski** received the CWI of the Year Award from District 12 Director **Sean Moran**.



Shown at the Chicago Section board meeting in January are (from left) Jeff Stanczak, Eric Krauss, Chuck and Ida Hubbard, Marty and Rita Vondra, Kim and Craig Tichelar, Hank and Vern Sima, and Anghelina and Cliff Iftimie.



Ken Karwowski (right) receives his CWI award from Sean Moran, District 12 director, at the Racine-Kenosha Section program.



Shown at the Racine-Kenosha Section program are (from left) Ken Karwowski, AWS President Victor Matthews, and Chairman Daniel Crifase.

District 13

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

CHICAGO

JANUARY 14

Activity: The Section held its board meeting at The Flame Restaurant in Chicago, Ill.

FEBRUARY 6

Activity: The Chicago Section members held their Valentine's program and dinner at the Party Barn in Chicago, Ill., for 30 attendees. The group also visited the Arabian Knights Farm in Willowbrook, Ill.

FEBRUARY 11

Activity: The Chicago Section held a board meeting at Bohemian Crystal Restaurant.



Working the Milwaukee Section vendors' expo were (from left) Daniel Crifase, Jon Taylor, and Paul Fischer.



Shown at the Chicago Section Feb. 6 program are (from left) Craig Tichelar, Hank Sima, Chuck Hubbard, Cliff Iftimie, Jim Greer, Pete Harris, and Eric Krauss.

District 14

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



Shown at the Chicago Section Feb. 11 board meeting are (from left) Craig Tichelar, Cliff Ifimie, Hank Sima, Pete Host, and Erik Krauss.



Mike Anderson discussed updates to the SENSE entry-level welder training program for the Indiana Section members.



Shown at the Arrowhead Section program are (from left) Chair Tom Baldwin, AWS President Victor Matthews, and Loren Kantola, vice chair.



Shown at the Northwest Section program are (from left) Chairman Todd Bridigum, Randy Anderson, District 15 Director Mace Harris, and Pam Lesemann.



John Penaz (center) receives his Silver Membership Certificate Award from District 15 Director Mace Harris (left), and AWS President Victor Matthews at the Northwest Section program in January.

INDIANA

JANUARY 22

Speaker: **Mike Anderson**, welding instructor, Section education chairman

Affiliation: New Castle Area Career Programs

Topic: Update on the SENSE program
Activity: The attendees participated in a question-and-answer session based on the changes to the SENSE entry-level welder training program. The meeting was held at Sutton-Garten Co. in Indianapolis, Ind.

LEXINGTON

JANUARY 24

District 15

Mace V. Harris, director

(612) 861-3870

macevh@aol.com

ARROWHEAD

JANUARY 20

Speaker: **Victor Matthews**, AWS president

Affiliation: The Lincoln Electric Co.

Topic: Welding history, education, and its importance in industry

Activity: The program was held at Mesabi Range College in Eveleth, Minn.

NORTHWEST

JANUARY 21

Speaker: **Victor Matthews**, AWS president

Affiliation: The Lincoln Electric Co.

Topic: The need for welders

Activity: The Section hosted its past chairmen's night in Shoreview, Minn. District 15 Director **Mace Harris** presented **John Penaz** the Silver Membership Certificate Award for 25 years of service to the Society. **Randy Anderson** and **Pam Lesemann** of Oxygen Service Co. were presented an appreciation plaque for their company's continued support of the Section's scholarship fund.

SASKATOON

DECEMBER 4



Des Moines High School Student Chapter members pose during their tour of Vermeer Corp. in February.



Iowa Section members pose during their January tour of Johnson Machine Works. Presenter Kelley Werts is at the far left.

Speaker: **Reza Moazed**, PhD candidate
Affiliation: University of Saskatchewan
Topic: Strength of welded square hollow section (SHS) to SHS thin-walled tubular connections
Activity: This Saskatoon Section program was held at the University of Saskatchewan, Saskatoon, SK, Canada.

District 16

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

Des Moines High School Student Chapter

FEBRUARY 10

Activity: Advisor **Ralph Young** took his Student Chapter members to Vermeer Corp. in Pella, Iowa, for a tour of its agricultural equipment manufacturing facilities and to see its 220 welders at work. The students had an opportunity to use their skills with a welding simulator. The presenters included **Don Landon**, **Karissa Hastings**, **Robert Larsen**, and **David Elsloo**. The speakers' topics emphasized the importance of safety, productivity, training, and blueprint reading.

IOWA

JANUARY 20

Activity: The Section members toured Johnson Machine Works in Chariton, Iowa, to study the company's methods for making large weldments for bridges,



Joe Gray demonstrated X-ray equipment for the Iowa Section and ASM Int'l members in February.

buildings, and taintor gates for dams. The tour was led by **Kelley Werts**, engineer and project manager.

FEBRUARY 17

Activity: The Iowa Section joined with the Central Iowa Chapter of ASM Int'l for a tour of the Iowa State University Applied Science Complex II in Ames, Iowa. **R. Bruce Thompson**, director, Center for Nondestructive Evaluation (CNDE), presented an overview of the facility with assistance from **Joe Gray**. Featured were demonstrations of eddy current and ultrasound testing of aluminum stir welded joints, and CT X-ray testing. **Paul Berge** coordinated the program including the dinner catered by Hickory Park Restaurant.

NEBRASKA

JANUARY 24



Shown at the Saskatoon Section program are (from left) Ike Oguocha, speaker Reza Moazed, and Srinu Sethuraman.

Activity: The Section hosted its third annual bowling event in Omaha, Neb. The fund-raising event included a silent auction, food, and door prizes. Twenty teams competed this year with six lane sponsors: Davis Erection Co., Ironworkers Local #21, Linweld, Olsson Associates, and Praxair. Secondary school Section schol-



Nebraska Section officers shown at the bowling event are (front row, from left) Eric Nordhues and Nick Weidenbach; (standing, from left) Rick Hanny, Monty Rodgers, Terry Gildon, Karl Fogleman, and Jason Hill.



Top winners in the Nebraska Section bowling event were Lori and Aaron Rodgers.



Speaker Chris Barrett (left) is shown with Rob Tessier, North Texas Section chair.



Shown at the Central Arkansas Section program are (from left) John Reed, speaker Phillip Wallace, and Chairman Dennis Pickering.



Rob Tessier (right in both photos), North Texas Section chairman, is shown with scholarship winners Douglas Lawhon (left) and David Page.



arships for \$250 each were presented to **Tyler Seals** and **Benjamin McClelland**. The \$1000 postsecondary scholarship was awarded to **Kelsy Orendach**. **Lori** and **Aaron Rodgers**, who won the tournament, donated their prize money to the Section scholarship fund. The participating officers were **Eric Nordhues**, membership; **Nick Weidenbach**, secretary; **Rick Hanny**, treasurer; **Monty Rodgers**, scholarship and technical representative; **Terry Gildon**, photographer; **Karl Fogleman**, chairman; **Jason Hill**, vice chair; and **Josh Mayne**, awards chairman.

District 17

J. J. Jones, director

(940) 368-3130

jjones@thermadyne.com

CENTRAL ARKANSAS

JANUARY 22

Speaker: **Phillip W. Wallace**, business agent

Affiliation: Pipeliners Union #798

Topic: Details of the oil pipelines in Arkansas

Activity: The program was held at Doc's Grill in Searcy, Ark.

NORTH TEXAS

JANUARY 20

Speaker: **Chris Barrett**

Affiliation: The Lincoln Electric Co.

Topic: Submerged arc welding, its present and future applications

Activity: The program was held for about 60 attendees at Humperdinks in Arlington, Tex.

FEBRUARY 17

Speaker: **Victor Matthews**, AWS president

Affiliation: The Lincoln Electric Co.

Topic: New technologies in welding equipment

Activity: Welding students **David Page** and **Douglas Lawhon** were presented \$500 scholarships by Chairman **Rob Tessier**. The program, held at Humperdinks in Arlington, Tex., attracted 108 attendees.

District 18

John Bray, director

(281) 997-7273

sales@affiliatedmachinery.com

HOUSTON

FEBRUARY 18

Activity: This students' night event was held at Brady's Landing in Houston, Tex. **Dan Allford**, president of ARC Specialties, and **Aldo Cruz**, Bellaire Robotics Team president, made presentations.



AWS President Victor Matthews (left) displays the speaker gift presented by Rob Tessier, North Texas Section chairman.



Speaker Rob Third (left) is shown with Al Sumal, British Columbia Section technical representative.

SAN ANTONIO

FEBRUARY 10

Speaker: **John L. Mendoza**, AWS vice president

Affiliation: CPS Energy, training and development analyst

Topic: Training of welding professionals for the power industry

Activity: The meeting was held at the Spaghetti Warehouse in San Antonio, Tex.



Shown at the Houston Section students' night program are (from left) Kevin Sevcik, Aldo Cruz, Lawrence Chen, Olivia Arena, Kristin Rice, Jared Hernandez, and Joe Sherwood.



San Antonio Section members are shown at the February meeting.



British Columbia Section members learn about Dynamic Structures operations in January.

District 19

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

BRITISH COLUMBIA

JANUARY 22

Activity: The Section members toured Dynamic Structures in Port Coquitlam, B.C., Canada, led by **Rob Third**, vice president, and president and COO of George Third & Son. Dynamic Structures is the fabricator of the Coast Meridian Overpass Project. Third discussed the work of the two companies then led a tour of the facility showing the heavy box-girder constructions used in the Overpass Project.



Shown at the Olympic Section program are (from left) Chairman Bob Plummer, speaker J. Dwight, and Rich Huston, an instructor at Bates Technical College.



Shown at the joint Colorado Section and ASNT program are presenters Colorado Section Chair James Corbin and Robbie Gall with ASNT Program Chair Ward Rummel.



The Colorado School of Mines Student Chapter members pose for a group shot during their tour of Northwest Pipe Co.



Shown at the Puget Sound program are (from left) speaker Paul Stone with Ken Johnson, vice chairman.



Rick Henson (right) receives the District Meritorious Award from Neil Shannon, District 19 director, at the Spokane Section meeting.

OLYMPIC

JANUARY 27

Speaker: **J. Dwight**, owner

Affiliation: Dwight Co., Inc.

Topic: Precision flame bending

Activity: Following the presentation, the 120 attendees studied a flame bending demonstration performed on an I-beam. The program was held at Bates Technical College in Tacoma, Wash.

PUGET SOUND

JANUARY 8

Speaker: **Paul Stone**, territory sales manager

Affiliation: ESAB Welding and Cutting

Topic: Oxyfuel welding, cutting, and heating applications and safety pointers

Activity: The program was held at Rock Salt Steak House in Seattle, Wash.

SPOKANE

FEBRUARY 18

Activity: The Section held its ladies' night program at Luigi's Restaurant in Spokane, Wash. District 19 Director **Neil Shannon** presented an overview of AWS then presented the District Meritorious Award to **Rick Henson**, sales manager with Oxarc, Inc., and the Dalton E. Hamilton Memorial District CWI of the

Year Award to **Phil Zammit**, QA manager with Brooklyn Iron Works, Inc. **Charlie Schmidt**, a local artist, presented a motivational talk.

District 20

William A. Komlos, director

(801) 560-2353

bkoz@arctechllc.com

COLORADO

JANUARY 8

Speakers: **Robbie Gall**, VP, NDE Services; and Section Chair **James Corbin**, director, quality and training, Steelstar Corp.

Topics: Gall presented insights on how the AWS D1.1 code refers to ASNT for NDE certifications and procedures; Corbin discussed inspector qualifications and the list of duties they must be qualified to perform as listed in AWS D1.1:2008, Clause 6.

Activity: The talks were followed by a question-and-answer session. This joint meeting with the local ASNT chapter was coordinated by ASNT Program Chair **Ward Rummel**. The event was held at Las Brisas Restaurant in Englewood, Colo.

Colorado School of Mines Student Chapter

DECEMBER

Activities: Advisor **Stephen Liu** led his Student Chapter members on tours of two industries during December. They visited Eaton Metal Products to watch pressure vessel fabrication, hosted by **Charles Hamre**, engineering manager. The Chapter members also visited Northwest Pipe Co. to study its pipe welding processes, described to them by **Dan Bingham**, engineering manager.

UTAH

JANUARY 21

Activity: The Section sponsored a special inspection seminar for 52 attendees in St. George, Utah, hosted by **Dick Simkins** of the St. George Dept. of Building Safety and presented by District 20 Director **William Komlos** of Arc Tech, LLC. The program provided insight on the issues of special inspection in accordance with the IBC Section 1704 requirements. **Ed Molitoris**, special inspector for the Clark County Dept. of Building Safety, spoke on the need for qualified inspectors and presented examples where inadequate inspection proved to be costly mistakes. Co-hosting the event were DJB Gas Services, **Ken Rivera**; Airgas Supply, **Marvin Jones**; Lincoln Electric, **Tony Noah**; S & S Steel Fabricators, **Jeff Staples**; and SME Steel Inc., **Woody Cook**.



The Colorado School of Mines Student Chapter members toured Eaton Metal Products in December.



District 20 Director William Komlos presented an inspection seminar for the Utah Section.



Blacksmithing students in the Arizona Western College Student Chapter are (standing, from left) Nathan Lipp, Becky Canada, Travis McCullum, Alexander Cordero-Torres, Tyler Rudkin, Miguel Pulido, Gloria Hampson, and Walter Francher; (front, from left) Prof. Shannon Aranmór, Troy Baughtman, and Filomeno Muñoz.



Dick Simkins (right) hosted the Utah Section inspection seminar; Ed Molitoris discussed the need for qualified inspectors.



San Francisco Section Chair Liisa Pine is shown with guest speaker Tyson Hickey.

District 21

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

Arizona Western College Student Chapter

JANUARY 30–FEBRUARY 1

Activity: Advisor Prof. **Samuel Colton Sr.** and Profs. **Shannon Aranmór** and **Miguel Pulido** worked with their welding students and blacksmithing class members to display their talents and interface with the public at the annual three-day Two Rivers Renaissance Faire in Yuma, Ariz. Each student had the opportunity to tell visitors about the college welding program and how welding has improved their job prospects, display photographs of class projects, and demonstrate various forgings of camp irons, decorative roses, fire pokers, and general metal-forming projects.

KERN

JANUARY 15

Activity: The Section members visited Bakersfield College, Bakersfield, Calif., for a tour of its modernized welding facility featuring 42 welding booths with state-of-the-art ventilation system. **Mike Komin**, welding instructor, led the tour.

L.A./INLAND EMPIRE LATTC Student Chapter

DECEMBER 3

Speaker: Chairman **George T. Rolla**
Affiliation: Advanced Weldtec, Inc., president
Topic: Changes in the new D1.1:2008, *Structural Welding Code — Steel*
Activity: Short talks were presented about JV Industrial Companies products and services by **Ralph Worsham** and **Tony Barraza**. Worsham is senior quality control specialist western division, and Barraza is western division quality systems

manager for JVIC. The program, held at Los Angeles Trade Technical College (LATTC), included a dinner prepared by the college's culinary arts students. **Alvaro Aguirre** won the top raffle prize, a D1.1:2008 code book.

District 22

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

SAN FRANCISCO

FEBRUARY 4

Speaker: **Tyson Hickey**, western regional manager
Affiliation: Welding Services, Inc.
Topic: Engineered solutions for complex challenges
Activity: About 55 members and guests attended this program, held at Spenger's Restaurant in Berkeley, Calif.



Shown at the Kern Section tour are (from left) presenter Mike Komin, Membership Chair Mike Gaetz, Treasurer Bobby Morgan, District 21 Director Nanette Samanich, Chair Dave Ebenhoe, and Ted Balestino, vice chair.



The LATTC Student Chapter members are shown with Los Angeles/Inland Empire Section officers at the December program.



Shown at the three-day Two Rivers Renaissance Faire are Arizona Western College Student Chapter members (from left) Miguel Pulido, Ed Garcia, Chair Alexis Favella, Prof. Shannon Aranmór, Shawn Hayden, Advisor Samuel Colton, Steven Seale, and Kevin Estrada.



Los Angeles/Inland Empire Section Chair George Rolla (left) and Vice Chair Tony Barraza (right) pose with D1.1 raffle prize winner Alvaro Aguirre.



Chile International Section Chair Mauricio Ibarra Echererria (third from right) participated in the INNOVA project meeting in Santiago de Chile.

International Section

CHILE

JANUARY 20

Activity: Section Chairman **Mauricio Ibarra Echererria** participated in the welding group formed by INNOVA project within The National Institute of Standardization in an effort to introduce welding standards for use in Chile. The meetings were held in Santiago de Chile.

Guide to AWS Services

American Welding Society
550 NW LeJeune Rd., Miami, FL 33126
www.aws.org; (800/305) 443-9353; FAX (305) 443-7559
(Staff telephone extensions are shown in parentheses.)

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CONVENTION and EXPOSITIONS

Senior Associate Executive Director
Jeff Weber.. jweber@aws.org(246)

Corporate Director, Exhibition Sales
Joe Krall.. jkrall@aws.org(297)
Organizes the annual AWS Welding Show and Convention, regulates space assignments, registration items, and other Expo activities.

Brazing and Soldering Manufacturers' Committee

Jeff Weber.. jweber@aws.org(246)

RWMA — Resistance Welding Manufacturing Alliance

Manager
Susan Hopkins.. susan@aws.org(295)

WEMCO — Welding Equipment Manufacturers Committee

Manager
Natalie Tapley.. tapley@aws.org(444)

PUBLICATION SERVICES

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Society and Section News Editor

Howard Woodward.. woodward@aws.org .(244)

Welding Handbook

Welding Handbook Editor
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Publishes the Society's monthly magazine, *Welding Journal*, which provides information on the state of the welding industry, its technology, and Society activities. Publishes *Inspection Trends*, the *Welding Handbook*, and books on general welding subjects.

MARKETING COMMUNICATIONS

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Webmaster
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Managing Director, Technical Operations
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Director, Int'l Business & Certification Programs
Priti Jain.. pjain@aws.org(258)
Directs all int'l business and certification programs. Is responsible for oversight of all agencies handling AWS certification programs.

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Director, Education Services Administration and Convention Operations
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AWS AWARDS, FELLOWS, COUNSELORS

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Director, National Standards Activities
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Personnel and Facilities Qualification, Computerization of Welding Information

Manager, Safety and Health
Stephen P. Hedrick.. steveh@aws.org (305)
Metric Practice, Safety and Health, Joining of Plastics and Composites, Welding Iron Castings

Technical Publications
AWS publishes about 200 documents widely used throughout the welding industry.

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Staff Engineers/Standards Program Managers
Annette Alonso.. aalonso@aws.org(299)
Automotive Welding, Resistance Welding, Oxygen Fuel Gas Welding and Cutting, Definitions and Symbols, Sheet Metal Welding

Stephen Borrero.. sborrero@aws.org(334)
Joining of Metals and Alloys, Brazing and Soldering, Brazing Filler Metals and Fluxes, Brazing Handbook, Soldering Handbook

Rakesh Gupta.. gupta@aws.org(301)
Filler Metals and Allied Materials, Int'l Filler Metals, Instrumentation for Welding, UNS Numbers Assignment

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Methods of Inspection, Mechanical Testing of Welds, Welding in Marine Construction, Piping and Tubing

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

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

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

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

Nominees for National Office

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

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

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

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

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

Treasurer: To be eligible to hold the

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

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

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

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

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

Honorary Meritorious Awards

The Honorary Meritorious Awards Committee makes recommendations for the nominees presented to receive the Honorary Membership, National Meritorious Certificate, William Irrgang Memorial, and the George E. Willis Awards. These honors are presented during the FABTECH International & AWS

Welding Show held each fall. The deadline for submissions is December 31 prior to the year of the awards presentations. Send candidate materials to Wendy Sue Reeve, secretary, Honorary Meritorious Awards Committee, wreeve@aws.org; 550 NW LeJeune Rd., Miami, FL 33126. Descriptions of these awards follow.

William Irrgang Memorial Award

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

George E. Willis Award

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

Honorary Membership Award

The honor is presented to a person of acknowledged eminence in the welding

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

National Meritorious Certificate Award

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

International Meritorious Certificate Award

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

AWS Publications Sales

Purchase AWS standards, books, and other publications from **World Engineering Xchange (WEX), Ltd.**
orders@awspubs.com; www.awspubs.com
Toll-free (888) 935-3464 (U.S., Canada)
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Welding Journal Reprints

Copies of *Welding Journal* articles may be purchased from Ruben Lara.
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AWS Foundation

AWS Foundation, Inc., is a not-for-profit corporation established to provide support for educational and scientific endeavors of the American Welding Society. Information on gift-giving programs is available upon request.

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AWS Mission Statement

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

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

POSTER ABSTRACT SUBMITTAL
Annual FABTECH International & AWS Welding Show
 Chicago, IL – November 15-18, 2009
 (Complete a separate submittal for each poster.)

Primary Author (Full Name):			
School/Company:			
Mailing Address:			
City:	State/Province:	Zip/Mail Code:	Country:
Email:			
Poster Title (max. 50 characters):			
Poster Subtitle (max. 50 characters):			
Co-Author(s):			
Name (Full Name): Affiliation: Address: City: State/Province: Zip/Mail Code: Country:		Name (Full Name): Affiliation: Address: City: State/Province: Zip/Mail Code: Country:	
Email:		Email:	
Poster Requirements and Selection Criteria: - Only those abstracts submitted on this form will be considered. Follow the guidelines and word limits indicated. Complete this form using MSWord. Submit electronically via email to techpapers@aws.org or print and mail. - Maximum size – 44 inches tall x 30 inches wide. (Vertical format, please). - Must be legible from a distance of 6 feet. A minimum font size of 14 pt. is suggested. - Posters must be submitted to AWS as a single flat printed medium (e.g. laminated print or foam core board mount). - Any technical topic relevant to the welding industry is acceptable (e.g. welding processes & controls, welding procedures, welding design, structural integrity related to welding, weld inspection, welding metallurgy, etc.). - Submittals that are incomplete and that do not satisfy these basic guidelines will not be considered for competition. Posters accepted for competition will be judged based on technical content, clarity of communication, novelty/relevance of the subject & ideas conveyed and overall aesthetic impression.			
Criteria by category as follows:			
(A) Student - Students enrolled in 2 yr. college and/or certificate programs at time of submittal. - Presentation need not represent actual experimental work. Rather, emphasis is placed on demonstrating a clear understanding of technical concepts and subject matter. - Practical application is important and should be demonstrated.		(B) Student - For students enrolled in baccalaureate engineering or engineering technology programs at the time of submittal. - Poster should represent the student's own experimental work. Emphasis is place on demonstrating a clear understanding of technical concepts and subject matter. - Practical application and/or potential relevance to the welding industry is important and should be demonstrated.	
(C) Student - For students enrolled in graduate degree programs in engineering or engineering technology at time of submittal. - Poster should represent the student's own experimental work. Poster must demonstrate technical or scientific concepts. Emphasis is placed on originality and novelty of ideas presented. - Potential relevance to the welding industry is important and should be demonstrated.		(D) Professional - For anyone working in the welding industry or related field. - Poster must demonstrate technical or scientific concepts. Emphasis is placed on original contributions and the novelty of the presentation. - Potential relevance to the welding industry is important and should be demonstrated.	
(E) High School - Junior or Senior high school students enrolled in a welding concentration at the time of submittal. - Presentation should represent technical concepts and application to the welding industry. - Practical application and creativity are important and should be demonstrated.			

Check the category that applies:

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

Poster Title (max. 50 characters):

Poster Subtitle (max. 50 characters):

Abstract:

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

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

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

Return this form, completed on both sides, via email to techpapers@aws.org
MUST BE RECEIVED NO LATER THAN April 3, 2009



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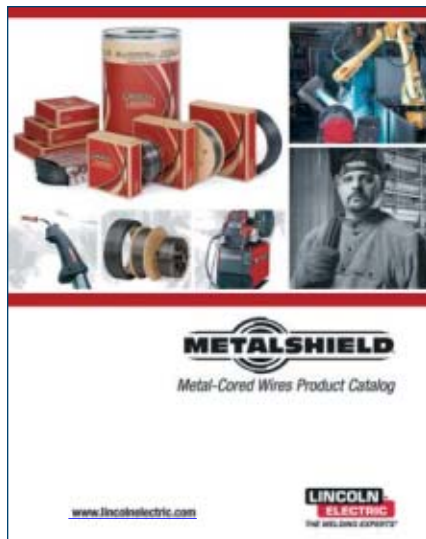


American Welding Society

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LITERATURE

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www.lincolnelectric.com
(888) 355-3213

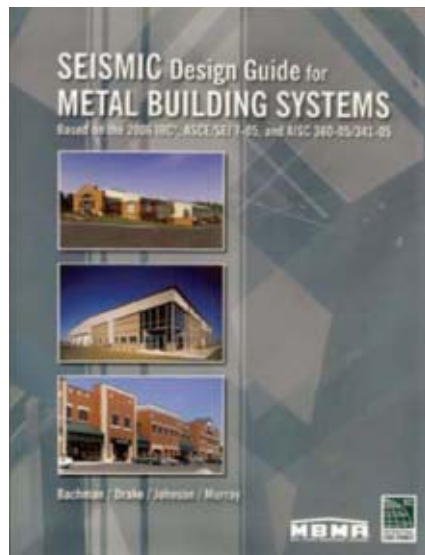
Power Tool Safety Featured on Updated Web Site

The company has launched a new Web site designed to be a user-friendly resource for power tool safety featuring simple navigation, online ordering of free publications, and easy-to-view videos. Downloadable PDFs are available for *Safety Is Specific*, in English or Spanish; and *A Teacher's Reference Guide to Power Tool Safety*, a 24-page brochure featuring lesson plans, student activities, quizzes, support materials, and references. Publications may be ordered in hard copy at no charge from the site. Four safety-related videos, 15 to 25 minutes long, with English or Spanish sound tracks, can be viewed online or ordered as free DVDs.

Other features include manufacturer members' profiles with links to their Web sites; glossary of common power tool terms; PTI voluntary procedures; plus numerous specific topics including corded and cordless drills, screwdrivers, power tool advisories, rechargeable battery recycling, and a checklist of safety maintenance items.

Power Tool Institute, Inc.
www.powertoolinstitute.com
(216) 241-7333

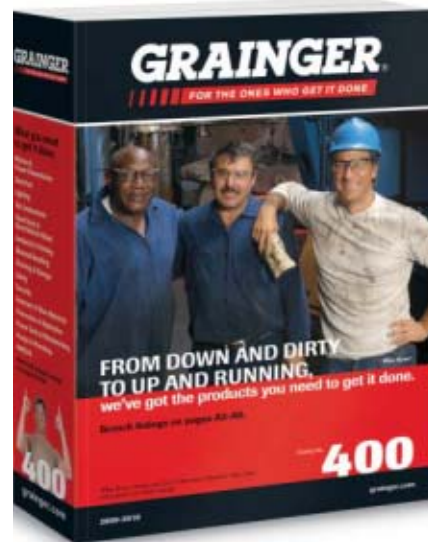
Seismic Design Guide Released



Seismic Design Guide for Metal Building Systems provides step-by-step guidance on the seismic design of metal building systems to meet the specific needs of the building site and soil type. It provides a practical and comprehensive resource to help engineers, building officials, and plan checkers ensure that designs are compliant with the requirements of the 2006 *International Building Code*®. Four practical design examples are provided in narrative form to illustrate the acceptable approaches dealing with the most common seismic design issues encountered with metal building systems. The publication provides background on the technical basis and insight into the impact of the more recent code developments. The 214-page book lists for \$79, \$63 for Council members. Order online or call toll-free.

International Code Council
www.iccsafe.org/seismicmetal2006
(800) 786-4452

Facilities Maintenance Catalog Expanded

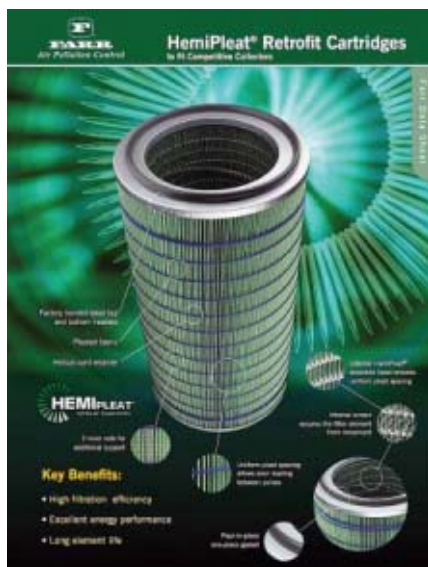


The 3922-page, well-indexed and illustrated 2009 *Grainger 400* catalog of facilities maintenance supplies can be ordered in hard copy online as well as viewed online in PDF. Included are motors, power transmissions, electrical lighting, test instruments, hand tools, fleet vehicle maintenance, janitorial supplies, painting equipment, material handling, shelving and storage, safety, security, fasteners, raw materials, pneumatics, hydraulics, power tools, metalworking items, pumps, plumbing, air-conditioning, ventilation, and heating. This edition features 64,000 new items not listed in last year's catalog including 8000 items in the electrical category, 15,000 metalworking-related products, and 41,000 products in various other categories. Included is contact information for all of the company's local branches. Desired products can be located quickly with the online catalog using the alphabetical drop-down product index menus that sort by manufacturer, brand name, item number, or category.

W. W. Grainger, Inc.
www.grainger.com
(847) 535-1000

Brochure Pictures Retrofit Dust Collector Cartridges

A new four-page, full-color brochure details the company's HemiPleat® line of dust-collection cartridges offering up-



graded performance in retrofit applications. A cross-reference table and ordering chart facilitate selecting the proper filter to replace virtually any type of cylindrical cartridge-style collector. Described is the cartridge's "open pleat" media technology that offers more effective cleaning with better airflow, longer element life, and energy performance. The brochure may be downloaded from the Web site

using the site's search feature or ordered from the toll-free number listed.

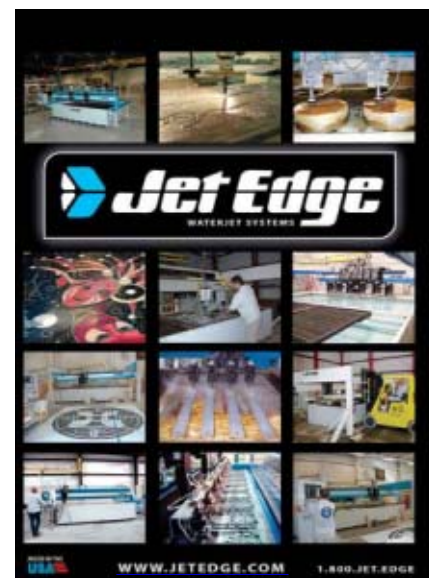
Farr Air Pollution Control
www.farrapc.com
(800) 479-6801

Aluminum Industry Buyer's Guide Updated

The sixth annual *Aluminum Now Buyer's Guide* includes sales contacts, addresses, and company information on more than 150 primary ingot, recycled ingot, and master alloys manufacturers, more than 200 extruders, and 125 companies specializing in drawing stock, bare wire, pigments and powder, forgings and impacts, ACSR and bare cable, and insulated/covered wire and cable. Included are about 200 nonferrous casting foundries, 100 aluminum distributors, and 350 suppliers to the industry ranging from coil coaters to lubricant manufacturers to makers of protective apparel. The guide, priced at \$40, may be ordered from the online bookstore or by phone.

The Aluminum Association
www.aluminum.org
(703) 358-2960

Abrasive Waterjet Systems Illustrated



A six-page, full-color brochure illustrates and describes the company's line of industrial waterjet systems for precision

— continued on page 109

We make companies, small or large, **Stand Out.**

About AWS Corporate Memberships:

The American Welding Society (AWS), understands that one size does not fit all. For that reason, we've created FOUR different levels of corporate membership, starting for as little as \$150 per year, allowing you to select a program that best fits with the way your company operates. With an 88-year history in the welding industry, and 50,000+ members worldwide, AWS Corporate Membership offers your company the ability to **INCREASE ITS EXPOSURE and IMPROVE ITS COMPETITIVE POSITION.**

American Welding Society

Contact Us:

CALL US FOR MORE INFORMATION, OR TO JOIN AT:
(800) 443-9353, EXT. 480, OR (305) 443-9353, EXT. 480.
OR VISIT US ON-LINE AT WWW.AWS.ORG/MEMBERSHIP.

PERSONNEL

Cryogenic Industries Names Managing Director



James Estes

Cryogenic Industries, Murrieta, Calif., has appointed **James Estes** managing director of ACD and the Cryogenic Industries Service Companies. Estes, with the company for 19 years, previously served as vice president of the North American service and repair group. His new position has responsibility for the cryogenic reciprocating and centrifugal pump and turboexpander manufacturing facility and the global service and repair network.

ThyssenKrupp Appoints Engineering Director

ThyssenKrupp Crankshaft Co., Dan-

ville, Ill., has appointed **Cesar Ungaretti** director of sales and product engineering. Ungaretti previously served in the automotive industry in the areas of sales, marketing, and general management, most recently as president of MSSC, a joint venture of ArvinMeritor and Mitsubishi Steel Mfg. based in Detroit, Mich.

CenterLine (Windsor) Signs on Marketing Director



Marc Levesque

Marc Levesque has rejoined CenterLine (Windsor), Windsor, Ont., Canada, as director, corporate marketing. Most recently, Levesque served as director, business development, at Global Vehicle Systems Inc., after serving more than 20 years with CenterLine in various positions, including sales manager.

Techalloy Names VP



Stan Merrick

Central Wire Group, Perth, Ont., Canada, has promoted **Stan Merrick** to vice president of Techalloy Welding Products, a supplier of stainless steel and nickel-alloy welding wires and electrodes. Previously, Merrick served as director of sales for North America.

Laser Institute Officers and Directors Named

Laser Institute of America, Orlando, Fla., has elected **Rajesh Patel** president, **Nathaniel Quick** president-elect, **Andreas Ostendorf** past president, **Klaus Löffler** secretary, and **Stephen Capp** treasurer, for 2009. The 2009–2011 board of directors includes **Milan Brandt**, **Ben Edwards**,



→ HELP FOUND

BETTER CANDIDATES, BETTER RESULTS

AWS JobFind works better than other job sites because it specializes in the materials joining industry. Hire those hard-to-find Certified Welding Inspectors (CWIs), Welders, Engineers, Welding Managers, Consultants and more at www.awsjobfind.com. You'll find more than 2,000 résumés of top job seekers in the industry!

THE TOOLS TO DO MORE

AWS JobFind provides companies with the tools to post, edit and manage their job listings easily and effectively, any day or time, have immediate access to an entire résumé database of qualified candidates, look for candidates who match their employment needs: full-time, part-time or contract employees, receive and respond to résumés, cover letters, etc. via e-mail.

POST JOBS, FIND JOBS AT THE INDUSTRY'S CAREER MEETING PLACE
VISIT WWW.AWSJOBFIND.COM

Bo Gu, Shaparak Kamarei, Lin Li, William O'Neill, Chuck Ratermann, Koji Sugioaka, Sri Venkat, and Sheldon Zimmerman. Patel is with Newport-Spectra Physics, Quick is with AppliCote Associates, Ostendorf is with Ruhr-University Bochum, Löffler is with TRUMPF, and Capp is with Lasera Technology Corp.

LMI Technologies Names Customer Sales Manager



Gemma Disher

LMI Technologies, Vancouver, B.C., Canada, a provider of 3-D machine vision solutions, has promoted **Gemma Disher** to manager, customer sales support. With the company for six years, Disher most recently served as a customer sales support representative.

Manufacturing Technology Association Reorganizes

The Association for Manufacturing Technology, McLean, Va., has consolidated all communications functions under **Peter Eelman**, vice president, exhibitions and communications; new member recruitment will be overseen by **Patrick McGibbon**, vice president, strategic information and research (SIR); and member retention initiatives have been assigned to **Jeffery Traver**, vice president, business development. **Bonnie Gurney** has been promoted to communications director and **Monica Haley** has been promoted to marketing communications manager. **Myrta Mason**, membership coordinator, and **Sarah Sebastian**, membership manager, have been assigned to SIR to serve in membership development projects.

Wolf Robotics Assigns SE Regional Manager



Patrick Clayton

Wolf Robotics, Fort Collins, Colo., has appointed **Patrick R. Clayton** regional manager for its southeast region, based in the Atlanta, Ga., area. Clayton has 25 years of experience in the industry, as a welding instructor, robotic welding application engineer, and in sales and management positions.

VP Operations Named at Bishop-Wisecarver



Marc Citro

Bishop-Wisecarver Corp., Pittsburg, Calif., manufacturer of DualVee® wheel-guided linear motion systems, has named **Mike Citro** VP of operations. Citro previously owned his own manufacturing business for 20 years, and served as director of operations for Micropump for 11 years and as director of operations and general manager at Tuthill Pump Group for nine years.

Aluminum Association Elects Board Members



Tom Brackmann



F. Henriques

The Aluminum Association, Arlington, Va., has elected **Thomas Brackmann** executive committee chairman, and **Fernando Simoes Henriques** to its board of directors. Brackmann is president of Nichols Aluminum, a subsidiary of Quanex Building Products Corp. Henriques is president of Hydro Building Systems Extrusion Americas unit where he is responsible for the company's operations in North and South America.

TRUMPF Announces West Coast Sales Representative



Larry Johnson

TRUMPF Inc., Farmington, Conn., has named **Larry Johnson** a district sales representative for southern California and Nevada. Johnson, with the company since 1998, most recently served as a supervisor in the sheet metal department at the company's North American headquarters in Connecticut.

NEW LITERATURE

— continued from page 107

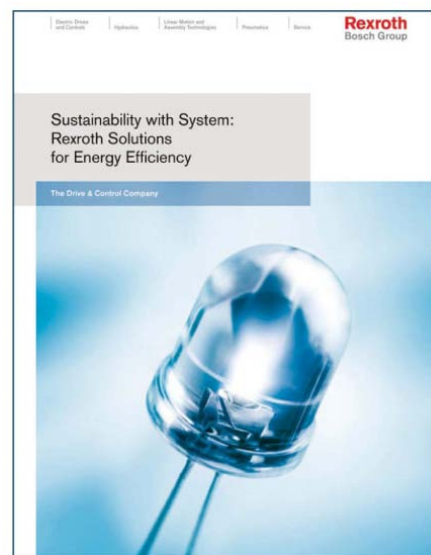
cutting, surface preparation, and coating removal. Shown are eight sound-insulated intensifier pump models featuring 30- to 200-hp electric motors, producing pressures from 60,000 to 90,000 lb/in.², with maximum rated cutting orifices from 0.011 to 0.028 in. Also shown is a high-rail gantry system 24 × 14 ft providing a large work envelope with multiple cutting heads for increased productivity. The displayed mid-rail gantry system includes a ball-screw drive for higher accuracy, and the pictured low-rail gantry travels on a floor-mounted rack-and-pinion drive system for applications requiring larger cutting envelopes. Also illustrated are the Omnijet® line of water cutting heads and Permalign® line of cutting heads for use with abrasives. Also shown are an abrasives delivery system, pneumatic drill, pressure valve, height sensor, closed-loop filtration system, and an in-line chiller. The brochure may be viewed and downloaded online or ordered by phone.

Jet Edge Waterjet Systems

www.jetedge.com

(800) 538-3343

Energy Efficiency Methods Highlighted in Literature



The 16-page, full-color brochure highlights the company's capabilities in overall energy-management concepts including closed-loop energy-recovery systems, mobile hydraulic regenerative braking, and specific technologies like intelligent

— continued on page 110

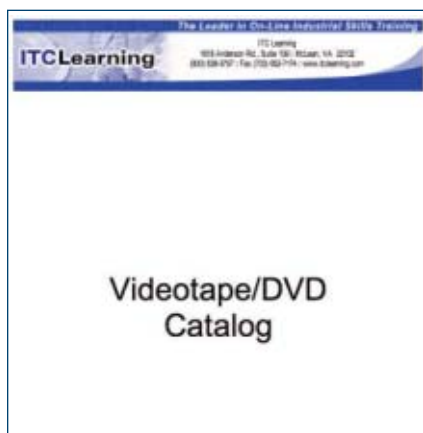
NEW LITERATURE

— continued from page 109

drives and controls, pneumatics, hydraulics, and linear motion. Also covered are generating and regenerating power exactly when and where it is needed, optimizing power according to machine performance needs, recovering energy and directing it elsewhere to provide on-the-spot power, and intelligent solutions for continuous “green” motion control. The brochure can be downloaded from the Web site or ordered by phone.

Bosch Rexroth Corp.
www.boschrexroth-us.com/sustainable
(847) 645-3600

Industrial Training Videos Listed in New Catalog



The 20-page *Videotape/DVD* catalog lists hundreds of industrial skills training videos including 12 DVDs (48 hours) on welding-related topics targeted for both the training of welders and for the multi-craft training needs of process and manufacturing facilities. The myriad subjects listed include air-conditioning, hydraulic systems, steam turbines, maintenance management, shop practices, pipefitting, boilers, programmable controllers, compressors, electric motors, relays, electrical safety, mechanical drive systems, centrifugal pumps, air compressors and blowers, training the trainer, etc. Many titles are available with a Spanish language soundtrack. The catalog can be viewed and downloaded online. Call the toll-free number for specific titles and prices.

ITC Learning
www.itclearning.com
(800) 638-3757

NEWS OF THE INDUSTRY

— continued from page 15

LA-CO® Industries Celebrates Milestone in Company's History



LA-CO Industries, Inc., Elk Grove Village, Ill., is celebrating 75 years of developing specialty chemical products designed to meet demanding industrial applications. In 1934, when Dr. Lester Aronberg first established Lake Chemical Co. in the heart of Chicago, he aimed at providing solutions for high-performance industrial marking. The company grew to develop three brands — Markal®, LA-CO®, and All-Weather®. To commemorate this milestone throughout the year, several activities are planned to show gratitude to its 140 dedicated employees (gathered in the photo) as well as loyal customers who have aided in the company's overall success.

Industry Notes

- **Aker Philadelphia Shipyard** recently cut steel on Hull 014, the tenth product tanker in a series of twelve to be built for American Shipping Co. It will carry refined petroleum products.
- The Nexsteps job board Web site located at www.nexsteps.org, a free service for members of the **American Society of Safety Engineers**, offers new employment openings.
- **Rockford Toolcraft Inc.**, Rockford, Ill., acquired an Amada LC-F1NT series laser cutting machine featuring a 6- × 12-ft shuttle table and meeting eco-friendly manufacturing needs.
- A renewal contract has been awarded to **MOR PPM, Inc.**, a subsidiary of EMCOR Group, Inc., from the Nebraska Public Power District for outage and maintenance support services for fossil and hydro facilities throughout the state of Nebraska.
- The Laser Marking division of **TRUMPF**, Farmington, Conn., recently presented its “Outstanding Sales Performance” award to Precision Technical Sales at the annual sales meeting.
- **Orbitform**, Jackson, Mich., has formed an alliance with Jay-Cee Sales & Rivet, Farmington Hills, Mich., to benefit manufacturers needing impact riveting and orbital riveting assembly automation systems.
- A division of The Linde Group, **Linde Gases**, Munich, Germany, made an agreement with Stena Aluminium, Sweden, for installing its low-temperature oxyfuel technology.
- **Engeron Technology Group's** new site e-techinfo.com presents all operating divisions of the group including industrial/welding supply – consulting/training, and machining services.
- Additional robotic welding equipment has been purchased by **DeWys Manufacturing**, Grand Rapids, Mich. It has also reconfigured its manufacturing systems to increase capacity.
- The **Illinois Manufacturers Association** concluded an agreement with the Manufacturing Skill Standards Council (MSSC) giving the organization exclusive rights to distribute and lead marketing the MSSC Certification System in Illinois.
- **VEC Technology LLC**, a majority-owned subsidiary of Genmar Holdings, Inc., Minneapolis, Minn., started delivering its built containers to the U.S. Army National Guard.
- Eagle Technologies Group, Bridgman, Mich., has been signed as a Preferred Packaging Partner for **Adept Technology, Inc.**, Pleasanton, Calif.

WELDING Journal

Guidelines for submitting electronic files

1. Platform:

Macintosh or PC accepted

2. Files accepted:

QuarkXpress, Adobe Photoshop, Adobe Illustrator, TIFF, EPS and PDF files only.

3. Color:

Send all files in as CMYK (for color) or Grayscale (for b/w).

4. Images:

Minimum resolution required for magazine printing is 300 dpi for full color artwork or grayscale at least 1000 dpi for bitmap (B&W/line art). Images and logos from Web sites are NOT usable for printing. They are low resolution images (72 dpi). Images taken with a digital camera are not acceptable unless they meet the minimum 300 dpi requirement.

5. Proof:

A proof of the images should **always** be provided.

6. Electronic File Transfer:

Files larger than 68k are not acceptable as an email attachment; please send it on a CD, you may also send files to the printer FTP site (a user name and password will be provided when requested)

Check list for submitting electronic files:

Colors: ☐ 4/C ☐ Grayscale ☐ B&W/line art

File Type: ☐ TIFF ☐ EPS

File sent via: ☐ Zip disk ☐ CD ☐ Email

☐ **Proof supplied/faxed**

☐ CMYK images at 300 dpi or higher, B&W/line art at 1000 dpi or higher.

☐ All color in all images set to CMYK process (not RGB)

When submitting ads, please send them to the attention of

Frank Wilson
Advertising Production Manager
American Welding Society
550 NW LeJeune Rd.
Miami, Fla. 33126



SCHOOL PROFILES APRIL 2009

Employers
Are you in need of
good welders?

Students
Are you searching for a
way to hone your skills?

Welders
Is it time to expand your
talents and knowledge?

Below are welding schools across the country that have taken this advertising opportunity to promote their resources both to industry in need of welders and to those searching for a solid career path to employment. Contact them and take advantage of the services they can provide.

You will find specific information on welding courses offered, degrees and certifications available, school locations near you, fax, phone, website search data and the like. We appreciate any ideas you might have for making this welding school guide more useful to you. Please send comments or requests to be on our mailing list to Rob Saltzstein at salty@aws.org, or Lea Garrigan Badwy at garrigan@aws.org. We will be sure your school is on our mailing list and e-mail list to receive advance information on future Welding School Profile edition of *Welding Journal*. Thank you.

University of Alaska Anchorage Welding and NDT Technology

Founded 1970

The Welding/NDT program at UAA offers a choice of certificates and an Associate of Applied Science degree that centers on welding skills, welding inspection and nondestructive testing. Program courses include skill development in major welding processes, pipe fitting and basic metallurgy, as well as hands-on NDT training in the RT, UT, MT and PT processes. Our program serves about 175 students each year.

UNIVERSITY of ALASKA ANCHORAGE
Community and Technical College
3211 Providence Drive GHH 111
Anchorage, AK 99508
(907) 786-6475
Fax: (907) 786-6474
www.uaa.alaska.edu/ctc/programs/cdt/welding

Advanced Welding Institute

Founded 2003

Advanced Welding Institute provides certified welders for fabrication, piping and structural industries. We focus on techniques in SMAW, GMAW and GTAW with classes no larger than twenty students. AWI is an accredited institution and offers a certificate program in structural and pipe welding. We also offer 40 hour courses in SMAW, GMAW and GTAW (aluminum and stainless steel). Courses can be tailored to meet specific needs. Financial aid is available for those who qualify.



2 Green Tree Drive, Suite 3
South Burlington, VT 05403
(802) 660-0600
Fax: (802) 660-0689



Akron Testing Lab. & Welding School Ltd.

Founded 1953

Akron Testing Lab and Welding School Ltd., has been training and qualifying welders for over 50 years. Founded in 1953 and located in Northeast Ohio, offers certificate classes or a Diploma program in "Welding Technology." Classes offered include SMAW, Pipe welding, GMAW steel and aluminum, GTAW, FCAW, Oxyfuel, and blue print reading. Customized training is offered to employers. Ohio Registration 79-01-0631T.



**Akron Testing Laboratory
and Welding School**
1171 Wooster Road N.
Barberton, OH 44203
atweldsch@att.net
(888) 859-0664
Fax: (330) 753-2268
www.akronweldingschool.com

Atlantic Technical Center

Founded 1973

Atlantic Technical Center provides a review for persons currently employed in welding occupations who wish to take an AWS test to become a Certified Welder, or first time students who are interested in learning advanced and basic welding skills techniques. Shop activities are an integral part of this course and provide instruction to develop skills in Industrial, Structural, Aircraft, Marine, Petroleum and Nuclear Welding. At the successful completion of laboratory activities, an AWS Welding Certification test is available. Accredited by the Commission of the Council on Occupational Education.



4700 Coconut Creek Parkway
Coconut Creek, FL 33063
(754) 321-5100
Fax: (754) 321-5380
Contact: Frank Rose,
Welding Instructor, Ext. 3108
www.atlantictechcenter.com



Bellingham Technical College Welding Technology Program

Founded in 1956

Bellingham Technical College's Welding Technology Program offers AAS and AAS-T degrees in Certified Welding and Fabrication for a vibrant community of Pipelines and Northwest Washington Refineries, Ship building and Repair, Transportation, and shops and fabricators. Our Award-Winning program is in an 80,000 sq. ft. State-of-the-Art facility that houses our 200 plus enrollment in Pipe Welding, Aluminum Welding and Fabrication, Steel Fabrication, and Creative Welding. Our Annual Welding Rodeo Sculpture Contest is a one-of-a-kind experience for Amateurs and Professional Artists throughout the Pacific Northwest.



3028 Lindbergh Ave.
Bellingham, WA 98225-1599
(360) 752-8301
www.btc.ctc.edu or www.weldingrodeo.com
danderso@btc.ctc.edu
rjones@btc.ctc.edu
mkuebelbeck@btc.ctc.edu



SCHOOL PROFILES APRIL 2009

Brazosport College

Brazosport College offers welding training on its campus on the beautiful Texas Gulf Coast. With over 40 years experience and customized classes, BC offers a top-rated program with employer-driven curriculum and lots of individual attention. NCCER recognized classes are offered at a variety of convenient times. Earn a certificate or associate of applied science degree in welding and quality assurance (CWI).



Brazosport College
500 College Drive
Lake Jackson, TX 77566
Jim Bailey at (979) 230-3307
james.bailey@brazosport.edu
Fax: (979) 230-3282

Southeast Technical Institute

Founded 1968

As the only authorized testing facility (ATF) in South Dakota, STI uses AWS SENSE-based training and an emphasis on workforce development to meet the needs of individuals and companies in the Sioux Falls region. Students are introduced to welding safety, metalurgy, weld symbols and blueprint reading. Welding processes include: OAW (Oxygen and Acetylene Welding), SMAW (Shielded Metal Arc Welding), GMAW (Gas Metal Arc Welding), GMAW-P, GTAW (Gas Tungsten Arc Welding), and FCAW (Flux Cored Arc Welding).



Business and Industry Training
A Div. of Southeast Technical Institute
2320 N. Career Ave.
Sioux Falls, SD 57107
(605) 367-7619
bit@southeasttech.edu
www.trainingsiouxfalls.com

Butte-Glenn Community College

Founded 1967

The Welding Technology Program is a vocational core of courses designed to produce qualified personnel for certified welding jobs. Program performance standards for certification are in accordance with those established by the American Welding Society and/or American Society of Mechanical Engineers. Courses are held in a completely modern and well-equipped welding lab. This program is designed to produce entry-level welding technicians in the 6-G pipe position (qualifies for all positions in plate and pipe). Heavy plate 3G and 4G are also obtainable. The student will be able to weld with SMAW, FCAW, GMAW, GTAW, OAW, OFC, PAC and AAC in all positions with a variety of metals and alloys. Students will be able to certify under at least one of the following codes: API, AWS, and ASME, according to individual skills.



BUTTE COLLEGE



3536 Butte Campus Drive
Oroville, CA 95965
Don Robinson, robinsondo@butte.edu
(530) 895-2469 Fax: (530) 895-2302
Mike Rabo, rabomi@butte.edu
(530) 895-2360 Fax: (530) 895-2302

Cal-Trade Welding School of Modesto

Founded 1975

Cal-Trade Welding School of Modesto has been operating since 1975. Using the industry employers as a guide, we teach SMAW, GMAW, GTAW, FCAW and pipeline welding. Welding technique training is primary and students are given one-on-one instruction. In the welding courses students have the opportunity to earn multiple certifications. Welding theory, mathematics for welders and blue print reading are also offered in the courses. Lifetime job placement assistance is available to students after graduation.



424 Kansas Ave.
Modesto, CA 95351
(209) 523-0753
Fax: (209) 523-8826

Center For Employment Training

Founded 1967

Center for Employment Training is accredited by the Western Association of Schools and Colleges (WASC). We are employer-driven teaching a curriculum that meets the workforce demands. Graduates will receive a welding fabrication certificate, along with the opportunity to receive six AWS D1.1 approved Certifications (SMAW E7018 3G & 4G, FCAW NR211, NR232 3G & 4G GMAW ER70-6 3G & 4G, GTAW ER70S-1 & ER4043). Customized training is available to employers. We are certified to train veterans and offer financial aid to those who qualify.



Center For Employment Training
1430 Cooley Court
San Bernardino, CA 92408
(909) 478-3818 or (888) 379-5358
Fax: (909) 478-9506
Office hours: 8:00 am to 5:00 pm PST
Email: mgonzalez@cet2000.org
www.cetweb.org

Central Wyoming College

Central Wyoming College, located in the beautiful Wind River Valley, offers an employer-driven welding curriculum designed to provide graduates with entry-level backgrounds in the different aspects of welding. Central Wyoming College welding students receive rigorous hands-on training in various welding and cutting processes including Oxyfuel, SMAW, GMAW/FCAW, GTAW, and pipe welding. Students have a choice of earning a credential, certificate or an Associate of Applied Sciences degree. Check out our program at www.cwc.edu.



2660 Peck Avenue
Riverton, WY 82501
(307) 855-2119
www.cwc.edu
Dudley Cole, (307) 855-2138
Admissions (800) 865-0193



Coffeyville Community College Welding Institute

Founded 1941

Rated the number one pipe welding school in Kansas by the Kansas Board of Regents and the Kansas Technical Education Authority, CCC provides hands-on instruction using SMAW, GMAW, FCAW, and GTAW procedures. Soldering, med-gas brazing, oxy/acetylene cutting, plasma arc cutting and carbon arc gouging techniques are taught using 52 booths on two campuses – Coffeyville and Columbus, Kansas. OSHA outreach courses are available. All instructors are CWI certified by the American Welding Society. Program graduates earn a college certificate or Associate of Applied Science degree. Dorm rooms and scholarships are available.

COFFEYVILLE Community College

400 W. 11th
Coffeyville, KS 67337
1-877-51-RAVEN

E-mail: dickr@coffeyville.edu
www.coffeyville.edu

College of Southern Nevada

The College of Southern Nevada, located in the Jewel of the Desert, fabulous Las Vegas, offers both a one year Certificate of Achievement and a two-year Associate of Applied Science degree in Welding Technology. As both a Sustaining Company and S.E.N.S.E. affiliate member, students have the opportunity to certify as Entry or Advanced Level welders. In addition, the college offers a specialty course for certified welding inspection preparation at a fraction of the cost of other institutions.



700 College Dr.
Henderson, NV 89002-8419
John W. Cavanaugh, Program Director
(702) 651-3065
john.cavanaugh@csn.edu

SCHOOL PROFILES APRIL 2009

College of the Canyons

College of the Canyons, an approved AWS and LADBS testing facility, has trained and certified welders for over 32 years. Courses are offered in metal fabrication, industrial welding, pipe, metallurgy, welding inspection, metallurgy and metal sculpturing. Training is offered in OFW, SMAW, FCAW, GMAW, and FCAW. Instructors are AWS CWI/CWE licensed. Certificates and degrees are offered. Courses are offered day and night, and most programs can often be completed in less than one year.



26455 Rockwell Canyon Road
Santa Clarita, CA 91355
(661) 259-7800

Email: tim.baber@canyons.edu
www.canyons.edu

Cosumnes River College

Cosumnes River College offers a "hands on" style welding certificate program. Students can become certified in SMAW, GMAW, FCAW and GTAW processes. The advanced welding courses offer AWS certifications in ASME and AWS D1.1 code standards. Graduating students can become a certified welding operator, welding inspector and shop supervisor for construction and manufacturing companies. The lead instructor, Jason Roberts is an AWS CWE/CWI and Federal OSHA Trainer.



For more information please contact:

Jason Roberts
(916) 691-7386
8401 Center Parkway
Sacramento, CA 95823
robertj@crc.losrios.edu

CTC Lackawanna Co, (Formerly Lackawanna Co AVTS)

Founded in 1973

CTC serves the secondary students and adult community of the greater Scranton (PA) region. Emphasis is placed on safety as well as blueprint reading, properties of metal, metal identification, types and use of electrodes, welding rods, electrical principles, and NDT. Secondary and adult students have the opportunity to take AWS and ASME certification tests. Accredited by Pennsylvania State Board of Education.



3201 Rockwell Ave
Scranton PA 18508
(570) 346-8471

Email: admctc@ctclc.edu
www.ctclc.edu

Cuesta College Welding Technology

Founded 1965

Located on the central coast of California, the Cuesta College Welding Technology program has a strong history of preparing students for work in industry. Students certify to AWS D1.1 and ASME Section IX and have the opportunity to obtain Associative Science degrees in Welding Technology. Our curriculum is well rounded with courses ranging from basic welding through certification, as well as courses in metallurgy, blueprint reading and welding power. The shop facility includes twenty multi-process welding stations newly appointed with current power supply technology. There are a total of 8 part-time instructors and one full time instructor representing a collective total of 184 years industry experience and 99 years teaching experience in welding technology. Four of our instructors are CWI's. Article sponsored by CB&I, San Luis Obispo, California.



P.O. Box 8106
San Luis Obispo, CA 93403-8106
(805) 546-3100 ext 2737
Rob Thoresen, rthorese@cuesta.edu



SCHOOL PROFILES APRIL 2009

Dalus, S.A. De C.V. Welder Training & AWS Certification Center In Mexico

Founded 2000

DALUS was founded in 2000 for the purpose of training and testing people in certifiable skills and knowledge that will help to integrate them into a world class workforce. DALUS is an AWS Accredited Test Facility (ATF) and a member of the S.E.N.S.E. (Schools Excelling through National Skills Education) program and administers SCWI, CWI and CWE prep course and exams three times a year. DALUS also offers courses designed to meet employer's specific needs.



**Parque Industrial Kalos
Monterrey, NL - MEXICO**
+52 (81) 8386-1717
info@dalus.com
www.dalus.com

Lynnes Welding Training, Inc. Dave's Welding & Metal Fab. Inc.

Founded 2004

Fast track your career in just a few weeks. Extensive hands on training w/blueprint reading. Small classes for more personal attention. Customized courses available for employers. Earn a certificate – GMAW, GTAW, SMAW, and Pipe (Tig or Stick). Assistance with job placement. Providing training since 2004 with over 450 students.



2801 1st Ave No
Fargo, ND 58102
(888) 356-0871
www.learn toweld.com

Davis Applied Technology College

Davis Applied Technology College (DATC) offers welding training on its Kaysville, Utah campus. Students can earn a basic and/or advanced certificate in as little as 8-12 months. Learn from welding experts who provide real-world training in the following areas: oxy fuel, SMAW, GTAW, GMAW, FCAW, SAW, plasma cutting, pipe welding, and more. Scheduling is flexible, tuition is affordable and financial aid and scholarships are available to those who qualify. Celebrating 30 years of quality education.



Davis Applied Technology College
550 East 300 South
Kaysville, UT 84037
(801) 593-2435
Email: kendel.oldfield@datc.edu
www.datc.edu/welding

DeKalb Technical College

Founded 1961

DeKalb Technical College welding program has a four-quarter diploma program and six technical certificates of credit in Oxy-fuel, SMAW, GMAW, GTAW, pipe welding and ornamental iron worker. DeKalb Tech offers customized courses to meet employer's needs. The majority of the welding program is hands-on in the lab. If you like working with your hands, building things and don't mind getting dirty, DeKalb Technical College Welding Program is where you need to get your training. Ask about the HOPE grant. Graduate debt free.



DeKalb Technical College
495 North Indian Creek Dr.
Clarkston, GA 30021
(404) 297-9522 ext 1218 or 1570
zappar@dekalbtech.edu
harveyw@dekalbtech.edu
www.dekalbtech.edu

Del Mar College

Founded 1935

Del Mar College is a comprehensive community college in Corpus Christi, Texas. The welding program offers training in SMAW, GMAW, GTAW, FCAW, and various other processes. Welding is done on plate and pipe. Training is based on AWS and industry standards. Certificate and Associate Degree programs are offered. Visit us on the web or call 1-800-652-3357 for information.



101 Baldwin Blvd.
Corpus Christi, TX 78404-3897
(800) 652-3357
www.delmar.edu

The Divers Academy International

Founded 1977

The Divers Academy offers the highest quality training in the shortest amount of time to jumpstart your career. It is known for its full-immersion training methodology and its modern training facilities. Underwater Cutting and Welding is just one part of a comprehensive 5-month curriculum. Founded in 1977, the Divers Academy International trains divers for commercial deep sea diving and wet welding, providing students with an employer's most sought-after qualification: on-the-job experience. Financial aid is available for those who qualify.



Lakeside Business Park
1500 Liberty Place
Erial, NJ 08081-1139
(800) 238-DIVE
admissions@diversacademy.com
www.diversacademy.com



SCHOOL PROFILES APRIL 2009

Delaware Area Career Center

Welding students at the Delaware Area Career Center design, engineer, build, and troubleshoot complex manufacturing solutions for actual clients. They learn to interpret blueprints and specifications using math and computer technology. They also develop the strength, work ethic, and stamina necessary for a career in fabrication. Upon completion, the students are prepared for NCCER (National Center for Construction Education and Research) Welding Certificate, AWS (American Welding Society) Certifications, immediate employment as an apprentice, and further education.



Scott Laslo
(740) 203-2238
www.DelawareAreaCC.org

Doña Ana Community College

Founded 1973

The Doña Ana Community College Welding Technology program has a national reputation for excellence, and is taught by top-notch AWS CWEs and CWIs. Our 75-90 full and part-time students take courses in SMAW, GMAW, GTAW, FCAW, SAW, steel, stainless, aluminum, pipe, metallurgy, NDT and DT, welding Codes, welding symbols and blueprint reading, pipe welding, fabrication, and welder qualification. Graduates leave as AWS/ASME certified welders. Courses are offered days or evenings. Certificate and Associate Degrees offered.



MSC 3DA,
3400 S. Espina St.
Las Cruces, N.M. 88003-8001
(575) 527-7500
David Twitty: dtwitty@nmsu.edu
Terry Mount: tmount@nmsu.edu
www.dabcc.nmsu.edu

Eastern Maine Community College

Founded 1966

EMCC offers a comprehensive welding program in Bangor, Maine. Students may earn a diploma or associate degree in welding or pipefitting technology including metallurgy and QA/QC to prepare them to successfully enter the workplace. SMAW, FCAW, GMAW, GTAW and cutting processes in both structural and piping applications are studied in a spacious training facility equipped with modern welding equipment. AWS testing facility offering weld testing, welder certification and customized training to the public and industry.



354 Hogan Road, Bangor, Maine 04849
(207) 974-4643
cmaseychik@emcc.edu
www.emcc.edu

El Camino College

Founded 1947

The El Camino College Welding Department strives to meet diverse student needs by providing quality instruction in morning, afternoon, and evening classes. Introductory through advanced courses are available in oxy-acetylene welding and cutting, GMAW, GTAW, FCAW, and SMAW. Special contact for women, call Women in Industry and Technology Program at 1-310-660-3593 ext. 6780. Welding Certificate and/or Associate of Science Degree are available.



Welding Department
16007 Crenshaw Boulevard
Torrance, CA 90506
(310) 660-3600
www.elcamino.edu

Ferris State University

Ferris State University's nationally recognized Welding Engineering Technology program is the largest of its kind in the United States. Since its inception the program is designed to produce plant-level welding engineering technology graduates who are involved in the concept, design and engineering of weldments and implementation of welding processes.



Welding Engineering Technology
915 Campus Drive, Swan 107
Big Rapids, MI 49307
(231) 591-2952

Jeff Carney
Associate professor/departement chair
carneyj@ferris.edu
www.ferris.edu/welding

Frank Phillips College

Frank Phillips College Welding Technology department is dedicated to providing students with superior performance-based training from basic oxy fuel skills through advanced alloy pipe welding, blueprint reading and pipe fitting techniques. With our new environmentally controlled facility and state-of-the-art equipment, our team has an excellent reputation for high job placement and producing quality craft personnel. Located in the heart of the Texas Panhandle, you can — "Start Here, Go Anywhere."



Welding Technology Department,
Borger, TX
(806) 457-4200, ext. 782
Email: msimmons@fpctx.edu



SCHOOL PROFILES APRIL 2009

Fresno City College

Founded 1910

Fresno City College's welding program prepares students for employment in welding and metal fabrication. Courses in blue print reading as well as reduced cost for qualification testing are available. Fresno City offers an associates degree in welding and offers Certificate of Achievements. Industry approved content includes skills in oxyfuel, SMAW, GMAW, GTAW, FCAW, air arc gouging, and plasma cutting with various metals. A variety of machinery and equipment used in the fabrication industry are utilized. Day and evening classes are available.



Fresno City College

1101 E. University Avenue
Fresno, CA 93741
(559) 442-4600

brett.camacho@fresnocitycollege.edu
www.fresnocitycollege.edu

The Grand River Technical School

The welding technology course is designed to prepare students for entry-level employment in the welding field. Students will acquire knowledge and hands-on experience in welding/cutting processes that are in high demand. Students will receive instruction on safety practices, printreading, work ethics, and pre-employment preparation. Upon successful completion students receive a certificate for 1080 hours, may become certified, and have the opportunity to receive an associates degree through a college articulation agreement.



1200 Fair Street
Chillicothe, MO. 64601
(660) 646-3414
Fax: (660) 646-3568
www.grts.org

Harper College

Harper College's 16 credit-hour certificate program provides students with entry-level skills in welding fabrication and repair. The program emphasizes advanced welding theory, extensive practice in major arc welding process, and out-of-position and multipass arc welding including GMAW, SMAW, and GTAW. Upon completion of the certificate program, students are prepared to pass guided bend tests to become certified welders in accordance with AWS (American Welding Society) D1.1 Structural Welding Code. Harper's program also provides custom training in welding and fabrication for employees of area businesses.



Harper College

GoForward®

Kurt J. Billsten
Coordinator of Maintenance Technology
1200 West Algonquin Rd.
Palatine, IL 60067
(847) 925-6149
Fax: (847) 925-6049
kbillste@harpercollege.edu
www.harpercollege.edu

Gadsden Technical Institute

Gadsden Technical Institute is an American Welding Society S.E.N.S.E school that prepares students for employment or advanced training in a variety of occupations in the welding industry. The Applied Welding Technology program is 1170 hours in length with certificates offered in SMAW, GMAW, FCAW, GTAW, and pipe welding. GTI also facilitates certification to AWS and ASME codes. Applied course work includes design and fabrication of challenging projects and participation in Skills USA activities.



Gadsden Technical Institute
201 Martin Luther King Jr. Blvd.
Quincy, FL 32351
(850) 875-8324
Fax: (850) 875-7297
clark_m11@ftrn.edu
www.gti.geps.k12.fl.us

Great Basin College Welding

Founded 1967

Great Basin College offers an Associates of Applied Science Degree and a one-year Certificate in Welding Technology, established in 1990. Currently, 20 students are enrolled in a program that prepare them with skills to create new products; repair existing products; and work in the mining, manufacturing, construction, transportation and agricultural industries. Program highlights include instruction in welding theory, blueprint reading, fabrication, quality control, metallurgy, qualification testing, destructive and nondestructive testing principles, and safety.



Elko, Nevada
(775) 753-2207 or (775) 753-2170
Rich Barton e-mail:
richardb@gvmail.gbcnv.edu
Jon Licht e-mail:
jonl@gvmail.gbcnv.edu
www.gbcnv.edu

Hill College

Founded 1923

Hill College offers comprehensive welder training on both its Hillsboro and Cleburne, Texas campuses. Students can choose from several program options ranging from marketable skill awards to an Associate of Applied Science degree. Employer-driven curriculum covers SMAW, GMAW, FCAW, GTAW, pipe welding, and blueprint reading. State-of-the-art technology combined with hands-on curriculum give Hill College students the experience to jump start their careers. Hill College also offers continuing education credits and customized courses for employers.



Welding Department
2112 Mayfield Parkway
Cleburne, Texas 76031
(817) 556-2809 ext.201
Email: bbennett@hillcollege.edu
www.hillcollege.edu



SCHOOL PROFILES APRIL 2009

Hobart Institute of Welding Technology

Founded 1930

Hobart Institute of Welding Technology's Course Catalog explains in detail the wide range of welding classes and certifications offered by Hobart Institute of Welding Technology. More than 25 separate welding courses are described by course objective, content, and testing requirements. Also inside the catalog are course schedules, training rates, and enrollment forms. Training may be done at our facility or yours. Also offered are complete training programs including DVDs, Instructor Guides, and Student Workbooks.



**HOBART INSTITUTE
OF WELDING TECHNOLOGY**
400 Trade Square East
Troy, OH 45373
(800) 332-9448
FAX: (937) 332-5200
www.welding.org

Hutchinson Community College/AVS

HCC offers Certificate, Associate in Applied Science Degrees and industry training in Welding Technology. The AWS Certified Program includes all welding processes, as well as experience in fabrication and manufacturing methods. The welding and employability skills taught result in excellent graduate placement, as well as job opportunities while students pursue their education. Morning, afternoon and evening classes are available, with multiple entry opportunities. Our locations include Hutchinson and Newton, Kansas. The Ade-Wifco Reno County Industrial Center in Hutchinson features newly remodeled and expanded welding and fabrication labs and classrooms.



1300 N. Plum
Hutchinson, KS 67501
(620) 665-3502
www.hutchcc.edu/weldit
fitzgeraldsd@hutchcc.edu in Hutchinson
(316) 273-7000
jensenl@hutchcc.edu in Newton

Lorain County Community College

Founded in 1963

The LCCC Welding Technology Program is designed to provide students with knowledge, skills, and behaviors necessary for a welding technician. The program is based on occupational analyses and needs assessment of the maintenance and fabrication welding industries. Employment opportunities exist in a variety of industries such as steel, construction, fabrication, pipelines and others. Students completing the program may take welding certification tests. LCCC offers a Certificate of Completion in Welding, a Welding Operator Certificate of Proficiency and an Associate of Applied Science in Welding Technology.



**Lorain County
Community College**

Joe Freconna, Advisor
1005 North Abbe Road
Elyria, OH 44035
(440) 366-7614
or (800) 995-5222
jfreconna@lorainccc.edu

Jamestown Community College State University of New York

Founded 1950

Be in demand! Jamestown Community College offers a one-year certificate program and a full associate degree program in welding technology in a state-of-the-art facility in cooperation with the Manufacturers Association of the Southern Tier. On-campus suite-style residence halls are available along with a dynamic campus life program including intercollegiate and intramural athletics. Small classes offer personal attention. Full employment services available.



525 Falconer Street
Jamestown, NY 14701
(800) 388-8557
admissions@mail.sunyjcc.edu
www.sunyjcc.edu

Kenai Peninsula College

Kenai Peninsula College is a branch of the University of Alaska located 150 miles South of Anchorage on the Kenai Peninsula. KPC offers certification on AWS D1.1, D .375 steel plate 3G and 4G SMAW, ASME Section IX pipe certification on steel 6-inch schedule 80 6G SMAW. Our certificate program includes Math, Blueprint, and English (students must certify on pipe to complete certificate). KPC students are provided with 3M® powered air purifying respirator welding hoods.



Kenai Peninsula College
UNIVERSITY of ALASKA ANCHORAGE

156 College Drive
Soldotna, AK 99669
(907) 262-0300
Fax: (907) 262-0395
Fritz Miller, Welding Instructor
(907) 262-0356
iffwm@uaa.alaska.edu
www.kpc.alaska.edu

Mesabi Range Community & Technical College

Mesabi Range offers a rigorous welding curriculum following national skills standards developed by the American Welding Society. The Entry Level Welder Diploma and the Advanced Welder Diploma, established in 1997, give the successful graduate very marketable skills in the welding industry. Experienced, knowledgeable instructors, a great staff, up-to date equipment, and a modern shop provide a great learning environment. We have 100% job placement in the last ten years. Welding certifications are available.



P.O. Box 648
1100 Industrial Park Drive
Eveleth, MN 55734
(218) 741-3095
Fax: (218) 744-7644
www.mnscu.edu



SCHOOL PROFILES APRIL 2009

Middle East Industrial Training Institute (MEITI)

Founded 2002

Middle East Industrial Training Institute (MEITI), is an AWS Educational Institution Member and an Accredited Test Facility providing specialized vocational and professional programs. Based in Abu Dhabi – UAE, MEITI offers a wide variety of Trades and Welding Technology programs. These programs includes welder skill training in SMAW, GMAW, FCAW and GTAW for entry level, advanced and expert. We also provide technical training related to fabrication, inspection, shipbuilding, pipeline, piping, bridges, equipment, and others, suitable for managers, engineers and other welding professionals.



Mr. Haytham Akkila, Managing Dir.
P.O. Box 33229, Abu Dhabi, UAE
+971 2 582 7445
Fax: +971 2 582 7994
meiti@eim.ae
www.meiti-uae.com

Mid-Plains Community College

Mid-Plains Community College's Welding and Machine Shop Technology is an open-entry, open-exit program that leads to a Diploma or Associate of Applied Science Degree for employment in the welding/machine shop field. Students may enter at different stages of readiness and progress according to his/her abilities and efforts. Upon completion of a set of prescribed technical competencies, students will be able to perform skills necessary to be successfully employed at the entry level or above with a selected occupation.



1101 Halligan Dr.
North Platte, NE 69101
(800) 658-4308
info@mpcc.edu
www.mpcc.edu

Monroe County Community College

Founded 1964

Monroe County Community College located in Monroe, Michigan offers a Welding Technology program which includes training in SMAW, GMAW, FCAW, and GTAW, plate and pipe in all positions, using mild steel, stainless steel and aluminum. Courses may be applied towards an associate degree in applied science, welding certificate or transferrable to a four year bachelor degree. American Welding Society QC-10 (Entry level) and QC-11 (Advanced Level) classes are available.



1555 South Raisinville Road
Monroe, MI 48161-9746

Parmeshwar (Peter) Coomar
(734) 384-4209 or
Becky Leonhardt
(734) 384-4112

Email: pcoomar@monroeccc.edu or
bleonhardt@monroeccc.edu

Moraine Park Technical College

Moraine Park Technical College offers a one-year welding diploma program focusing on GMAW, FCAW, SMAW and GTAW on steel, stainless and aluminum. The program includes Print Reading and Fabrication courses that focus on the manufacturing process of a product from conception to final production via basic layout tools and CNC equipment. Instruction includes AWS and ASME welding codes, including qualification tests and writing WPSs, with the opportunity to weld-certify upon completion of the program.



235 N. National Avenue,
Fond du Lac, WI 54935
www.morainepark.edu

Our welding instructors:

Jeremiah Johnson, (920) 887-4490
jjohnson@morainepark.edu
Larry Clark, (920) 887-4494
lclark@morainepark.edu
Jeff Beach, (920) 924-6438
jbeach@morainepark.edu

NAIT

An Institute of Technology Committed to Student Success

NAIT's Welding Department trains over 1700 Apprentices per year. Apprentices learn how to setup, use, and maintain equipment required for welding and cutting processes. Apprentices develop the hand skills required to properly perform welding and cutting operations. Basic metallurgy, weld profiles, symbols, procedures, faults, and working with applicable codes are areas covered at NAIT. Related subjects such as math, blueprint reading, pattern development, rigging and a fully functional trade science lab complete the scope of training.



11762-106 Street NW
Edmonton, Alberta, Canada T5G 2R1
(780) 378.1100
cmanning@nait.ca
www.nait.ca

New Castle School of Trades

Founded 1945

The New Castle School of Trades offers welding training at it's western Pennsylvania campus. Earn a Diploma in Combination Welding. Hands on training in SMAW, GTAW, GMAW, FCAW, PAC, CAC and pipe welding. Support courses such as welding blueprint reading, pipe blueprint reading and welding fabrication. AWS Certifications offered for all processes. Enjoy small classes, free tutoring, and personal attention. Customized courses available for employers. Teaching America's trades since 1945. Real people—Real training—Real jobs.



NCST, 4164 US 422
Pulaski, PA. 16143
(800) 837-8299

Email - ncstrades@aol.com
www.ncstrades.com



SCHOOL PROFILES APRIL 2009

North Dakota State College of Science

The North Dakota State College of Science is a two-year, residential college that offers degrees, certificates and diplomas in over 80 academic options in traditional career and technical studies and in the liberal arts. NDSCS offers one-year certificates, two-year diplomas and A.A.S. degrees in Welding Technology. The college is an American Welding Society S.E.N.S.E. certified facility. Last year, 95 percent of NDSCS graduates entered the workforce or continued their college education. Unlike more two-year colleges, NDSCS offers a university atmosphere for students – residence halls, clubs and organizations, fine arts, athletics and numerous social activities.



**North Dakota
State College of Science™**
800 Sixth St. North
Wahpeton, ND 58076-0002
(701) 671-2170
Joel.Johnson@ndscs.edu

Northeast Community College / South Sioux City Education Center

Earn a welding diploma in one year at the South Sioux City, Neb. location. Curriculum includes SMAW, GMAW, GTAW, FCAW, OA and plasma torch. Support courses include metallurgy, related drafting, shop tools operations, blueprint reading, basic machine tool and OSHA 30 hour safety. Advanced Training available for iron pipe welding and fitting (6G Qualification skills). Full time instructor has 35 years field experience, 20 years ASME qualified. Affordable tuition, quality education, and small class sizes.



South Sioux City Education Center
3309 Daniels Lane, PO Box 989
South Sioux City, NE 68776
(402) 241-6405 or (888) 698-6322
Email: russell@northeast.edu

Northeast Wisconsin Technical College

Northeast Wisconsin Technical College offers training in welding, weld inspection and nondestructive testing in Green Bay and Marinette, Wisconsin, and by contract at worksites nationwide. NWTC welding graduates can build and repair metal components using major welding processes used by industry and knowledge of blueprints, metallurgy and layout; can weld to AWS and ASME codes; can work as maintenance welders, qualified welders, structural welders, welder/fabricators, and pipe welders.



2740 West Mason Street
P.O. Box 19042
Green Bay, WI 54307-9042
(800) 422-NWTC, ext. 5444
www.nwtc.edu

Odessa College

The Welding Technology Department at Odessa College in Odessa, Texas, offers a full range of certificate and associate degree options. The lab areas are equipped with 45 modern welding stations for training in SMAW, GMAW, FCAW and GTAW processes as well as 15 OFW stations. Currently, classes are offered in the morning and evening to accommodate an average of 100 students each semester. Odessa College received a U.S. Department of Labor grant for \$1.75 million in January 2007 for the Welding Training Center. This new 30-station training facility opened in January 2008 and offers 8-week "Introduction to Welding Fundamentals" courses through the continuing education division. The Welding Training Center received the AWS "Image of Welding Award" in October 2008.



201 W. University
Odessa, TX 79764
(432) 335-6474

James Mosman – Coordinator
Email: jmosman@odessa.edu

Orange Coast College *Founded 1947*

The Orange Coast College welding curriculum has been a part of this college curriculum since the college was first conceived. Our program offerings include both a Welding Certificate of Achievement and an Associate in Science Degree. We are proud to offer a comprehensive welding program which includes Oxyacetylene welding and cutting, SMAW, GMAW, FCAW, GTAW, orbital welding and plasma arc cutting. On our academic side we teach metallurgy for welders, codes and specifications for welders, math and fabrication for welders and testing and inspection for welders. Our instructors have AWS QC-1 CWI and CWE credentials as well as California Community College teaching credentials. We qualify welders to ANSI standards and we are a licensed Los Angeles City testing laboratory. Our testing laboratory does both destructive and non-destructive examinations.



2701 Fairview Road
Costa Mesa, CA 92626
(714) 432-5820

Ozarks Technical Community College *Founded 1990*

Ozarks Technical Community College offers multiple welding programs, providing opportunities for full- or part-time students, as well as customized training for employers. The Welding Technology program includes courses in several types of welding and welding inspection, leading to either a certificate or an A.A.S. The College also offers an accelerated 20-week Master Welder certificate program. The Center for Workforce Development offers short-term, non-credit welder training for local businesses. OTC is a fully equipped, fully accredited AWS certified test facility.



1001 E. Chestnut Expwy
Springfield, MO 65802
(417) 447-7500
www.otc.edu
ask@otc.edu



SCHOOL PROFILES APRIL 2009

Pennsylvania College of Technology

Founded 1989

Pennsylvania College of Technology, a Penn State affiliate since 1989, offers "degrees that work" in more than 100 careers including welding. In addition to an associate's degree and certificate, Penn College offers a unique bachelor's degree in Welding and Fabrication Engineering Technology that prepares graduates for technical careers and positions in mid-management, supervision, sales, service, and research. The College also is a regional partner for the National Center of Excellence in Welding Education and Training.



One College Avenue
Williamsport, PA 17701
(800) 367-9222
PCtinfo@pct.edu
www.pct.edu/aws

Polaris Career Center

Polaris Career Center offers Welding training in Middleburg Heights, Ohio. Earn AWS certification in SMAW and GTAW welding. Welding certification through NCCER is also available. The 600 hour course is designed to give the students theory and practical application related to Oxy-Fuel welding and brazing, GTAW, GMAW, and FCAW. Course topics include Open-V-groove welds, Pipe welds, and Vertical welding. The Adult Education program is offered in the evening allowing students to work during the day.



7285 Old Oak Blvd.
Middleburg Hts., OH 44130
www.polaris.edu
(440) 891-7600
Johnny Napier,
Welding Program Coordinator
jnapier@polaris.edu

Rock Valley College

RVC's welding program currently includes 60 students trained in the facility which includes a lab with 28 welding booths. Welding processes being taught include: GMAW, FCAW, GTAW, SMAW, and Oxyacetylene. RVC is an AWS Certified Accredited Testing Facility. The welding lab has been at current location for eight years staffed by one full time and five part-time faculty. RVC is a certified ICAR welding testing center. For information, contact Mike Merriman.



Rockford, Illinois
(815) 921-3015
(815) 921-3010
Mike Merriman

Email: m.merriman@rockvalleycollege.edu
www.rockvalleycollege.edu

Santa Fe College

Serving Alachua and Bradford Counties
Founded 1966

The Applied Welding Technologies Program is a one and one-half year certificate program that consists of SMAW, GMAW, GTAW, FCAW, Oxy Fuel Welding/Cutting, blueprint reading and power tool and equipment operation performed on carbon steel, stainless steel and aluminum. The training helps prepare students to pass nationally recognized plate and pipe welding certification tests. The welding lab at SFC is an AWS Accredited Testing Facility.



SANTA FE
COLLEGE

3000 NW 83rd Street
Gainesville, FL 32606
(352) 395-5253
Fax: (352) 395-5364
joseph.mahoney@sfcollge.edu
www.sfcollge.edu

Solano Community College

Founded 1945

Solano Community College offers welding education and training at its Northern California campus in Fairfield, located between San Francisco/Oakland and Sacramento, California. Earn a Certificate or A.S. Degree with day, evening, Saturday and summer classes. Industrial driven curriculum teaches skills in SMAW, GTAW, GMAW, FCAW, Oxy-Acetylene and ornamental iron welding along with various cutting processes utilizing manual, semiautomatic and automatic processes. Customized courses are available for employers. Benefit from free qualification testing and tutoring, affordable tuition and personal attention. Elective courses and schedules are listed at www.scc-careertech.com.



4000 Suisun Valley Road
Fairfield, CA 94534-3197
(707) 864-7279

Robert.Johnson@solano.edu
www.solano.edu

South Plains College

Founded: 1957

The SPC Welding Technology Program offers basic and advanced certificates along with an Associate of Applied Science degree. Entry level and advanced training certificates through AWS are also awarded to those who qualify. Specific areas of training include: OFC, PAC, SMAW plate and pipe, GMAW plate and pipe, FCAW plate and pipe, GTAW sheet and pipe, welding symbols, blueprint reading, welding metallurgy and structural and pipe layout and fabrication.



Pete Stracener
South Plains College
1401 College Avenue
Levelland, TX 79336
(806) 716-2284

pstracen@southplainscollege.edu
www.southplainscollege.edu/welding/index.htm



SCHOOL PROFILES APRIL 2009

Southern Maine Community College

Southern Maine Community College offers courses in Introduction to welding, structural welding I. A. W. American Welding Society D1. 1 and the advanced process, GTAW, FCAW, GMAW and metal art. Earn a certificate in welding or an associate degree in integrated manufacturing that combines welding with machining. In addition to small classes and personal attention, SMCC students enjoy picturesque 80-acre campus surrounded on three sides by water with a sandy beach, a pier, and a working lighthouse.



2 Fort Road
South Portland, ME 04106
(207) 741-5500
Email: jbolduc@smccme.edu
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If for some reason you could not participate this year and would like for us to send you information on how your school can be included in the 2010 edition, just e-mail a note to Rob Saltzstein at salty@aws.org or to Ms Lea Garrigan Badwy at garrigan@aws.org.

You can send us a fax at 1-305-443-7559. Please include the name of your welding school, the mailing address, the contact person, phone, fax and e-mail information.

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Development of a Multiline Laser Vision Sensor for Joint Tracking in Welding

New algorithms improve the reliability and precision in high-speed joint tracking with a multiline laser vision sensor using multiple-range data

BY K. SUNG, H. LEE, Y. S. CHOI, AND S. RHEE

ABSTRACT

In recent years, laser vision sensors have been widely used to track the weld joint. However, they could not be used to detect the joint precisely for high-speed welding. A multiline laser vision sensor (MLVS), which was used in this work overcame the problem.

Five laser lines, which were made by an aspheric lens with a point laser source, provided important information to find the weld joint lines. Clearer images were obtained through the medium, an erosion/dilation filter, and hence, five enhanced range data were obtained by the extraction method.

Through the proposed method, 20 images per second could be processed. Experiments were performed with the MLVS attached to a robot. The weld joint line was tracked with speeds of 10, 15, and 20 m/min, and the mean error was 0.3 mm and a maximum error was 0.6 mm. It was found that this MLVS was very reliable for tracking the weld interface.

Introduction

Laser vision sensors are widely used in automated manufacturing processes in noisy environments, such as welding, because such sensors are robust even in the presence of extreme noise. Smati et al.

(Ref. 1), Clocksin et al. (Ref. 2), and Agapakis (Ref. 3) obtained the feature point from the range data of a base metal using a conventional laser vision sensor, and they suggested that the joint can be found and tracked. Since then, Suga and Ishii (Ref. 4) have applied a laser vision sensor in welding process control and automatic welding inspection. Recently, many kinds of high-speed welding processes have been introduced in an effort to improve productivity. If high-energy sources are used in thin-plate welding, it is possible to weld at 10 m/min or faster (Ref. 5).

Laser vision sensors using a high-speed charge-coupled device (CCD) to obtain high-speed performance have been investigated. However, the cost of this is significantly high. The Oxford Sensor Co. (Ref. 6) in England has attempted to achieve reasonable cost along with enhanced reliability by using circular patterns. However, it was then necessary to have separate rotational scanning devices using galvanometers. Also, there are methods that employ multiple laser sources and CCDs (Ref. 7). However, the resulting vision sensor would be large and expensive.

In addition, Lee et al. (Ref. 8) used a high-speed laser vision sensor to detect the weld defects on the shock absorber of a car. A CCD with a speed of 100 ft/s was used to measure the welding part. However, because the laser vision sensor was large and heavy, they chose to fix the laser vision sensor and move the shock absorber. Also, other studies have used mul-

tiples laser strips. Kang et al. (Ref. 9) used two lasers to obtain the images of wide area. Park et al. (Ref. 10) also used two lasers with different angles of incidence to solve the problem of the high difference of the angles of the workpieces. Bonser et al. (Ref. 11) studied the method of finding the joint in the saddle of a bicycle using 32 or more laser lines. They inserted the entire welding part into the laser area and imaged the laser lines to find the joint at once. This method can find the joint very quickly, but this is possible only when the welding part is small and cannot be applied if real-time tracking is needed.

In this study, a method was developed to process multiple-range data simultaneously using multilaser patterns in an image. This method produced a high data acquisition rate, even while using a standard CCD. By employing a 5-laser-line pattern using a single laser source and lens, a simple, lightweight sensor structure could be fabricated. The prototype for the multiline laser vision sensor (MLVS) was constructed in this way and applied to tracking the joint for high-speed lap joint welding.

Basic Principles of MLVS

The laser vision sensor obtains range data through optical trigonometry. A MLVS can acquire data for multiple laser lines using the same method employed by single-line laser vision sensors.

Figure 1 shows the basic principles of a laser vision sensor. Figure 1A depicts a conventional laser vision sensor, which projects a line-shaped structural laser onto the workpiece and acquires range data by measuring the form of this laser plane with a CCD. The multiline patterned laser vision sensor shown in Fig. 1B utilizes the same principle to obtain range data, but the latter differs from the former in terms of the image obtained by the CCD. The image from the latter contains multiple laser lines whereas the former contains

KEYWORDS

Laser Vision Sensor
Image Processing
Joint Tracking
Lap Joint
Multiline Structured Laser
Triangulation

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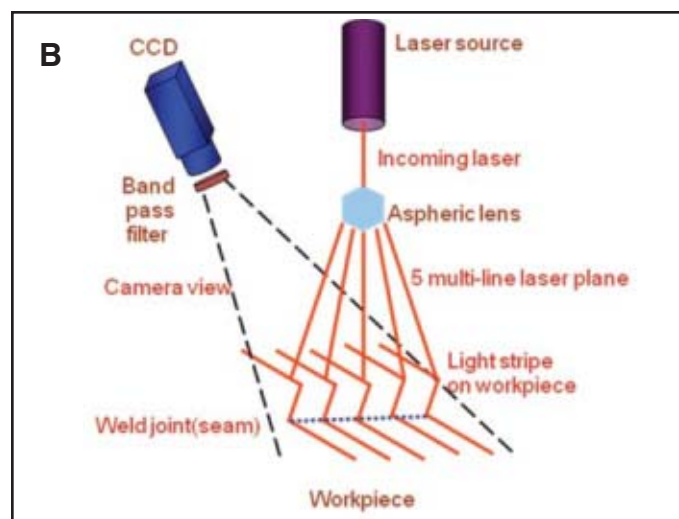
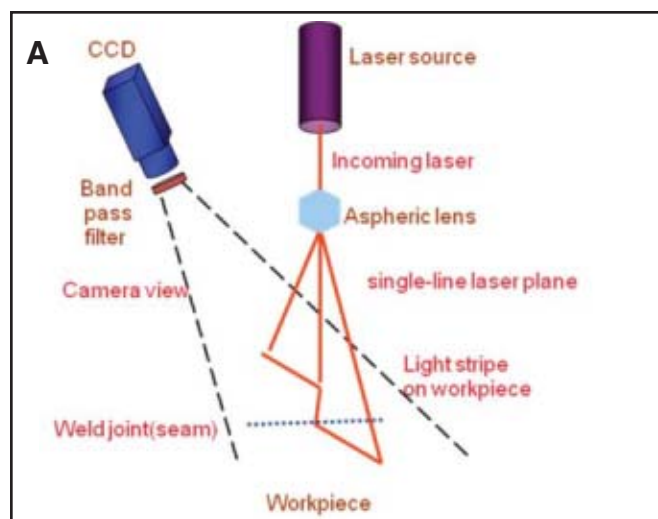


Fig. 1 — Basic configuration of a laser vision sensor. A — Single line; B — multiple lines.

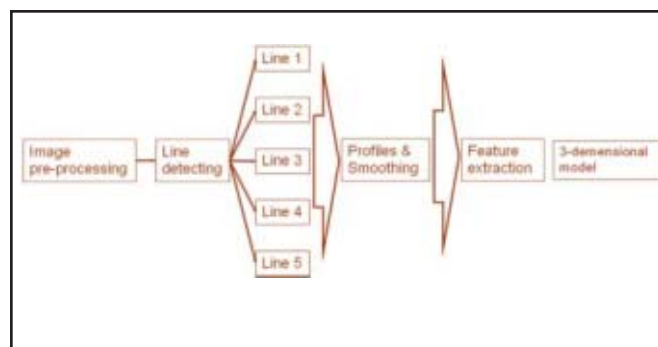


Fig. 2 — Schematic diagram of image processing for multiple laser lines.

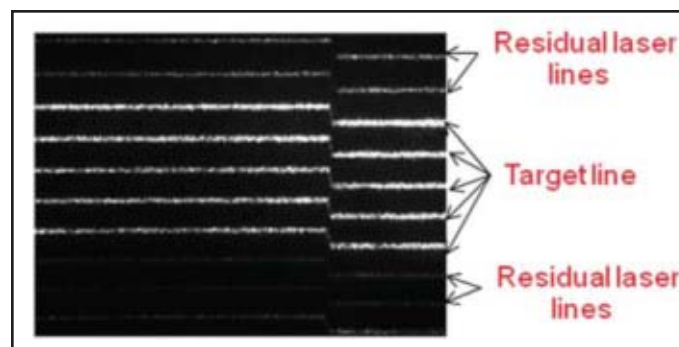


Fig. 3 — Raw image data of the MLVS including noise.

Table 1 — MLVS Validation for High-Speed Lap Joint Tracking

	MLVS : Prototype
Profile fail	1.5%
Valid rate of profile	92.59% (600pixel) 93.21, 93.47, 91.57, 92.05 92.73 (%)
Tracking error	Average: 0.3076 mm Max.: 0.5756 mm

only a single laser line. Therefore, this method requires the additional process of extracting and discriminating multiple laser lines included in the image.

In addition, when the CCD is structurally perpendicular to the ground in the MLVS, each laser plane has a different incidence angle to the workpiece and distance from the starting position to the sensing position, causing the light intensity to change greatly. In such cases, differences in laser

line intensity transmitted to the workpiece will increase, and the thickness and intensity of the laser lines generated on each laser plane will vary. Therefore, the MLVS image processing algorithm should take this phenomenon into account. This new image processing algorithm is shown after this section.

Image Preprocessing and Acquisition of Range Data

Laser lines are extracted from the acquired image, and within the laser lines, the range data are determined by processing the line position. To extract laser lines, image preprocessing, laser-line extraction, and feature extraction are generally implemented.

Figure 2 shows the image processing and range data acquisition process of the MLVS. It is similar to that of a conventional laser vision sensor but differs by having the capability to acquire multiple laser lines from an image, corresponding to multiple-range data.

Since the MLVS acquires multiple-range data from an image, the MLVS requires a more complex processing system than conventional systems, for example, sorting the laser lines after image preprocessing. Nevertheless, in our study, image processing was accomplished within an interval of 20 m/s.

Image Preprocessing

The images obtained from the CCD include not only laser lines but also noise due to spatter, arc light, or overlapped reflection. To extract the laser lines precisely, noise in the CCD images must be removed. This process is referred to as image preprocessing. A smoothing filter and a convolution mask are generally used for this in conventional laser vision sensors (Ref. 12).

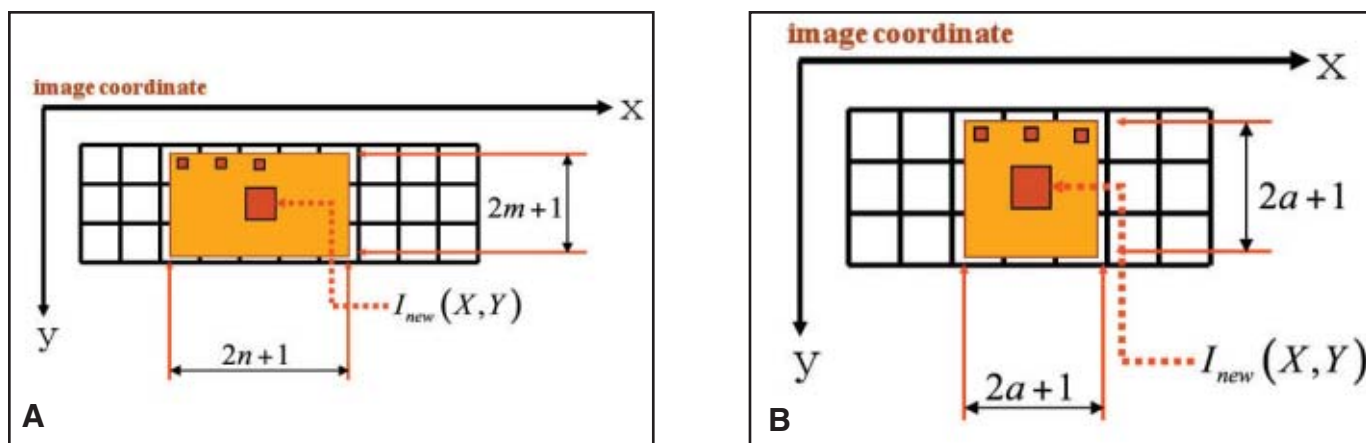


Fig. 4 — Preprocessing filters. A — Advanced median filter mask; B — simplified erosion/dilation filter mask.

In Fig. 3, the additional laser lines, other than the five main lines, are noise. In our system, the point lasers are converted into five main laser lines using an aspheric lens. However, the aspheric lens (Refs. 13, 14) also generates additional noise, which has the same pattern of light intensity as the five main lines, cannot be distinguished from them by a convolution mask. Consequently, a new method is required.

In this study, advanced image preprocessing techniques are proposed. For the first step of preprocessing, an advanced median filter (Ref. 15) was used to remove or reduce the noise within the image. Specialized masks were used for this filter to intensify the laser lines and to weaken the noise. The filter is expressed in Equation 1 and Fig. 4A.

$$I_{new}(X, Y) = \frac{\sum_{j=Y-m}^{Y+m} \sum_{i=X-n}^{X+n} I_{raw}(i, j)}{(2n+1)(2m+1)}$$

where $X = n \cdots (640 - n), Y = m \cdots (480 - m)$ (1)

In Equation 1, I_{raw} is the raw image intensity from the CCD in the image coordinate, and I_{new} is the image intensity after advanced median filtering. $(2n + 1)$ indicates the pixel number within the mask in the x-axis direction, and $(2m + 1)$ shows the pixel number within the mask in the y-axis direction.

Through this process, spot noise and relatively low-intensity line and area noise were removed. The line noise due to spatter in the orthogonal direction against the laser line was merged into spot noise. To completely remove the remaining noise and to strengthen the laser lines, erosion and dilation filters were also used. Equation 2 is an erosion filter, and Equation 3 is a dilation filter (Ref. 16).

$$I'_{new}(X, Y) = \begin{cases} I_{new}(i, j) & \text{if } \prod_{j=Y-a}^{Y+a} \prod_{i=X-a}^{X+a} I_{new}(i, j) > 0 \\ 0 & \text{otherwise} \end{cases}$$

where $X = a \cdots (640 - a), Y = a \cdots (480 - a)$ (2)

$$I''_{new}(X, Y) = \begin{cases} \frac{\sum_{j=Y-a}^{Y+a} \sum_{i=X-a}^{X+a} I'_{new}(i, j)}{(2a+1)^2} & \text{if } \sum_{j=Y-a}^{Y+a} \sum_{i=X-a}^{X+a} I'_{new}(i, j) > 0 \\ 0 & \text{otherwise} \end{cases}$$

where $X = a \cdots (640 - a), Y = a \cdots (480 - a)$ (3)

In Equation 3, I''_{new} is the image intensity after the erosion and dilation filtering. In Fig. 4B, each mask size of the erosion and dilation filter is the same at $(2a + 1)$.

Finally, an advanced half-thresholding method was used to reinforce the contrasts of the intensity (Ref. 17). This made the extraction of laser lines from the image easy. Figure 5 shows the advanced half-thresholding method that was implemented using Equation 4 for each of the Y values. In Equation 4, I represents the final image after advanced half-thresholding. In Equation 5, n is the pixel number of the mask in the direction of the y-axis.

$$I(X, Y) = \begin{cases} 0 & \text{if } I''_{new}(i, Y) < th - value, (i = 0 \cdots 640) \\ I''_{new}(i, Y) & \text{otherwise} \end{cases}$$

where,

$$th - value = \max \left[\frac{\sum_{k=j-n/2}^{j+n/2-1} I''_{new}(k, Y)}{n} \times 0.7 \right]$$

$(j = n/2 \cdots (640 - n/2))$ (5)

Line Discrimination and Extraction Process

Laser line data were extracted from the image after image preprocessing. Then,

each single laser line was discriminated from the other extracted laser lines and was converted into range data. The laser lines were properly ordered to enable extraction of accurate range data.

Following preprocessing, the image was divided into black parts and nonblack parts. It was assumed that any areas other than the black parts within the image were composed of laser lines.

The time available for image processing was limited; therefore, a new algorithm was developed that could extract and discriminate the laser lines simultaneously. Figure 6 shows that the preprocessed image was converted into 5 discriminated laser lines by the extraction and discrimination method.

The column intensity was used for extracting laser lines. As in Fig. 7A, the A-A' line had a width of 1 pixel. The A-A' line is expressed as a column intensity, as in Fig. 7B. The column intensity is represented at $I_k(i)$, where k is the column number along the x-axis in the image coordinates (Fig. 7A) and i is the position of the x-axis in the column intensity function — Fig. 7B.

There are additional laser lines beyond the main five lines, as shown in Fig. 3. To eliminate such noise, it is necessary to determine the peak points and to select the valid groups as shown in Fig. 8. This process consists of the following tasks: determining the peaks from the column intensity, grouping the peaks sequentially by decreasing the intensity, and selecting the group of peaks that has the highest mean intensity. If such a process is applied to each pixel column, a collection of laser lines is obtained for each column.

Extraction of Feature Point

Range data represent the cross-sectional form of a workpiece. A simple

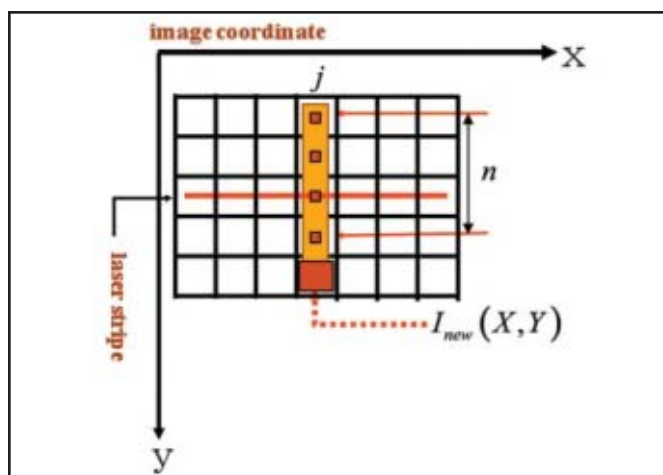


Fig. 5 — Advanced half-thresholding method.

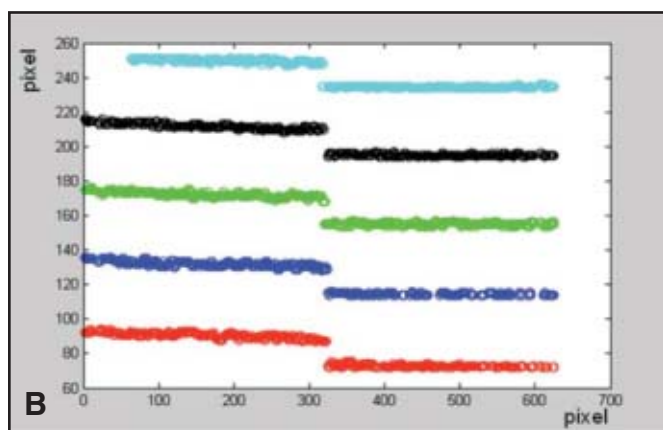


Fig. 6 — Line extraction and discrimination from a preprocessed image. A — Processed image data; B — discriminated laser profile data.

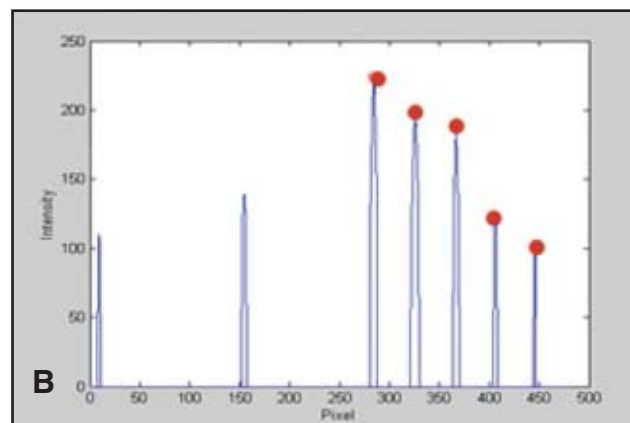
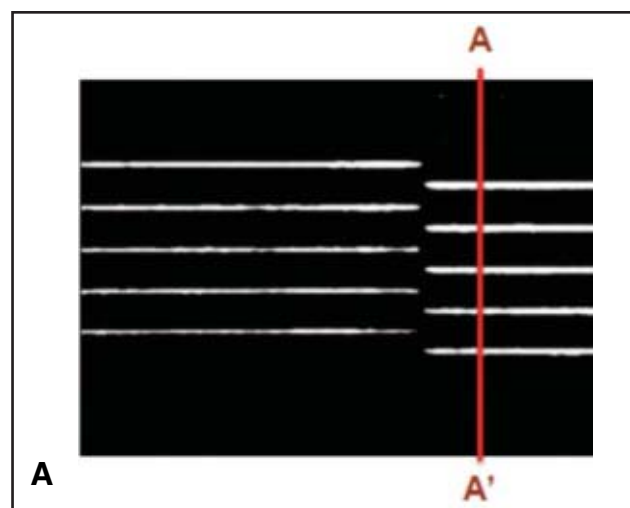


Fig. 7 — Determination of the column intensity from processed image data. A — Processed image data; B — column intensity for section A-A'.

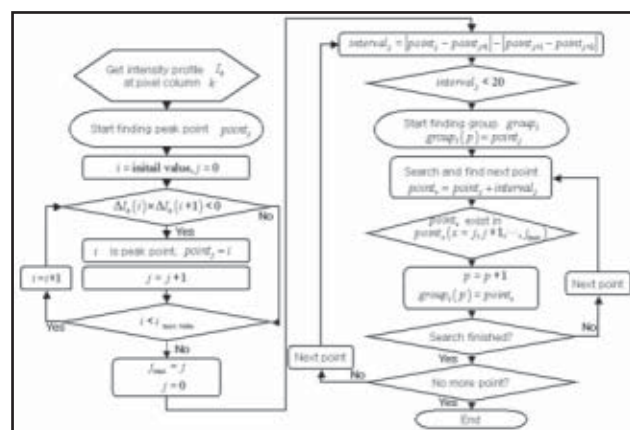


Fig. 8 — Flow chart for the line discrimination and extraction process.

template matching method is used to track the joint (specific point) (Ref. 18). This method extracts the feature points from the range data. Because the MLVS was applied to lap joint joint tracking, two horizontal lines and one sloped line were used, as shown in Fig. 9.

The traditional “split and merge” method was adapted for feature extraction in this study (Ref. 19). The adopted split

and merge method employs a technique that generates straight lines based on three points and then measures the angles among them. This method can minimize errors near the feature points and increase the processing speed.

Because we used the split and merge method, the merged point in Fig. 10 is unified in a straight line if the angles of the line stay near 180 deg, as shown in Fig.

11A. As indicated in Fig. 11B, a noise that is a white point in Fig. 10 is removed when the angle between the two lines exceeds a certain threshold. If the method is repeated, only the feature points, which are solid, will remain in the end. Thus, the template is matched with the feature points, and the tracking point is found.

The joint was constructed by determining the trends of the tracking points. The

MLVS relies on measured fields that partially overlap; hence, tracking errors could be detected through a comparison of current tracking points with prior tracking points, enabling the MLVS to safely track the joint even at higher speeds.

MLVS System

The MLVS system consists of a laser source, aspheric lens, and CCD camera. The laser used for MLVS was a IIIb-class diode laser with power of 100 mW and wavelength of 650 nm. An aspheric lens made by StockerYale, Inc., was used to generate five laser strips. This aspheric lens can generate five laser lines at 120 mm, which are 7 mm apart. A ½-in. CCIR CCD with 640 × 480 pixels was also used to capture the maximum 30 frames per second. A 650-nm band pass filter with band width of 10 nm was installed in this device. This sensor is shown in Fig. 12.

To process the incoming images in the CCD, image grabber Meteor MC was used (Ref. 20). The digital images were obtained from analog images with this grabber. An industrial computer was used to process images and calculate robot motions. The image processing program was written on the basis of C++. Also, for real-time tracking, the image processing program was created in such a way as to be integrated into the robot control program.

The horizontal and vertical resolutions of MLVS were 0.06 mm. The MLVS software includes an image processing program that is capable of processing more than 20 frames per second. In terms of a conventional single-line laser vision sensor, this would be the equivalent of more than 100 frames per second.

Results

Experimental Setup

The weld joint tracking system was composed of a Samsung 6-axis welding robot, the fabricated MLVS, and an industrial PC with image grabbing board as shown in Fig. 13. If the joint was very long, the 4-axis bogie-type robot was used. The industrial PC received image signals from the MLVS and performed image processing and analysis; in addition, the PC played a role in controlling the robot through the Ethernet, and in using the subsequent results. The software for these functions was developed as part of our study.

Results of Joint Tracking

Figure 14 shows the laser lines projected onto the workpieces by the MLVS, and the images acquired from the workpieces are depicted in Fig. 15A. The images before preprocessing noticeably

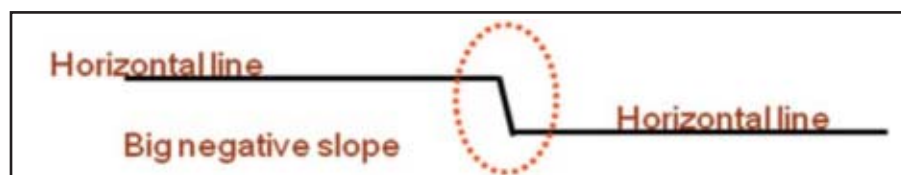
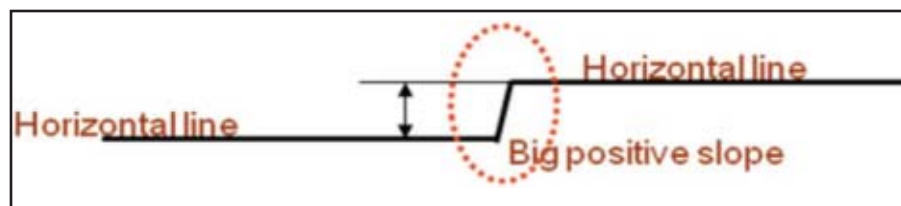


Fig. 9 — Lap joint template for feature extraction. A — Big positive slope; B — big negative slope.

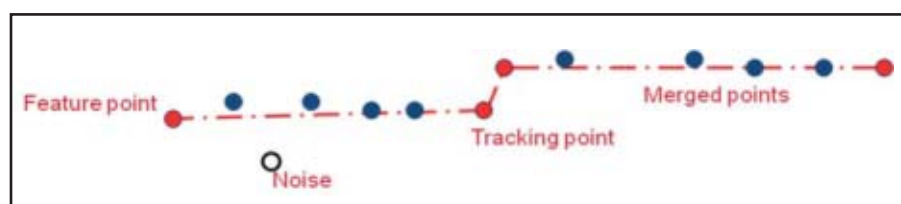


Fig. 10 — Advanced “split and merge” algorithm for the plane surface in a welded joint.

include a great deal of noise in addition to the laser lines. Figure 15B demonstrates the features of noise removal and the reinforcement of the laser lines by the advanced median filter. In a subsequent stage, the erosion/dilation filter was able to reduce the remaining noise even further while subtly enhancing the laser lines. Finally, images could be acquired without noise, as shown in Fig. 15C, using the half-threshold method developed for this study.

An experiment to obtain range data in a straight-line lap joint was conducted. The experiment checked the image processing algorithm of the MLVS and the accuracy of the range data extraction. Range data were obtained while moving along a 1-meter path 5 times at each of the following speeds: 10, 15, and 20 m/min. Figure 16 shows the range data obtained from MLVS at 15 m/min tracking speed. The x marks in Fig. 16 are tracking points.

The probability of obtaining false range data was 7.4% on average, according to the experiment. Thus, about 44 points were incorrectly positioned among 600 points in one set of range data. However, most of the incorrect points were positioned near the beginning or end of the range (#1~50 or #550~600 pixel data positions). The beginning and end of the range data are relatively less important than the other parts.

It would be possible to examine the mutual relationships among the five laser lines, and to modify them, so as to remove

additional errors. After completing this, the probability of errors in the range data created by the laser line would be less than 1%.

The “Profile fail” in Table 1 indicates a case where one of the frames obtained only incorrectly positioned welding parts in the aforementioned experiment. These were mainly cases involving errors in the range data for the fifth laser line. There were no cases in which a preponderance of range data involving all five laser lines caused incorrectly positioned welding parts. The “valid rate of profile” is the rate of the number of range data points normally obtained in the range data acquired from a frame. It is assumed that the weld joint is a completely straight line and that there are no robot tracking errors. When generating the robot’s welding path by extracting tracking points from range data under this assumption, the “tracking error” is the difference of the robot’s welding path from the weld joint.

The results demonstrated that the MLVS could extract five range data values simultaneously from a frame by using the new image processing method and range data extraction algorithm while employing existing hardware. Such range data were found to be accurate and was obtained quickly enough to support tracking applications using robots.

The laser vision sensor is located in front of the welding gun to extract the joint in advance. For a single-line LVS, the

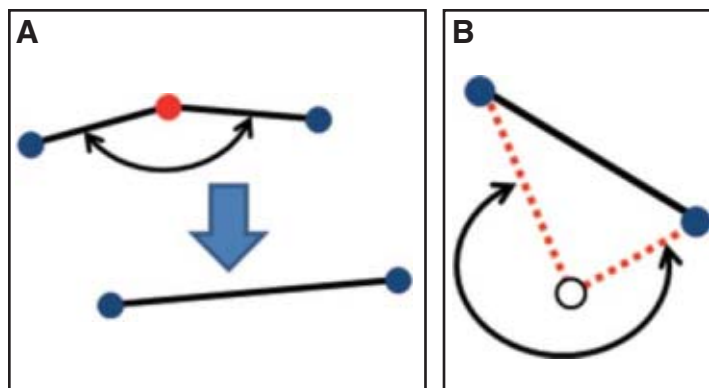


Fig. 11 — Advanced split and merge feature extraction algorithm for joint tracking. A — Simplified split and merge polygonal approximation; B — noise detection using polygonal approximation.

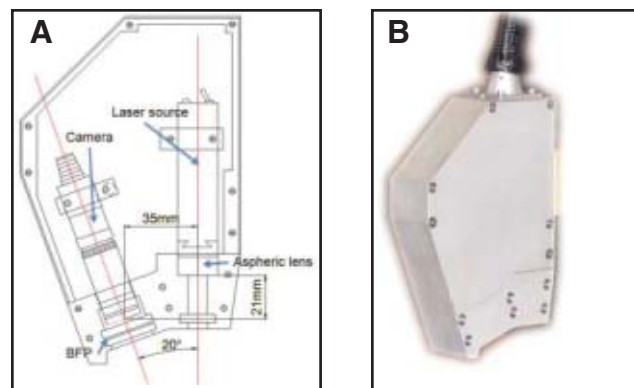


Fig. 12 — Design and fabrication of MLVS. A — Design of MLVS; B — fabricated prototype MLVS.

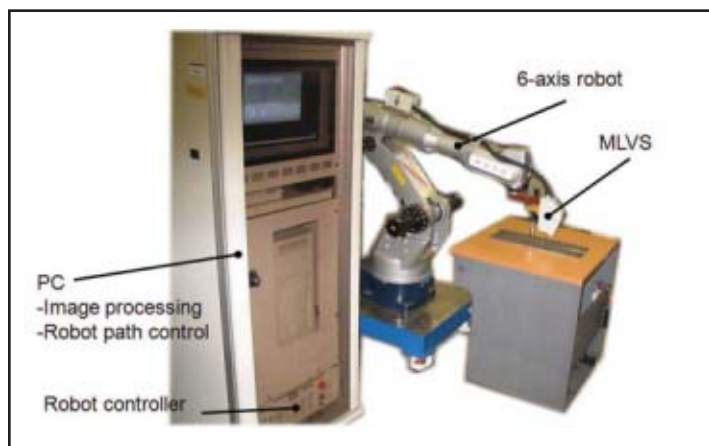


Fig. 13 — Joint tracking system configuration.

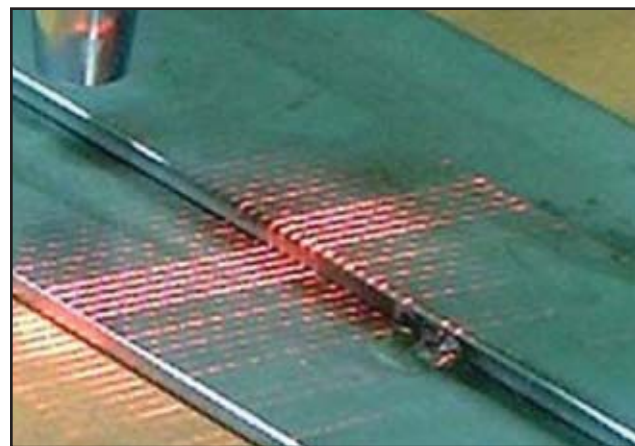


Fig. 14 — Projected laser stripes.

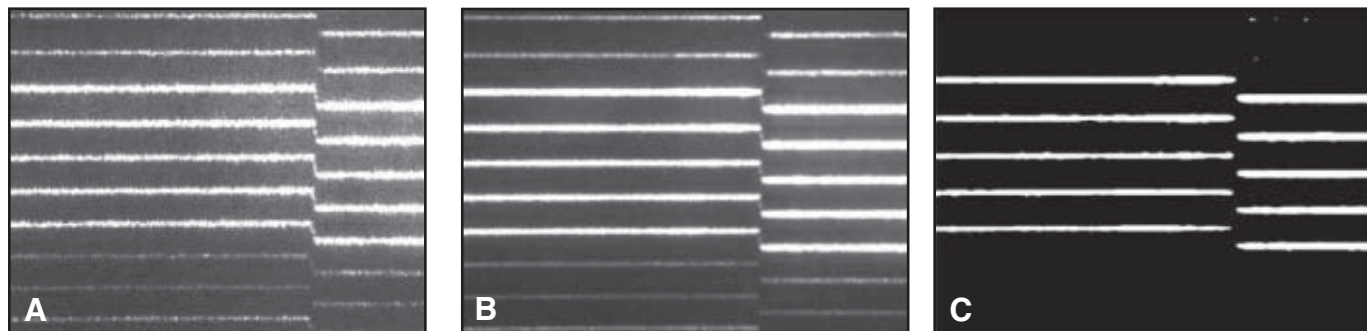


Fig. 15 — Image processing procedure. A — Raw data; B — used advanced median filter; C — final image

data for the joint line were obtained at intervals of 5 mm for a welding speed of 10 m/min. In the case of MLVS, the information for the joint line was obtained every 2 mm. Therefore, a more accurate and stable joint tracking was possible.

Conclusions

In this study, we developed a multiline laser vision sensor that improved the

tracking capability and reliability of conventional laser vision sensors so as to apply high-speed joint tracking. New algorithms applied in the MLVS enabled multiple range data to be obtained concurrently within a single image by using multiple laser stripes.

To increase the reliability and precision in high-speed joint tracking, the MLVS uses multiple-range data. In this study, a single laser optical system and a single

CCD were used to obtain multiple-range data from an image. This process can be modified to be compact so that it would be suitable for an automatic system.

Since the MLVS acquires multiple-range data from an image, the adapted preprocessing method was advanced to be suitable for this research. Also, a new algorithm was developed to extract and discriminate the laser lines from the preprocessed image. Advanced prepro-

cessing adapted a median filter and an erosion/dilation filter that were modified to be suitable for this study. A new method to threshold, half-thresholding, was proposed to make an easier line separation and extraction process.

To minimize the processing time, a new algorithm was developed to extract and discriminate the laser lines simultaneously. This algorithm enables ranges to be distinguished, which are considered to be the laser lines within the image, and put the most suitable laser lines into the valid group by comparing each line with the patterns. The whole image processing was accomplished within 20 ms, and the range data have 93% accuracy on average.

In this study, a prototype MLVS was designed and fabricated using a conventional CCD. A simple template matching method was used to determine tracking points using the feature extraction algorithm. Determined tracking points were transmitted to the welding robot by using the Ethernet. This system was constructed and applied in high-speed (max. 20 m/min) joint tracking in a lap joint and tracked a joint successfully, less than 0.3 mm average error.

This study conducted the MLVS at nearly the same size and cost of the previous laser vision sensor and increased the precision and reliability of high-speed joint tracking by acquiring multiple-range data within an image.

Acknowledgments

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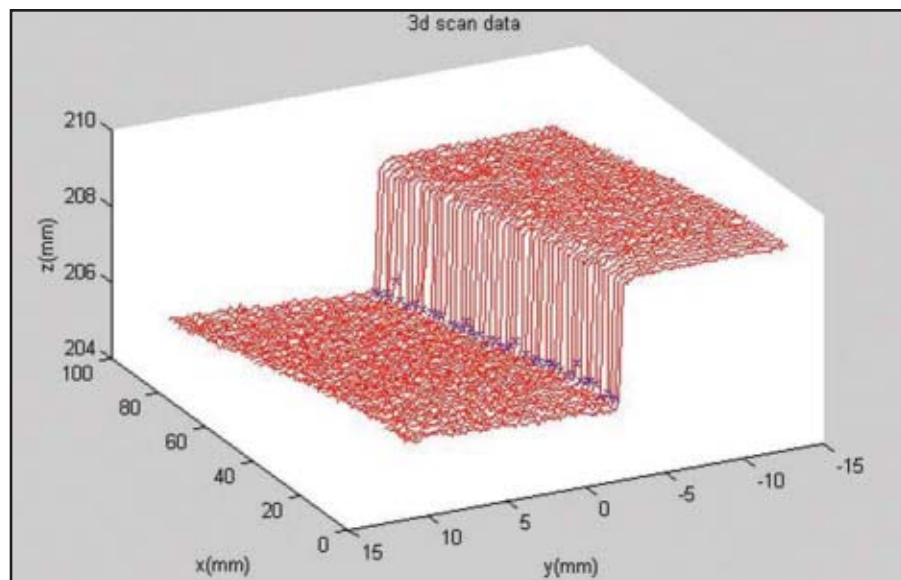


Fig. 16 — Three-dimensional information of the weld joint and workpiece.

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Correction

In the research paper authored by R. Rai et al., which appeared on pages 54-s to 61-s of the March issue, two of the references are incorrect. The Welding Journal regrets the error. The correct references follow:

41. Kim, C. H., Zhang, W., and DebRoy, T. 2003. Modeling of Temperature Field and Solidified Surface Profile during Gas Metal Arc Fillet Welding. *Journal of Applied Physics* 94(4): 2667 to 2679.

42. De, A., and DebRoy, T. 2004. Probing Unknown Welding Parameters from Convective Heat Transfer Calculation and Multi-variable Optimization. *Journal of Physics D: Applied Physics* 37(1): 140 to 150.

Effect of Buffer Sheets on the Shear Strength of Ultrasonic Welded Aluminum Joints

Experiments showed the buffer sheets reduced sticking and part marking

BY M. BABOI AND D. GREWELL

ABSTRACT

Ultrasonic metal welding is a solid-state joining process that is extensively used by the electronics industry. Other industries also have a strong interest in extending its use in high-strength aluminum alloys, stainless steels, and other advanced materials. In some applications, adhesion between the tooling and parts, and marking of the parts can be issues. To address these issues, a series of experiments were conducted using buffer sheets of copper or zinc between the tool (horn) and the samples to be welded. The main objectives of this work were to reduce sticking between the horn and sample as well as reduce part marking. It was seen that the buffer sheets reduced the tool/part adherence (sticking) and part marking. It was believed that buffer sheets absorbed a portion of the ultrasonic energy reducing part marking. While the copper buffer sheets reduced the ultimate weld strength this effect was not observed with zinc buffer sheets. In addition, part thickness affected the impact of the buffer sheets. For example, thicker samples (3 mm) exhibited a greater loss in weld strength with the use of buffer sheets compared to thinner (2-mm) samples welded with buffer sheets.

Introduction and Background

Ultrasonic metal welding (UMW) — invented more than 50 years ago — is a process that consists of joining two metals by applying ultrasonic vibrations under

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moderate pressure. High-frequency vibrations (+20 kHz) locally soften the faying surfaces to form a solid-state weld through progressive shearing and plastic deformation. Figure 1A details a typical ultrasonic setup and motion. Preexisting oxides and contaminants are removed by the motion (scrubbing) producing pure metal/metal contact between the parts allowing intermetallic bonds to form. Beyer states that “Ultrasonic welding of metals consists of interrelated, complex processes such as plastic deformation, work hardening, breaking of contaminant films, fatigue crack formation and propagation, fracture, generation of heat by friction and plastic deformation, recrystallization, and interdiffusion” (Ref. 1). Also, it is worth mentioning that “the dominating mechanism for ultrasonic welding is solid-state bonding, and it is accomplished by two different processes: slip and plastic deformation” (Ref. 1).

Because tool/part adhesion (stickage) and part marking can be issues during manufacturing, finding a solution may allow UMW of aluminum to be further utilized in industry. Copper is known to improve the strength of the aluminum as an alloying element (Refs. 2, 3). It is proposed here, that by increasing the strength of the aluminum alloy, the risk of horn tip penetration in the top part should be reduced. Also, by placing a Cu sheet between the horn tip and the top part prior to ultrasonic welding, the tool/part adhesion should be greatly reduced because of the low/steel,Cu affinity, as well as the strengthening effect of Cu (Refs. 2, 3).

KEYWORDS

Aluminum Alloys
Friction Welding
Ultrasonic Welding
Part Adherence
Part Marking
Buffer Sheets

Figure 1 illustrates the buffer sheet placement and the part marking that can be experienced after UMW. It is seen that part marking is produced on both the horn and anvil sides, but the horn side exhibits relatively more marking. Thus, the focus of this work was to reduce part marking at the horn interface. While it is known that the welding tip and anvil must be designed properly to match the base material and part thickness, part marking remains an issue. For example, Gao (Ref. 4) reports successful welding with similar tip design.

As previously noted, zinc buffer sheets were also studied to reduce the risk of galvanic corrosion in long-term applications (Ref. 5).

In addition, while not reported in detail here, several tip coatings, namely hard-type coatings such as Balinit® C Coating, carbide coatings/insert, and plasma treatments, were also evaluated and found to have adverse effects on part/horn adhesion. That is to say, these coatings either increased sticking/part marking or promoted premature failure of the horn and were thus abandoned.

Objective

The main objective of this work was to characterize the use of buffer sheets to reduce part marking and sticking between the horn and sample. Because buffer sheet placement could be automated as is already done in the plastics industry, the proposed solution would increase productivity by reducing the effort required to separate the horn and part and increase part quality.

Experimental procedure

Experimental design

In order to determine the optimum weld energy value for the various amplitude settings, welds were made at various energy levels ranging between 800 and 5500 J. The weld energy was measured by the power supply in terms of electrical energy. The weld cycle was terminated once

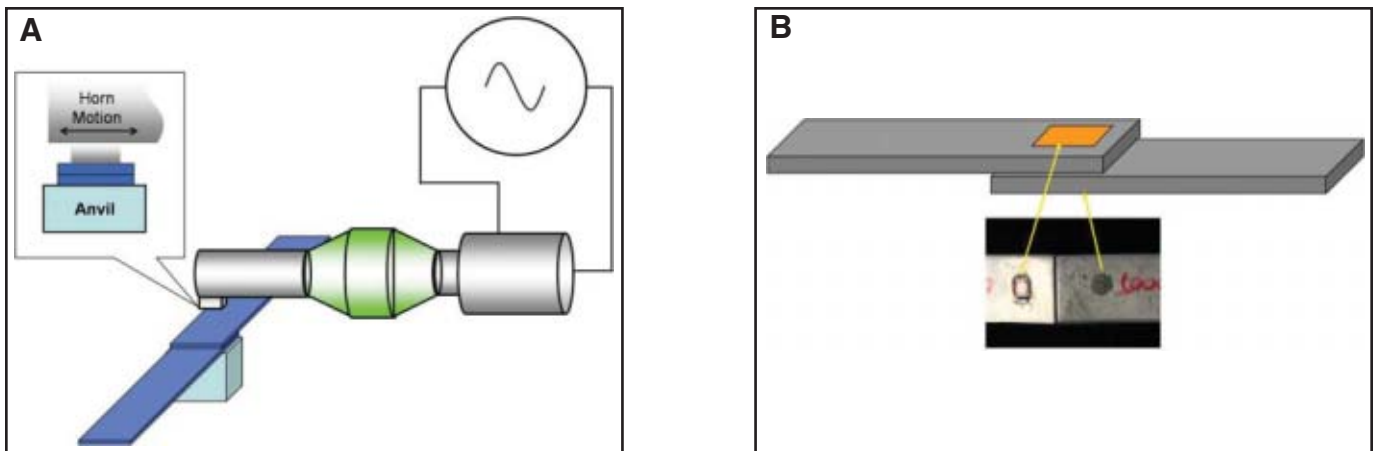


Fig. 1 — A — Illustration of ultrasonic metal welding; B — buffer sheet placement on top and part marking at the bottom.

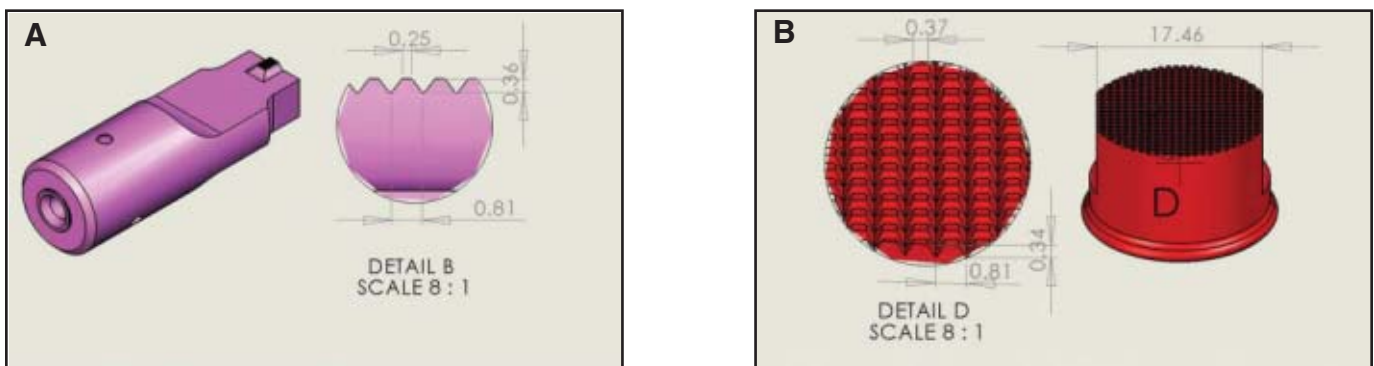


Fig. 2 — Design details (in mm) of the following: A — The welding tip; B — anvil tip.

the preselected value was achieved. This range was selected based on screening experiments that showed values above and below these values resulted in no welds or significant part damage, respectively. The welds were made in increasing order of weld energy level setting with increments of 500 or 1000 J and were not randomized. Ten samples were welded for each energy level setting. The weld amplitudes studied ranged from 43 to 60 μm_{pp} at the various energy values. Additional details of the amplitude settings are defined in the equipment section. The weld force was set to a constant value of approximately 3400 N (90% of the machine maximum capability) based on screening experiments that indicated lower weld force values resulted in inconsistent welding results independent of the amplitude setting.

Table 1 shows the variation of the amplitude and energy values studied in this paper with and without copper and zinc buffer sheets.

Materials

The UMW was completed with alu-

minum AA5754-H111 coupons with thicknesses of 2 and 3 mm. The samples were used in an “as-received” condition and were purchased from Novelis, Inc. The weld configuration was two 25.4- × 100-mm overlapping coupons, with a 25.4-mm (1-in.) overlap and the weld centered on the overlap. Copper and zinc buffer sheets were cut from approximately 0.1-mm-thick chemically pure sheet and were approximately 5 × 5 mm in size. In screening experiments it was found that thicker buffer sheets greatly reduced weld strength and thus a thickness of ~0.1 mm was selected.

Equipment

In order to ensure optimized conditions, both constant amplitudes (60 and 40 μm_{pp}) and the amplitude profiling (60–43 μm_{pp}) with buffer sheets (Cu or Zn) were studied. Amplitude profiling was included in this study because it has been shown to improve weld strength (Ref. 6). In more detail, with conventional UMW, the amplitude remains constant throughout the entire weld cycle. In contrast, with ampli-

tude profiling the amplitude is adjusted to match the various phases of the weld. For example, initiating the weld with a relatively high amplitude then reducing it as the weld progresses, promotes a fast, relatively uniform weld that undergoes reduced shearing at the later stages of the weld cycle that enhances weld strength.

The weld amplitude was varied using a WPC-1 controller manufactured by Branson Ultrasonic Corp. Based on screening experiments, the switch-over mode was selected as time for amplitude profiling and was held constant at 2.0 s. The switch-over mode is the parameter that defines when the amplitude is switched from an initial value “A” (typically 60 μm_{pp}) to a secondary value “B” (typically 43 μm_{pp}). In this work, only time was evaluated as this is the simplest mode to visualize.

The horn was a standard knurled tip and the anvil was a standard “flex” anvil (designed by SonoBond Inc.). They are detailed in Fig. 2. In screening experiments a rigid anvil was used, but in all cases the resulting welds were extremely weak and thus, this anvil design was abandoned. It was theorized that with a rigid

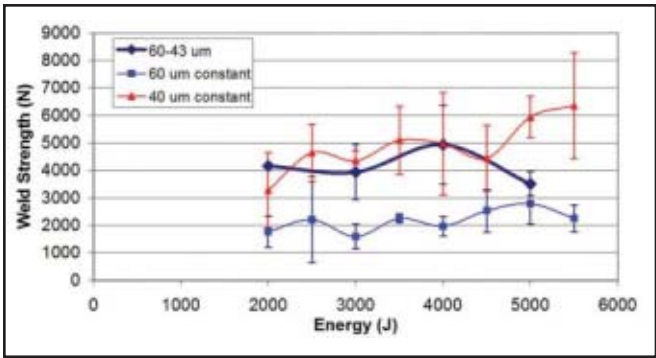


Fig. 3 — Weld strength with Cu buffer sheets for amplitude profiling and constant amplitude for 3-mm coupons.

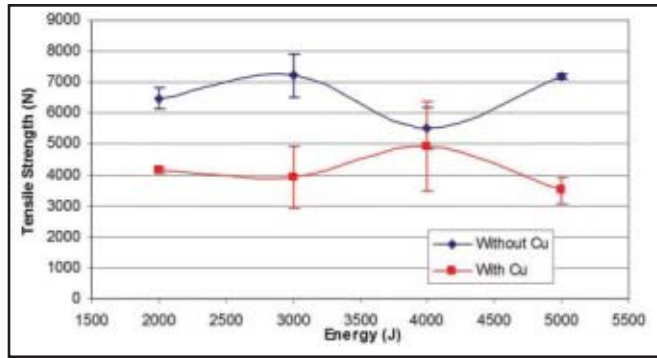


Fig. 4 — Weld strength vs. energy with amplitude profiling with and without copper buffer sheets for 3-mm samples.

anvil the weld was continuously exposed to high shear forces during the entire weld cycle, which fractured the resulting weld in the final phases of the weld cycle when the weld is being formed. In contrast, with a flexible anvil, which had sufficient rigidity to allow motion between the two samples, the relative motion between the anvil and weld tip was reduced as the weld grew in

size and became stronger. While not reported here (see appendix) this effect was documented using a laser vibrometer that recorded the instantaneous displacement of the anvil. A squeeze time of 0.2 s was used to allow the force to fully develop prior to activation of the sonics. The actuator was a specially designed pneumatic linear system that had linear rails to reduce rotation of the

stack assembly during welding that had a maximum force of 3700 N, which is consistent with typical optimized weld forces reported by others (Refs. 7–12).

Characterization

All welds were tested in tension at a crosshead speed of 10 mm/min. The maximum sustained load was correlated to the ultimate strength. Shims were not used in the grips with the sample and thus bending stresses were not minimized. It is important to note that while weld size was generally proportional to weld energy, it was not recorded and only final weld strength was reported in terms of maximum load. Also, it should be noted that although the coupons were tested in tension, the welds were mostly in shear.

Results and Discussion

Study of the 3-mm Aluminum 5754 Coupons Using Cu Buffer Sheets

For those experiments involving Cu buffer sheets, weld strength as a function of the energy graph is seen in Fig. 3. It is seen that at the relatively high amplitude (60 μm_{pp}), the weld strength is relatively low and rarely exceeded 3000 N. This is due to shearing of the weld, which prevented proper joining of the faying surfaces. In more detail, the shearing promoted fracture of the faying surface at the end of the cycle. With the lower amplitude of 40 μm_{pp} and with amplitude profiling from 43 to 60 μm_{pp} , the weld strength was typically over 4000 N, suggesting that lower amplitudes enhance joining as previously reported (Ref. 6). It is important to note that with amplitude profiling a final amplitude of 40 μm_{pp} was not used because of frequent power supply overloads. That is to say that the available power from a power supply is generally proportional to amplitude setting. Thus, at lower amplitude settings, the maximum avail-

Table 1 — Amplitude and Energy for Coupons with and without Cu and Zn Buffer Sheets						
Amplitude (μm_{pp})	3 mm Energy (J) with Cu Buffer sheet	3 mm Energy (J) w/o Cu Buffer sheet	2 mm Energy (J) with Cu Buffer sheet	2 mm Energy (J) w/o Cu Buffer sheet	3 mm Energy (J) with Zn Buffer sheet	3 mm Energy (J) w/o Zn Buffer sheet
60	2000		2000		2000	
	2500		3000		2500	
	3000		4000		3000	
	3500		5000		3500	
	4000				4000	
	4500				4500	
	5000				5000	
	5500				5500	
	2000		1000			
	2500		1500			
40	2000		2000			
	3000		2000			
	3500		2500			
	4000		3000			
	4500					
	5000					
	5500					
43					2000	
					2500	
					3000	
					3500	
					4000	
					4500	
					5000	
60-43	2000	2000	900	800	2000	2000
	3000	3000	1000	900	2500	2500
	4000	4000	1100	1000	3000	3000
	5000	5000	1200	1100	3500	3500
			1300	1200	4000	
			1400		4500	
			1500		5000	
					5500	

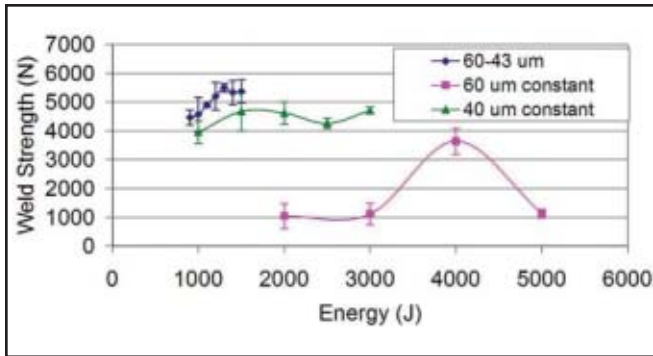


Fig. 5 — Weld strength with Cu inserts. Strength function of energy for amplitude profiling and constant amplitude with 2-mm coupons.

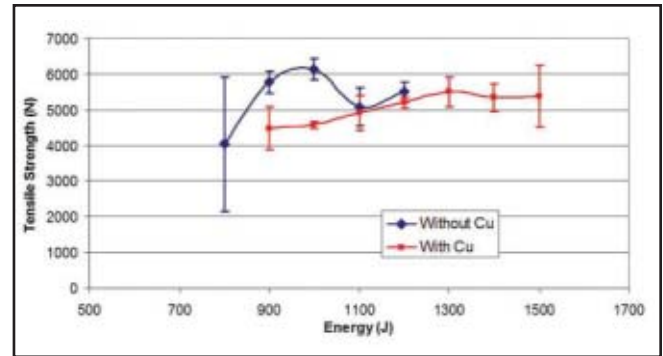


Fig. 6 — Weld strength vs. energy with amplitude profiling with and without Cu buffer sheets for 2-mm samples.



Fig. 7 — Part marking. A — Without, and B — with Cu buffer sheets.

able power is reduced. In more detail it is important to note that the maximum power capacity of the power supply is directly proportional to the set amplitude level. In addition, it is assumed that there is no difference between welds made with 40 and 43 μm_{pp} . It is seen that at the lower amplitude the weld strength exceeded 6000 N with weld energy of 5500 J. This most likely resulted from the lower amplitude at the end of the weld cycle allowing the weld to bond under lower shearing conditions, promoting good joining. In more detail, assuming a constant attenuation, shearing of the weld interface is proportional to the weld amplitude. It is important to note that without amplitude profiling, the cycle times for the welds made with the lower amplitudes were typically two to three times longer.

Because amplitude profiling was seen to have some benefits in the ultrasonic welding of aluminum, such as relatively high weld strength, Fig. 4 shows the weld strength as a function of energy only for welds made only with amplitude profiling. The graph compares the weld strength values of the samples welded with and with-

out copper buffer sheets. It is seen that the maximum weld strength for the samples welded without buffer sheets was slightly over 8 kN. In contrast, the samples welded with copper buffer sheets had a maximum weld strength of ~ 5 kN. It is important to note that the copper buffer sheets noticeably reduced part marking and the tool/part adhesion as will be detailed later.

Study of the 2-mm Aluminum 5754 Coupons Using Cu Buffer Sheet

For the experiments involving Cu buffer sheets for the welding of 2-mm-thick 5754 coupons, weld strength as a function of the energy graph is seen in Fig. 5. Interestingly, the welds made with thinner samples produced higher weld strengths compared to the previous results with the thicker samples. For example, in the previously detailed experiments with thicker samples, the weld strength rarely exceeded 5000 N. However, with the thinner 2-mm-thick samples, it is seen that for many conditions, the weld strength exceeded 5000 N. With the thicker samples (3 mm), the amplitude is attenuated and

inertial effects reduce the true amplitude at the faying surface. In contrast, with the thinner samples, the amplitude is less attenuated and thus welding is more effective. This is supported by the observation that with the thinner samples and higher amplitudes, where shearing of the fused joint promotes failure, the weld strength was typically only 1000 N and never exceeded 4000 N. It is also seen that amplitude profiling produced relatively high weld strengths. For example, with a constant amplitude of 40 μm_{pp} , the maximum weld strength was less than 5000 N. Higher weld energies (>3000 J) with a constant amplitude of 40 μm_{pp} experienced impossible welding due to complete sinking through coupons and were excluded from this study. When amplitude profiling was utilized, the weld strength was as high as 5500 N. In addition, when the copper buffer sheets were used, sticking and marking were reduced. As previously noted, welds made with a constant amplitude had cycle times two to three times longer compared to those welds made with amplitude profiling.

Due to the higher weld strengths that

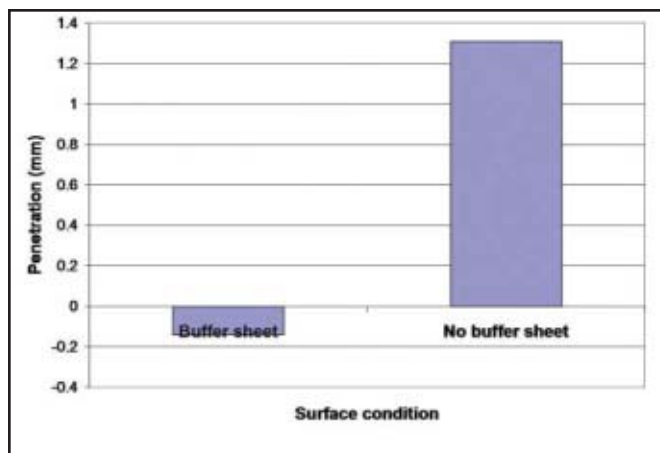


Fig. 8 — Penetration with and without buffer sheets (1200 J, 2-mm sample).

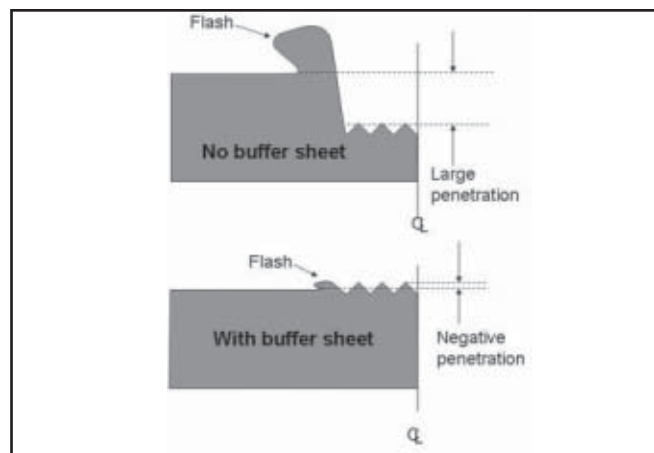


Fig. 9 — Illustration detailing penetration measurements at the weld center-line (CL).

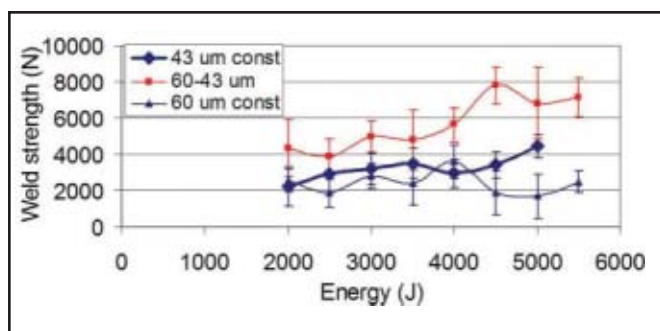


Fig. 10 — Strength vs. energy for amplitude profiling and constant amplitude with Zn buffer sheet.

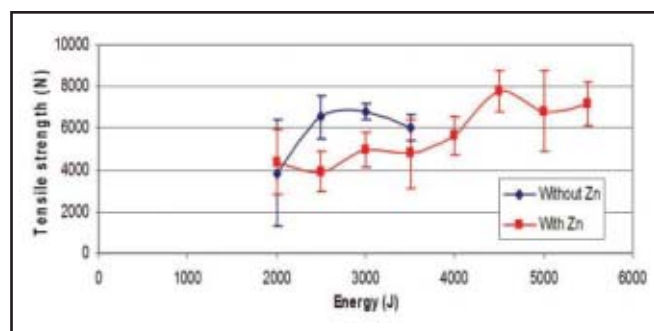


Fig. 11 — Weld strength function of energy (with and without Zn buffer sheet).

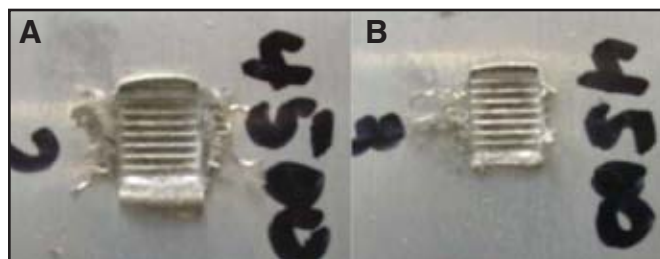


Fig. 12 — Part marking without (A) and with (B) Zn buffer sheets.

were observed from welds made with amplitude profiling, a more detailed study focused only on welding with amplitude profiling with and without copper buffer sheets. Figure 6 shows weld strength as a function of energy for 2-mm-thick samples welded with and without copper buffer sheets. The maximum weld strength achieved without copper buffer sheets was slightly over 6 kN. In comparison, the samples welded with copper buffer sheets had a maximum strength of ~5.5 kN. However, the copper buffer sheets reduced part marking and tool/part adherence. Welding was impossible due to complete sinking through samples beyond 1200 J for samples welded without buffer sheets and beyond 1500 J for samples welded with buffer sheets. Also, it can be seen that the

standard deviation is, in general, lower for the samples welded with copper buffer sheets. It is also important to note that with the 2-mm-thick sample, weld strength was not significantly affected.

Figure 7A shows a photograph of part marking without the use of buffer sheets.

It is seen that without a buffer sheet there is deep penetration and, consequently, noticeable part marking. In addition, disengagement of the part from the horn required relatively large forces. In contrast, Fig. 7B shows part marking made with the use of a copper buffer sheet. It is seen that the weld made with a buffer sheet exhibited less part marking.

To compare the depth of penetration for the welds made with and without a copper buffer sheet, the depth was measured using a depth gauge. For example, the depth of penetration for welds made with 2-mm-thick samples using 1200 J and an amplitude profile of 60–43 μm is shown in Fig. 8. In this figure, it is seen that the penetration for the sample made without a buffer sheet was

much larger compared to the weld made with the buffer sheet. It is important to note that the penetration is negative for the weld made with a buffer sheet because of the displacement of material from the knurled pattern on the horn. In more detail, because the penetration was nearly zero, the knurled pattern “pushed” material above the surface as depicted in Fig. 9.

Study of Aluminum 5754 Coupons Using Zn Buffer Sheet

Figure 10 shows a graph of weld strength as a function of energy with zinc buffer sheets using a constant amplitude (60 and 43 μm_{pp}) and amplitude profiling (60 to 43 μm_{pp}). It is seen that with constant amplitudes of 60 or 43 μm_{pp} , the weld strength is relatively low and rarely exceeded 3500 N. This is most likely due to shearing of the weld, which prevented proper joining of the faying surfaces. With amplitude profiling of 43 to 60 μm_{pp} , the weld strength was typically ~8000 N. With amplitude profiling and with the zinc buffer sheets, part marking and tool/part adherence were reduced. Also, the cycle times for the welds made with lower amplitude were typically two to three times longer.

Additional experiments with zinc buffer sheets and amplitude profiling were

conducted. For example, Fig. 11 shows weld strength as a function of weld energy with and without zinc buffer (amplitude profiling only). It is seen that in the energy range of 2000–3000 J, the joint shear strength for the coupons welded with Zn buffer sheets is lower compared to the joint shear strength of the coupons welded without the buffer sheets. However, for the energy range beyond 4000 J, a much higher value of the weld strength was noticed; that is, 8000 N, which was never achieved without Zn buffer sheets. It is important to note that there are no data for the weld strength of coupons welded without buffer sheets beyond 4000 J because the weld was impossible due to complete sinking through the coupons.

Part marking was also reduced, as can be seen from the Fig. 12A (without zinc buffer sheets) and Fig. 12B (with Zn buffer sheets). Thus, in summary it is seen that the zinc buffer sheets are more effective in reducing part marking and do not reduce weld strength, which may be due to zinc's relative hardness.

Conclusions

Placing buffer sheets of copper or zinc between the tool (horn) and the top part prior to the ultrasonic welding of aluminum reduced tool/part adhesion and part marking. Also, the use of zinc buffer sheets during the ultrasonic welding of aluminum 5754 alloys resulted in higher maximum weld strength values compared to using copper buffer sheets. It was seen that copper buffer sheets reduced weld strength and this effect is more pronounced with thicker (3-mm) weld samples.

Thus, in summary:

- Buffer sheets significantly reduced part marking and part/tool adhesion.
- Zinc buffer sheets resulted in higher weld strength compared to copper buffer sheets.
- Copper buffer sheets reduced weld strength, especially for thick samples.

Acknowledgments

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Appendix

The chart shown in Fig. 13 follows details motion of the anvil tip as measured with a laser vibrometer. As seen in the figure, the motion of the tip increases as the weld cycle progresses. This confirms that as the weld progresses, there is less relative motion between the weld tip and anvil.

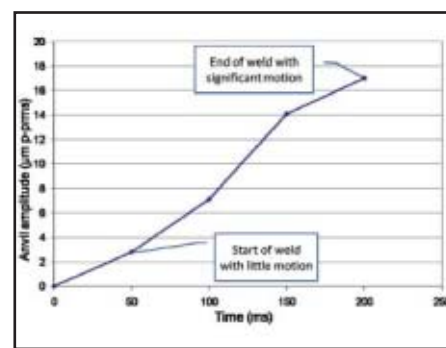


Fig 13 — Motion of the anvil tip as measured with a laser vibrometer

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Methodology for Parameter Calculation of VP-GMAW

A straightforward procedure is presented for the calculation of welding parameters to reach both arc and metal transfer stability

BY L. O. VILARINHO, A. S. NASCIMENTO, D. B. FERNANDES, AND C. A. M. MOTA

ABSTRACT

The development of electronic power sources has allowed the study of innovative processes, generally with the objective to improve productivity allied to low levels of heat input. The existing processes are based on metal transfer evaluation and the development of different waveforms for improving the process control. The variable polarity gas metal arc welding (VP-GMAW) process is a derivative process of conventional GMAW that joins the advantages of the use of positive polarity, as the good stability of arc and cathodic cleaning, with the supplied ones for the negative polarity, which is the high melting rate of the electrode and low heat input to the base metal. However, this process still has a limited use due to shortage of technical and scientific literature devoted to parameter calculation, as the one observed for DC pulsed GMAW (Refs. 1, 2). Also, most of literature is dedicated to aluminum welding (Refs. 3–7). Thus, in this work, a methodology for determination of the process parameters is proposed and evaluated for different waveforms and variable electrode negative ratio (percentage of time at negative polarity). Both arc and metal transfer stabilities are observed as indicators. The experimental procedure was carried out with bead-on-plate welding of mild steel and employing high-speed filming and analysis of bead geometrical features. It is concluded that the proposed methodology is suitable for parameters calculation during VP-GMAW, where a positive base time after the negative one is more effective in reducing abrupt polarity changes and therefore provides more stable arcs and avoids spattering. Finally, it is possible to select the best combination of waveform and electrode-negative time for the application, using the equations presented to predict the weld bead geometry.

Introduction

The alternating current gas metal arc (AC GMA) process is also known as variable polarity gas metal arc welding (VP-GMAW), where the term “variable polarity” is more exactly used to describe waveforms in which the ratio of the two polarities can vary (Ref. 4). Yet the term AC is normally used to describe a sine wave, although it can also be used to describe a current that alternates between positive and negative polarities.

The VP-GMAW process combines the advantages of conventional GMAW (direct current electrode positive (DCEP)) with the increase in the melting rate of the wire and the reduction of thermal contribution when the GMAW process is operated with the electrode in the negative polarity mode (direct current electrode negative (DCEN)) (Refs. 5, 8). Therefore, it is possible to summarize the characteristics of the arc at both polarities as follows:

DCEP

- Electron flow from the workpiece to the electrode wire;
- Lower melting efficiency; and
- Most of the heat concentrated in the base material.

DCEN

- Electron flow from the electrode wire to the workpiece;
- Higher melting efficiency; and
- Most of the heat concentrated in the electrode.

Negative or combination polarities have been successfully used in processes that utilize fluxes such as brazing, flux

cored arc welding, and submerged arc welding. The use of negative polarity (DCEN) to control the thermal contribution on the base metal and penetration in these processes have generated similar interest in GMAW. However, an obstacle that has limited the use of DCEN and variable polarity (or AC) in this process is the instability problem of the arc that comes with the use of negative polarity.

This problem is readily solved with the addition of stabilizing elements in processes that utilize fluxes. Instability problems in solid wire (GMAW) are more difficult to solve than the fluxed processes, which is why the welding with solid wire is operated almost exclusively with positive polarity. Direct current electrode negative polarity is usually limited to globular transfer, and it is seldom used because the resulting arc is unsteady and has an unacceptable spattering level (Refs. 9–11).

Most problems inherent to the DCEN use in GMAW are due to the strong repulsive force that acts under the droplet at the electrode wire tip (cathode). Since the electron flow is from the electrode wire toward the workpiece, repulsive force acting under the droplet appears due to electron emission, generating an erratic cathodic root and therefore an asymmetrically repelled droplet (Ref. 6).

The electrode activation has been employed to improve the electrons emission efficiency and to stabilize the cathodic points in DCEN. This is achieved through the addition of alkaline and rare-earth metals on the wire, but that is an expensive and not very popular method (Ref. 3). The use of blended shielding gases (Ar and O₂ and/or CO₂) has been reported as useful in the success of arc operation in DCEN. This is usually possible only at relatively high currents.

In order to overcome the reignition problems of the arc when the current

KEYWORDS

Variable Polarity
Alternating Current
Pulsed Current
Negative Electrode

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passes through zero during the polarity change in AC, high voltage peaks are applied to keep the ionization of the arc column. However, the high voltage has always been a safety issue (Ref. 6). According to Harwig (Ref. 4), the voltage values applied when the current goes through zero depend on the amount of carbon dioxide in the shielding gas, and it can exceed 400 V.

With the advance of electronic technology, solutions for the past AC problems were found. The technology of inverters has made it possible and inexpensive to produce sources capable of generating almost all the conceivable waveforms (Ref. 3). Problems such as arc reignition when the current goes through zero are easily eliminated by the use of a rectangular waveform, which reduces the amount of time in which the current remains at or near zero (Ref. 3). This advantage eliminates the need for risky high voltages necessary to avoid the reignition problems with sine waveforms.

Characteristics such as low heat input, control over the bead geometry, low deformation, and higher melting rate compared to DCEP have called the attention of the industry, especially the automotive sector. Nevertheless, there is still little technical and scientific literature on the subject (Refs. 3–7), which contributes to the process' low popularity. In addition to that, the difficulty in determining parameters that provide good arc and metal transfer stability further discourage investments in VP-GMAW. Therefore, in this work, a methodology was developed to determine parameters in VP-GMAW for four different waveforms and variable negative-electrode rate at three levels. Looking for the effects of the welding parameters on the process operational performance and the weld metal quality, it is expected to contribute to the development of knowledge and optimization of the VP-GMAW application, promoting its popularization in different industrial segments.

Experimental Procedure

In this work, a study was made focusing on the main parameters used in the VP-GMAW process to define a methodology that allows determination of such parameters in order to obtain both arc and metal transfer stability. In addition, an evaluation of the effect of the waveform and the negative polarity (%EN) on the geometrical features of the welding bead was made as well. Therefore, for a better understanding, the work will be divided in the three steps further described.

The experimental procedure consists of bead-on-plate weldments carried out on mild steel coupons ($250 \times 37 \times 6$ mm), with AWS ER70S-6 wire, 1.2 mm diameter, using Ar+2%O₂ as shielding gas at 15 L/min. A secondary-chopped power source

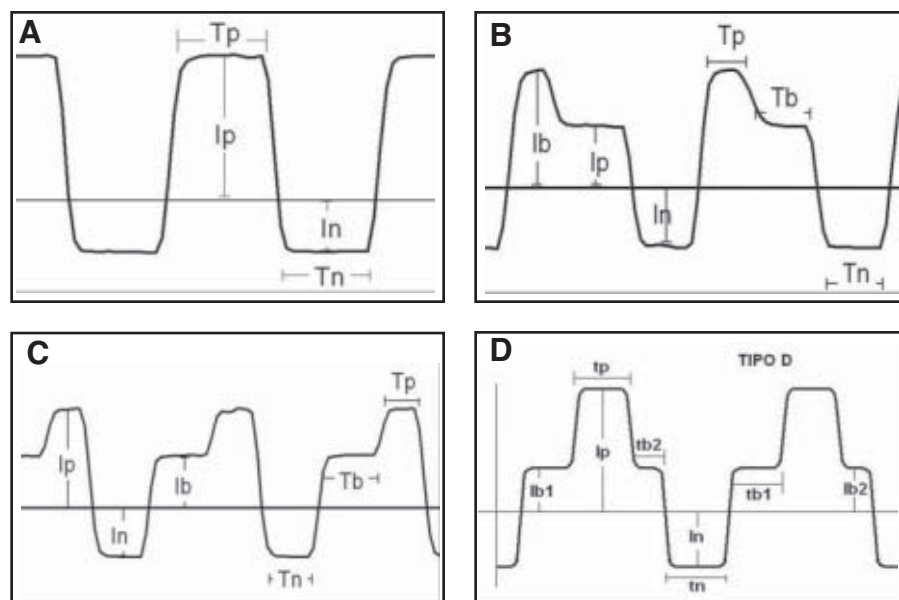


Fig. 1 — Studied waveforms. A — Type A; B — type B; C — type C; and D — type D.

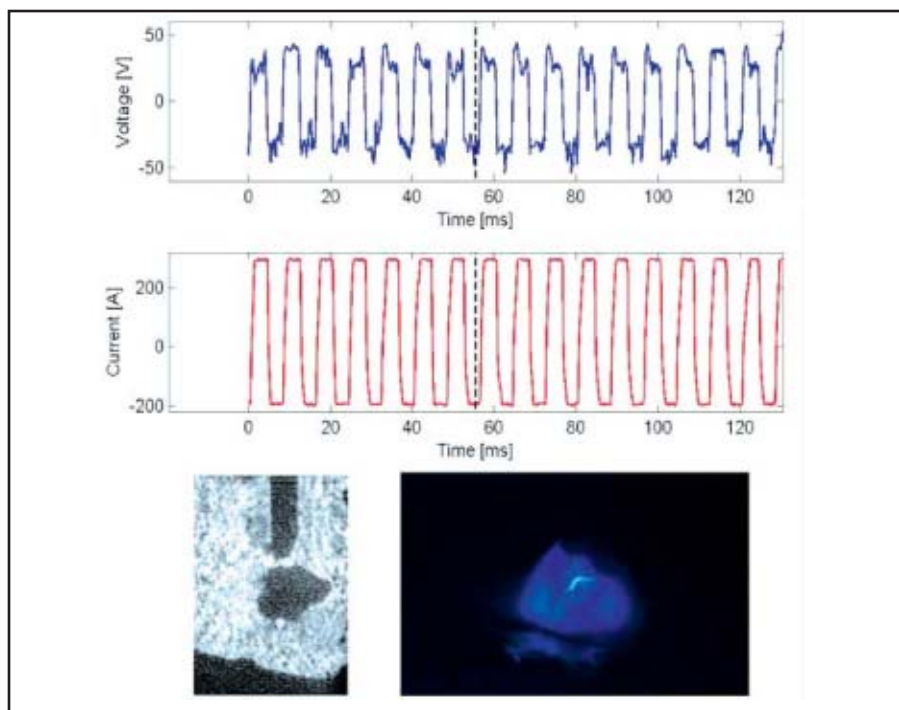


Fig. 2 — Synchronized high-speed images for waveform A and 50 %EN.

was used as well as software/hardware for controlling it. This allows drawing of any waveform shape. For the workpiece displacement, an automatic XY coordinated table was used. The torch was at a fixed position to allow high-speed visualization of the metal transfer by backlighting the electrode wire. In this case, two high-speed filming cameras were employed, both synchronized between themselves and with the

electrical signals (current and voltage) (Ref. 12), which were acquired by a DAQ system at 10 kHz and 16 bits.

Step 1: Determination of the Consumption Equation in the Positive and Negative Polarities

The equation of the melt-off rate (Ref. 13) $WFS = \alpha I_m + \beta LI_e^2$ is a function of

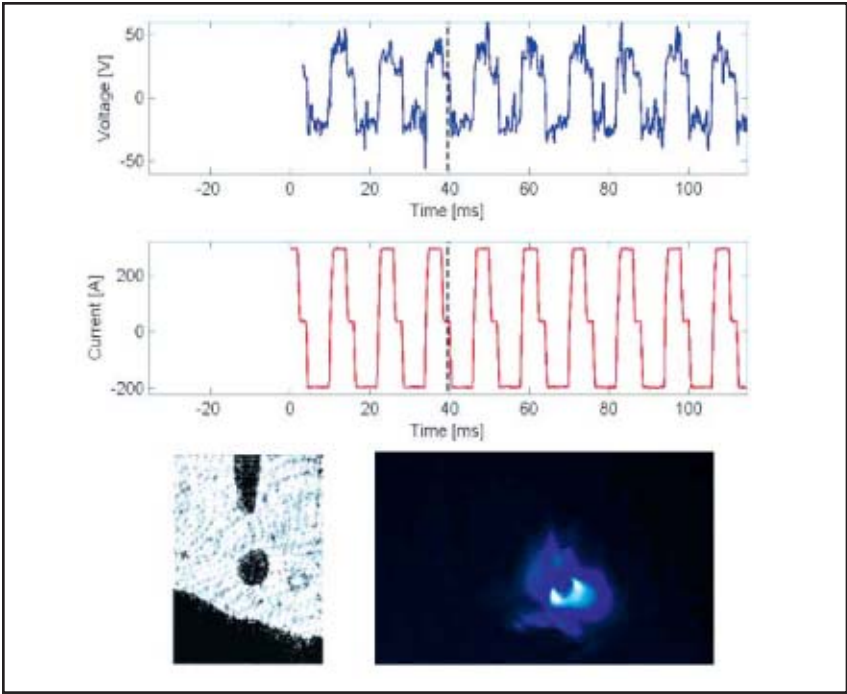


Fig. 3 — Synchronized high-speed images for waveform B and 50 %EN.

the constants α and β , which results in non-linear parameter estimate (nonlinear regression), starting from the experimental determination of the other terms of the equation, where WFS is the wire feed speed, I_m is the mean current, L is the elec-

trode extension, and I_{ef} is the RMS current.

The knowledge of the consumption equation in both polarities is fundamental to avoid the variation of arc length that occurs during the polarity change and, consequently, arc instabilities. Therefore, ex-

periments were made in the positive as well as in the negative polarity where wire feed speed varied, keeping the arc length constant and the resulting values of medium current (I_m) and efficient current (I_{ef}), were then registered. With the data obtained experimentally, a nonlinear regression was carried out to determine the values of the constants α and β .

Step 2: Determination of Parameters that Guarantee Arc Length Stability

One of the main issues that generate instabilities in VP-GMAW is the arc length variation that occurs with the polarity inversion, since the melt-off rate in the negative polarity (DCEN) is greater than in the positive polarity (DCEP). Therefore, in order to obtain a constant arc length, a methodology was created for the determination of parameters based on the premise that the melt-off rate in the positive polarity be equal in the negative polarity, which is why it is so important to have knowledge of the melt-off rate equation.

This is a crucial point of the proposed methodology. The premise of making both positive and negative polarities equal always guarantees both arc stability and bead uniformity. However, stable condition sometimes can be reached at different melt-off rates. It means that the proposed methodology brings robustness to the welding process, which is the first step for its effectively industrial implementation.

Table 1 — Experimental Results in DCEP

I_m (A)	I_{ef} (A)	WFS (m/s)	L (m)
139	139	0.0500	0.015
171	171	0.0667	0.015
170	170	0.0667	0.015
194	194	0.0833	0.015
194	194	0.0833	0.015
218	218	0.1000	0.015
242	242	0.1167	0.015
282	282	0.1333	0.015

I_m : mean current; I_{ef} : RMS current; WFS: wire feed speed; and L : electrode extension.

Table 2 — Experimental Results in DCEN

I_m (A)	I_{ef} (A)	WFS (m/s)	L (m)
69	69	0.0500	0.015
117	117	0.0833	0.015
154	154	0.1167	0.012
200	201	0.1500	0.012
198	200	0.1500	0.012
241	246	0.1833	0.012
318	329	0.2167	0.012
297	332	0.2500	0.012

I_m : mean current; I_{ef} : RMS current; WFS: wire feed speed; and L : electrode extension.

Table 3 — Calculated Parameters for the Waveform A

Waveform A	I_p (A)	t_p (ms)	I_n (A)	t_n (ms)	%EN
	300	4	198	1.7	0.30
	300	4	198	4.0	0.50
	300	4	198	9.3	0.70

I_p : pulse current; t_p : pulse time; I_n : current; t_n : time at negative polarity; and %EN: percentage of electrode at negative polarity.

Table 4 — Calculated Parameters for the Waveform B

Waveform B	I_p (A)	t_p (ms)	I_n (A)	t_n (ms)	I_b (A)	t_b (ms)	%EN
	300	4	198	2.6	40	2	0.30
	300	4	198	6.0	40	2	0.50
	300	4	198	14.0	40	2	0.70

I_p : pulse current; t_p : pulse time; I_n : current; t_n : time at negative polarity; and %EN: percentage of electrode at negative polarity.

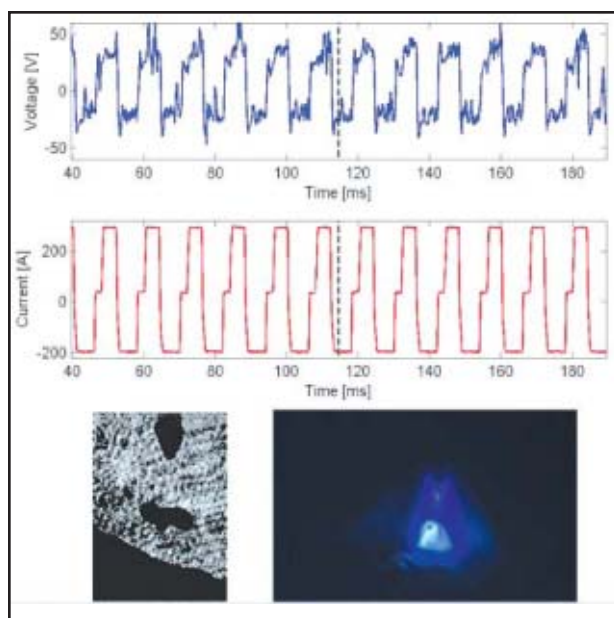


Fig. 4 — Synchronized high-speed images for waveform C and 50%EN.

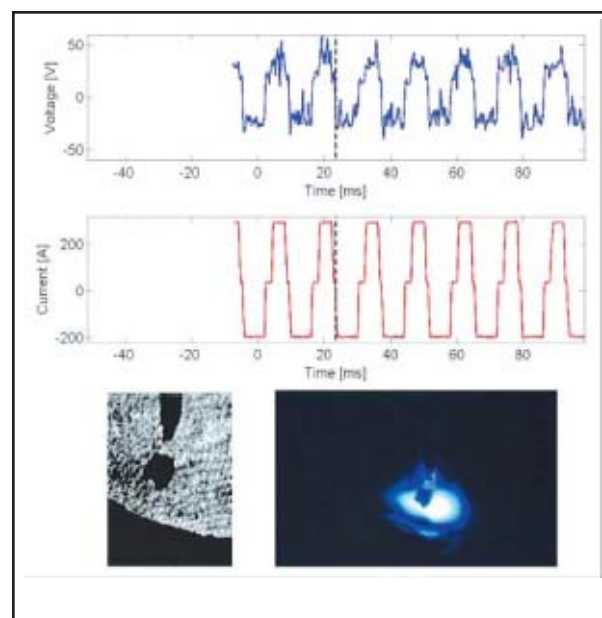


Fig. 5 — Synchronized high-speed images for waveform D and 50 %EN.

The base metal, welding wire, and shielding gas were the same as in the previous step, but now two fundamental parameters are analyzed in VP-GMAW:

- Waveform. Four different waveforms found in the literature (Refs. 4, 14) were evaluated, as shown in Fig. 1, in order to verify the effect of the sudden polarity change on the arc stability.

- EN rate. Three negative electrode percentage levels were evaluated (30, 50, and 70%) to verify their effects on the metal transfer. The %EN is defined by the ratio between the time length in which the electrode operates in the negative polarity and the period of time (time length in the negative plus the time length in the positive), as shown in Equation 1.

$$\%EN = \frac{t_{EN}}{t_{EN} + t_{EP}} \quad (1)$$

where t_{EN} is the time at negative polarity and t_{EP} is the time at positive polarity.

With the influence factors defined, a calculation strategy was set to determine the parameters that guarantee both arc and metal transfer stability at a constant arc length.

Calculation strategy:

- Define pulse current (I_p) and pulse time (t_p) that guarantee one drop per pulse (ODPP);
- Define base current (I_b) obeying the arc stability criterion ($I_b > 20A$) (Ref. 2);
- Define base time (t_b) according to required %EN;
- Calculate negative current (I_n) for the waveforms, equalizing the melt-off

rates at both polarities (WFS+ = WFS-);

- Calculate time in the negative (t_n) for the levels of %EN required, through Equation 2:

$$t_N = \frac{\%EN \cdot t_p}{(1 - \%EN)} \quad (2)$$

where t_p = total positive polarity time.

Step 3: Evaluation of the Influence of Waveforms and %EN on the Bead Geometrical Features

With the parameters obtained in Step 2, bead-on-plate weldments were carried out in plain position, keeping the ratio between the wire feed speed and the welding speed (WFS/WS) constant. The bead features (depth, width, and reinforcement) and its superficial aspect as well as the spattering level were evaluated by visual inspection.

Results and Discussion

Results from Step 1: Determination of the Consumption Equations in the Positive and Negative Polarities

Tables 1 and 2 present the experimental results of the average and RMS currents for the negative and positive polarities, respectively.

The values calculated for α and β for the two polarities were, in the positive polarity case (DCEP) $\alpha = 2.74 \times 10^{-4}$ m/(s.A) and $\beta = 5.1 \times 10^{-5} s^{-1} A^{-2}$, which are coherent with literature (Ref. 15) ($\alpha =$

3×10^{-4} m/(s.A) and $\beta = 5 \times 10^{-5} (s^{-1} A^{-2})$). In the negative polarity case (DCEN), the values calculated were $\alpha = 7.14 \times 10^{-4}$ m/(s.A) and $\beta = 1.2 \times 10^{-5} s^{-1} A^{-2}$. It is necessary to point out that in the positive polarity case both constants had statistical significance for 95% confidence. However, in the negative polarity case, only the α constant presented statistical significance for that confidence interval. Since the main heat-generating mechanism happens in the cathodic region, the results came to confirm this statement, because the α constant refers to that heat generation, while the β constant relates to the Joule effect, which starts to have a lesser effect in the case of DCEN, since lower current level is necessary for the same melt-off rate in DCEP.

Results from Step 2: Determination of Parameters that Guarantee Arc Length Stability

Following the calculation strategy, the current and pulse time were chosen based on a previous study (Refs. 1, 2) and were $I_p = 300 A$ $t_p = 4 ms$. According to the arc stability criterion, the chosen base current was $I_b = 40 A$. The base times were $t_{b1} = 2 ms$ and $t_{b2} = 1 ms$.

The value of negative current is calculated based on the chosen I_p , which is substituted in the equation of melt-off rate for DCEP. The resulting wire feed speed value is used in the melt-off rate equation for DCEN, and finally obtain the negative current to guarantee constant arc length ($I_n = 198 A$). Tables 3–6 present the pa-

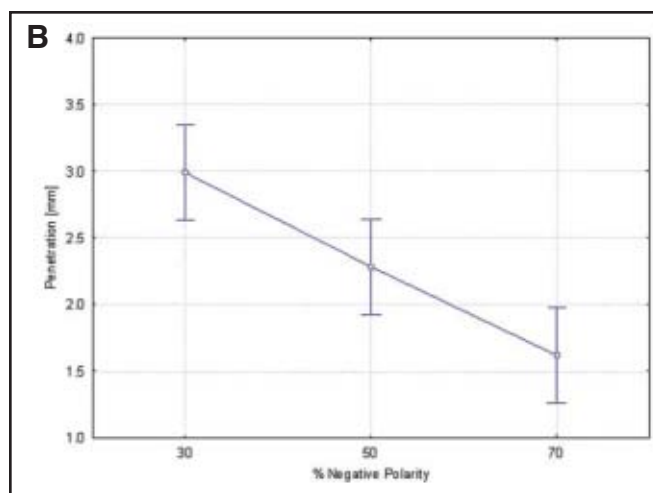
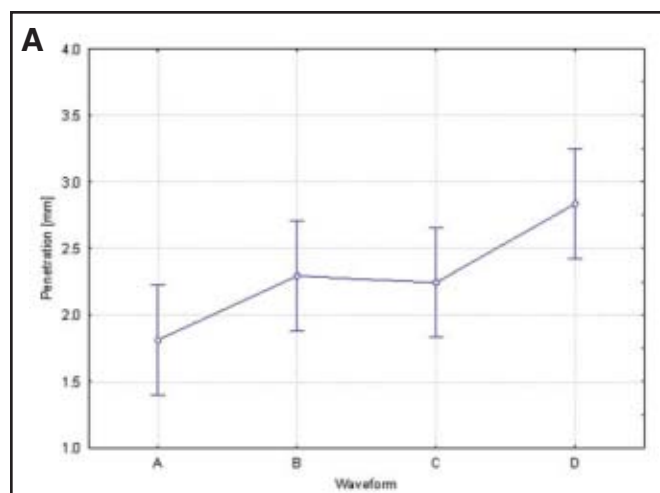


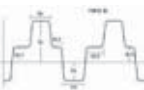
Fig. 6 — Effect of the waveforms (left, with $p = 0.02915$) and percentage of time at negative polarity (right, with $p = 0.00172$) on the penetration (for the whole model $p = 0.003981$). Vertical bars denote 0.95 confidence intervals.

Table 5 — Calculated parameters for the Waveform C

Waveform C	I_p (A)	t_p (ms)	I_n (A)	t_n (ms)	I_b (A)	t_b (ms)	%EN
	300	4	198	2.6	40	2	0.30
	300	4	198	6.0	40	2	0.50
	300	4	198	14.0	40	2	0.70

I_p : pulse current; t_p : pulse time; I_n : current; t_n : time at negative polarity; and %EN: percentage of electrode at negative polarity.

Table 6 — Calculated Parameters for the Waveform D

Waveform D	I_p (A)	t_p (ms)	I_n (A)	t_n (ms)	I_{b1} (A)	t_{b1} (ms)	I_{b2} (A)	t_{b2} (ms)	%EN
	300	4	198	3.0	40	2	40	1	0.30
	300	4	198	7.0	40	2	40	1	0.50
	300	4	198	16.3	40	2	40	1	0.70

I_p : pulse current; t_p : pulse time; I_n : current; t_n : time at negative polarity; and %EN: percentage of electrode at negative polarity.

rameters calculated for the studied waveforms and negative-electrode rate.

Through the analysis of the filming records and the weld coupons, it is possible to state that the highest level (70%) of the negative-electrode rate (%EN) presented the highest metal transfer instability for all waveforms. The droplets were usually three times as large as the electrode diameter and with an unacceptable amount of spatter, due to the intensified action of the repulsive force that actuates over the droplet when in DCEN. In addition, the excessive spatter

accumulated within the nozzle, reducing the area of passage of the shielding gas, which caused interruptions of the arc and even the dislocation of droplets onto the nozzle border.

It was not possible to achieve the ODPP condition in the welding made with waveform A, without positive base current to “smooth” the polarity inversion. The drop detachments happened in an irregular and unstable way, with large drops and a large amount of spattering for all the %EN levels.

As for waveforms B–D, at the %EN levels of 30 and 50%, it was possible to achieve the ODPP condition, with drops of the same diameter as the wire. However, the waveform B presented beads with higher lateral spattering level, due to the fact that the base current in the positive polarity, which aims to “smooth” the current inversion, happens after the droplet transfer had occurred.

Figures 2–5 present results from the synchronization of the two high-speed cameras synchronized with current signal and voltage. The four figures refer to the %EN level of 50%. Figure 2 is related to waveform A and 50 %EN, and it can be noticed that the detached droplet has a much larger diameter than the electrode, due to the repulsive forces that retard the detachment; besides the detachment occurred in the negative polarity but not regularly.

The metal transfer in the waveforms B and C occurs regularly, always in the positive cycle, and it is stable. However, as can be observed in Fig. 4, the detachment of waveform C occurs at the end of the positive pulse and the droplet suffers action of repulsive forces that happen in the negative polarity. This decelerates the droplet, reducing its momentum, which allows it to be transferred more “gently” and reduces spattering. This phenomenon does not occur in waveform B, observed in Fig. 3, where the droplet is transferred quicker to the molten pool and always during the positive period. Therefore, because of the greater momentum, it causes more disturbance in the molten pool and, consequently, more spatter.

Finally, Fig. 5 represents the waveform D for 50% of %EN. In this condition, the metal transfer is very stable, since the change in polarity is not so sudden, due to the positive base before and

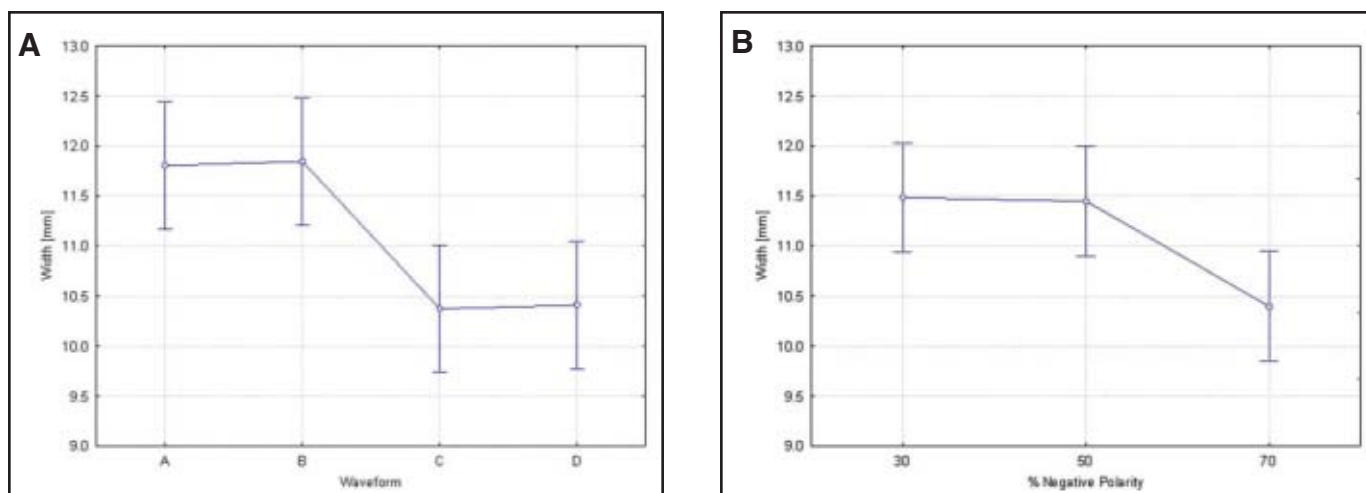


Fig. 7 — Effect of the waveforms (left, with $p = 0.00917$) and percentage of time at negative polarity (right, with $p = 0.02347$) on the bead width (for the whole model $p = 0.009120$). Vertical bars denote 0.95 confidence intervals.

after the detachment pulse.

Results from Step 3: Evaluation of the Influence of Waveforms and %EN on the Bead Geometrical Features

Table 7 presents the results of the geometrical characteristics of the beads in function of the waveform and negative-electrode rate (%EN). It also shows the coded variables for statistical analysis with the purpose of creating mathematical meta-models.

Figures 6–8 present the penetration, width, and reinforcement variation, respectively, as a function of the waveform (A, B, C, and D) and negative-electrode rate levels (%EN).

It is possible to perceive through the analysis of Fig. 6 that there is a clear tendency to reduction of penetration with the increase of the %EN for all four waveforms. This fact occurs because the %EN increase represents a longer negative polarity time and in that condition the heat is more concentrated in the electrode. Consequently, less thermal contribution in the base metal represents less penetration. Ueyama et al. (Ref. 8) found in their analyses on aluminum that by using 40 %EN the thermal contribution diminished and the maximum temperature on the plate was 140°C lower than in pulsed DC welding.

The same argument is used to explain the tendency of width reduction observed in Fig. 7, mainly for the 50 to 70%EN variation. Because the lower heat input, which occurs with the increase of the %EN, makes the wetting and melting of the base metal more difficult. Hence, the molten metal tends to concentrate on the surface of the pool increasing the reinforcement with the %EN increase, observed in Fig. 8.

On the other hand, waveform D at 70%EN did not follow this trend and experienced a smaller reinforcement value. This fact occurred due to the great instability generated by the high values of negative-electrode time, which intensified the repulsive forces on the droplet, which generated a loss of material due to spattering.

Mathematical models confirmed that could represent the behavior of the geometrical characteristics of the bead in function of the waveform and the negative-electrode rate (%EN). Two approximation models were tested and are represented by Equations 3 and 4:

$$y = A_0 + A_1P_1 + A_2P_2 \quad (3)$$

$$y = A_0 + A_1P_1 + A_2P_2 + A_3P_1P_2 \quad (4)$$

where A_0 , A_1 , A_2 , and A_3 are constants; p_1

and p_2 are the parameters of influence (waveform and %EN, respectively); and y the response variable (penetration, width, or reinforcement).

For all the response variables, the average quadratic error, which considers the interaction of factors, was smaller for the first model (Equation 3) than for the second approximation model (Equation 4). This is the reason why a hypothesis test was made comparing the two models. Therefore, the best model for the response variable y is the one of Equation 3.

Equations 5–7 represent, respectively, the models resulting for penetration, width, and reinforcement in function of the waveform and %EN. It should be pointed out that the levels of the variables were coded, and they are shown in Table 7. These equations can be used for a technological point of view for predicting the weld bead geometry.

Table 7 — Results for Geometrical Features

Waveform Type	Coded	%EN Value	Coded	P (mm)	W (mm)	R (mm)
A	1	30	-1	2,41	12,43	3,48
A	1	50	0	1,58	12,56	3,56
A	1	70	1	1,45	10,42	4,27
B	2	30	-1	2,76	12,07	4,3
B	2	50	0	2,3	12,26	4,7
B	2	70	1	1,82	11,2	4,9
C	3	30	-1	2,98	10,92	4,47
C	3	50	0	2,45	10,28	4,88
C	3	70	1	1,3	9,92	4,89
D	4	30	-1	3,8	10,5	4,9
D	4	50	0	2,8	10,68	5,16
D	4	70	1	1,9	10,05	4,63

Weld bead dimensions: P = penetration, W = width, and R = reinforcement.

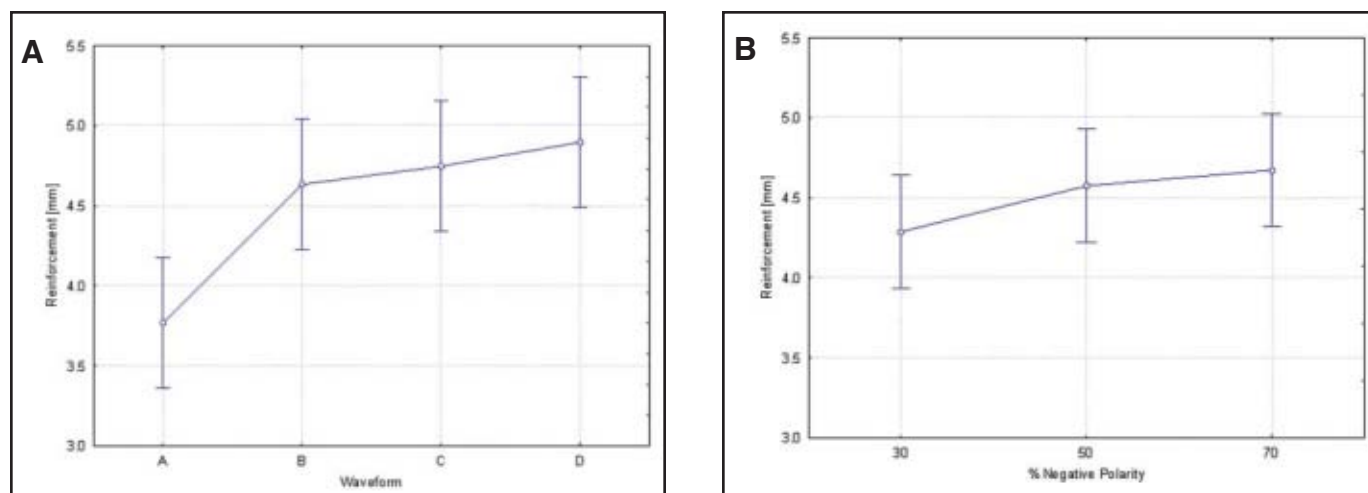


Fig. 8 — Effect of the waveforms (left, with $p = 0.01151$) and percentage of time at negative polarity (right, with $p = 0.22611$) on the reinforcement (for the whole model $p = 0.022157$). Vertical bars denote 0.95 confidence intervals.

$$P = 1.5433 + 0.3WF - 0.685EN \quad (5)$$

$$W = 12.52 - 0.565WF - 0.541EN \quad (6)$$

$$R = 3.6383 + 0.349WF + 0.1925EN \quad (7)$$

where P is the penetration, W is the width, R is the reinforcement, WF is the waveform, and EN is the %EN.

Conclusions

In general terms, it is possible to conclude that the proposed methodology for parameter calculation successfully accomplished the task of reaching both arc and metal transfer stability. More specifically, it can be conclude that

- The knowledge of the melt-off rate equation in the negative and positive polarities is fundamental to determine parameters in VP-GMAW that provide a more stable arc with constant length;
- The positive base before and after the pulse (waveform D) is beneficial in reducing abrupt polarity changes, but, for higher %EN, long negative time always generates great instability;
- Waveforms B and C provide arcs that are stable and with ODPP. However, the base before the pulse (waveform C) is more effective in avoiding spattering;
- There is a reduction in the penetration with the increase of the %EN due to the reduction of the thermal contribution, which allows thin-plate welding and linings application;

- It is possible to select the combination of waveform and %EN more adequately depending on the application, using the equations presented to predict the weld bead geometry.

Acknowledgments

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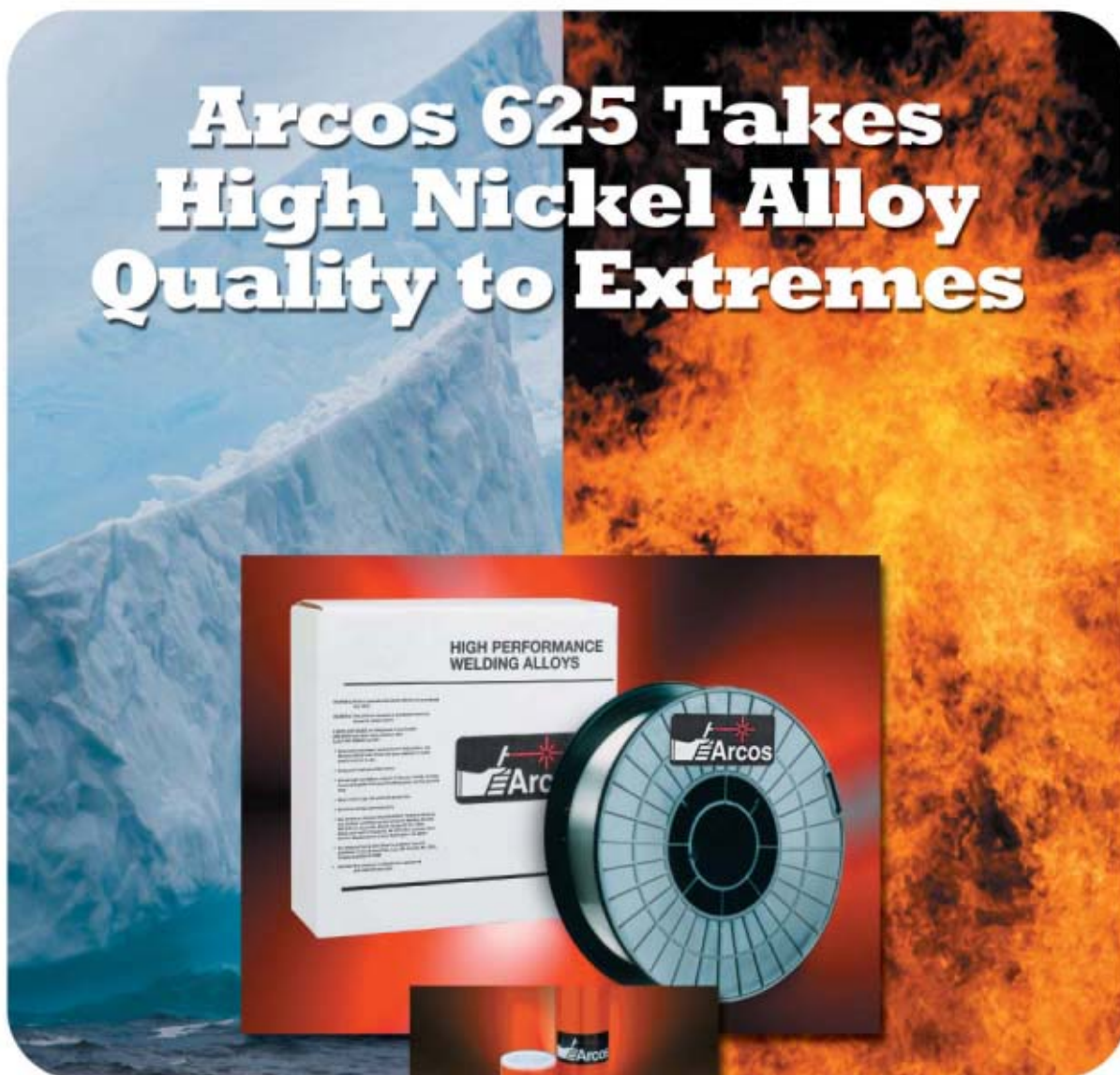
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