WELDING Journal

November 2007

•Fabtech International & AWS Welding Show Preview

•Welding Tank Cars

•Implementing Automation

•Changes to A5.23

•Containing Radioactive Material

WELDING JOURNAL • VOLUME 86 NUMBER 11 • NOVEMBER 2007

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

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CONTENTS

November 2007 • Volume 86 • Number 11

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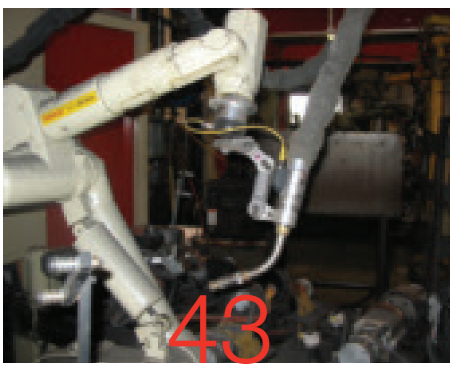

Features

Welding Research Supplement

On the cover: Internal welding of the girth weld using SAW in the tandem configuration. The girth weld is one of the main weld joints that joins several rings to construct a tank. (Photo courtesy of UTLX Manufacturing, Inc., Alexandria, La.)

Departments

Welding Journal (ISSN 0043-2296) is published monthly by the American Welding Society for $120.00 per year in the United States and possessions, $160 per year in foreign countries: $7.50 per single issue for domestic AWS members and $10.00 per single issue for nonmembers and $14.00 single issue for international. American Welding Society is located at 550 NW LeJeune Rd., Miami, FL 33126-5671; telephone (305) 443-9353. Periodicals postage paid in Miami, Fla., and additional mailing offices. **POSTMASTER:** Send address changes to Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126-5671.

Jiangbei Steel Processing Orders Welded Tube Plant

Jiangbei Steel Processing and Logistics Co. Ltd., part of the Chinese WISCO steel group, has recently placed an order with SMS Meer, a company of the SMS group, Germany, to build a high-frequency welded tube plant. According to the company, the continuous welding line in Wuhan, China, on the Yangtze River will be the largest of its kind in the world. At the end of 2008, it is scheduled to go into operation and will then produce up to 350,000 tons of pipes per year.

The pipes to be produced will have diameters from 244 to 660 mm (9.6 to 26 in.) with wall thicknesses up to 24 mm (0.9 in.). They will have a maximum length of 18.5 m (60 ft). The delivered coils will be up to 2.13 m (7 ft) in width and weigh about 45 tons.

The plant will produce pipes for the oil and gas industry and for the building sector. In addition, it is designed to produce structurals and square/rectangular hollow sections required in the construction industry in dimensions up to 500 × 500 mm (20 × 20 in.) and 600 × 400 mm (24 × 16in.), respectively.

Great Lakes Air Systems Joins with Praxair, Bureau Veritas to Educate Industry

Great Lakes Air Systems, Columbus, Ohio, has begun work with Praxair and Bureau Veritas to help educate and offer solutions designed to assist potential and current customers in complying with hexavalent chromium exposure levels.

"The collaboration among these three companies allows us all to offer the best solutions to those dealing with this issue at the plant level," said Jim Reid, vice president of Great Lakes Air Systems. "It gives the opportunity to troubleshoot before they become OSHA violations."

Together they can address diagnosis, process, or material change, engineering controls, and a continual compliance plan based upon the needs of each facility.

Alcoa Launches Innovation Web Site to Showcase Technology Solutions for Design Engineers

Alcoa, Pittsburgh, Pa., has launched a new technology Web site at *www.alcoa.com/innovation* with detailed scientific information on aluminum and other light metals that will help design engineers develop new products.

The site features a growing database of the company's patents and scientific research papers. Scientists, engineers, and product development specialists can search the Alcoa technology library for solutions in metal coating, casting forming, alloys, structure, and design to develop new applications. Also, it highlights the company's global innovation network of collaboration with universities and external partners.

Magna Car Top Systems Expands Manufacturing Footprint and Capabilities in North America

Magna Car Top Systems, an operating unit of Magna International Inc., Aurora, Ont., Canada, has recently completed the acquisition of certain manufacturing assets and equipment, including a leased facility located in Toluca, Mexico.

The facility, Magna Car Top Systems de Mexico, S.A. de C.V., manufactures and assembles convertible tops for several General Motors vehicles. It is 276,000 sq ft, employs 309 people, and the current capabilities include stamping, machining, coating, cutting and sewing, welding, and convertible top final assembly.

Northwest Pipe to Supply $10 Million of Steel Pipe

Northwest Pipe Co., Portland, Ore., has been named as pipe supplier by S. J. Louis Construction of Waite Park, Minn., for the Folsom South Canal-Clay Station to Jack Tone Road Pipeline for the East Bay Municipal Utility District near Sacramento, Calif.

The company will supply approximately 33,000 ft of steel pipe valued at approximately $10 million for an engineered and custom-fabricated piping system. Delivery is scheduled to begin in the first quarter of 2008, and the pipe is expected to be manufactured in the company's Adelanto, Calif., and Portland, Ore., divisions.

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Make It Your Kind of Show

This is the exciting time of the year when our welding industry is on display in Chicago at the AWS Welding Show. This is the 55th year for our Show, and we look forward to demonstrating to the world the many solutions through welding that can positively impact the global economy.

With our partners at FABTECH, we feel that the FABTECH International & AWS Welding Show has a lot to offer. Following are just some of the highlights:

- **Location.** Chicago has always been a great venue, and the facilities are first class for a Show of our magnitude. To quote Frank Sinatra, Chicago is "My Kind of Town" for the Show.
- **Welding.** When AWS refers to welding it does so in the broad definition of the term. When we say welding is on display, we mean welding and its allied processes, including joining, brazing, soldering, cutting, and thermal spraying.
- **Exhibitors.** The number of welding exhibitors will total close to 460 with 160,000 square feet within the welding part of the Show. You'll find exhibits on every type of welding product and process, and exhibitors willing to share their expertise. The total square footage including welding, fabrication, and tube and pipe is 475,000.
- **NAM (National Association of Manufacturers).** NAM has joined the FABTECH/AWS alliance as an Industry Partner, which should assist in drawing additional attendees.
- **International Thermal Spray Asssociation.** This year's exhibition features a special pavilion of thermal spray-related exhibitors and an introduction to thermal spray coating processes.
- **Leadership Summit.** The shortage of welders is one of the hottest topics in welding today; come hear industry leaders discuss ways to solve the problem.
- **Conferences.** Friction Welding and Hot Wire Welding and Cladding are just two of the top-notch conferences taking place this year.
- **Seminars.** Eight continuing education seminars will provide you with opportunities to increase your practical knowledge.
- **RWMA.** The Resistance Welding Manufacturing Alliance Welding School will be held.
- **Professional Program.** This comprehensive program focuses on the latest in welding research and commercial developments. In addition, you can view the entries in the AWS Poster Session.
- **Education Sessions.** These free sessions will highlight the latest developments in education and training.
- **AWS Professional Welders Competition.** Stop by and watch professional welders as they demonstrate their skills for prizes.
- **International Brazing and Soldering Symposium.** Features information on research and applications.
- **Job Fair and Work Force Development Pavilion.** Representatives from prospective employers will be on hand.
- **End User Forum.** This forum was created to bring together the end user welding community.
- **Image of Welding Awards.** Special awards will be presented to those companies and individuals who have demonstrated outstanding achievements in promoting welding.
- **FABTECH Technical Sessions.** More than 40 technical sessions in 10 technology areas are being offered.

These are just some of the events that will be held at this year's Show. I believe there's something to interest everyone involved with welding. We're anticipating approximately 25,000 individuals attending during the four days of the Show. I hope you'll be one of them. Please join us in Chicago and experience "My Kind of Show." You will be glad you did.

Ray W. Shook
AWS Executive Director

UA Apprentice Competition Revived after 33 Years

Gerald Arnold (left), the welding award winner at the International Apprenticeship Competition held in August, is pictured with William Hite, general president of the UA. Hosted by the United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada, the Copper Development Association also helped support and judge the contest. This year's event is the first since the competition program was discontinued in 1974.

At the first International Apprenticeship Competition to be held in 33 years, plumbing and pipefitting apprentices recently participated in five days of troubleshooting, rigging, bending, cutting, leveling, welding, and brazing. The United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada hosted the contest. In addition, it was supported and officiated in part by the Copper Development Association (CDA).

The event was held during the annual UA Instructor Training Program, August 11–16, in Ann Arbor, Mich. Although none of the 30 contestants had yet reached journeyman status, all were five-year veterans of the UA apprentice program.

"The most difficult part we had was to create a competition that could really test all their abilities," said CDA Regional Manager Dale Powell, one of many industry professionals who helped set up the event.

Joining Powell as a judge for the copper segment of the competition was CDA National Program Manager Andrew G. Kireta Jr. They were assisted by Myron Havis, the association's midwest regional manager. Participating as head judges for the welding competition at Washtenaw Community College were Albert Hermida, AWS, and Brandon Muelbrandt, Lincoln Electric.

Each of the six regions within the UA — five from United States and one from Canada — were represented. The competition was divided into five disciplines that included welding, plumbing, pipefitting, sprinkler installation, and mechanical and electrical service.

The CDA provided all of the copper tube, pipe, and fittings used in the competition, along with instructors for training courses during the event.

The copper segment of the competition covered four of the five disciplines and included testing the apprentices' skills at joining copper tubing. A separate brazing contest was held for the remaining discipline, welding.

Among the events the apprentices underwent during the week were a written test, two bending tests, HVAC troubleshooting, a "welding practical," and tube bending.

The following winners from the five disciplines were announced at the ITP graduation ceremony: Welder — Gerald Arnold of Local #208 (Region 5), Denver, Colo.; HVAC — John Johnson of Local #50 (Region 2), Toledo, Ohio; Pipe Fitter — Andrew Kennedy of Local #50 (Region 2), Toledo, Ohio; Plumber — Greg Bartus of Local #690 (Region 2), Philadelphia, Pa.; and Sprinkler Fitter — Kevin Holbrook of Local #669 (Region 2), Columbia, Md. Top honors included $1000 awards for each of the winners and copper trophies donated by CDA.

Hobart Brothers Co. Celebrates 90 Years

More than 300 employees attended the 90th anniversary celebration at Hobart Brothers Co., Troy, Ohio. Shown above is Scott Santi, executive vice president of Illinois Tool Works, speaking at the event.

On August 29, Hobart Brothers Co. celebrated its 90th anniversary during a company-wide event at its headquarters in Troy, Ohio. This consisted of a luncheon with first-shift employees, and it was attended by Troy city officials as well, including Mayor Michael L. Beamish. Beamish delivered a proclamation to celebrate this business milestone and recognize the company's ongoing contributions to the Troy community.

In attendance were Scott Santi, executive vice president, Illinois Tool Works (ITW), parent company of Hobart Brothers, and Grant Harvey, vice president of Hobart Brothers North American tubular wire division. They both spoke of the importance of the anniversary and the company's 690 employees.

"Ninety years of product quality and innovation is impressive in today's manufacturing world," said Harvey. "We are all incredibly proud to be part of such a fine, long-standing organization, and to have had so many dedicated employees throughout the years."

Since Charles Clarence Hobart founded the business in 1917, Hobart Brothers has become a foremost provider of quality welding filler metals. It has maintained operations in Troy since its inception, and was family-owned and operated until being acquired by ITW in 1996.

ArcelorMittal and Noble International Combine Their Laser Welding Businesses

ArcelorMittal and Noble International, Ltd., a large producer of laser-welded steel products, have recently completed the transaction to combine their laser-welded tailored blanks businesses.

ArcelorMittal will receive from Noble, in exchange for its laser-welded blanks business in western and eastern Europe, China, India, and United States (TBA), consideration of approximately $300 million.

EWI Launches Online Weld Simulation Tool

Edison Welding Institute (EWI), Columbus, Ohio, has launched E-Weld Predictor, a new online weld simulation tool. It can be accessed through the Virtual Joining Portal section of the organization's Web site at *calculations.ewi.org*.

The product allows welding engineers to evaluate the changes in temperature profiles, material microstructures, residual stresses, and welding distortion to reduce the extent of experimental trials during the design of welded joints. Engineers can explore a wide range of "what if" combinations and simulations. Additionally, the number of trials will be reduced since only the most promising welding procedures are sent to the mock-up stage.

Resulting from a partnership announced last November, the product integrates EWI's engineering domain knowledge with the supercomputing power of Ohio Supercomputer Center. The organization worked with the center's staff on the engineering application and collaborated on the user interface design.

Indiana High School Students Compete in IMSTEA Super Mileage Challenge

Earlier this year at the Indianapolis Raceway Park, seven high school juniors and seniors participated in the 2007 IMSTEA Super Mileage Challenge on behalf of the New Castle Area Career Programs in Indiana. For this competition, they built a singleperson vehicle powered by a standard small engine and burning a standard fuel. Also, the students explored ways to achieve the highest miles-per-gallon figures over a fixed course. Patrick Smith, Garrett Smith, Brian Oldham, Josh Norris, Bryce Justice, Kyle Gibson, and Eric Young from the engineering and design, machine trades, and welding classes at New Castle Chrysler High School, Shenandoah High School, and Hagerstown High School competed in the event. They finished in 9th place in the state of Indiana in total mileage for a stock vehicle and obtained an average of 334 miles per gallon of gas.

Sciaky Earns NASA Contract for Electron Beam Gun System

Sciaky, Inc., Chicago, Ill., currently has a contract in place with NASA's Langley Research Center, Hampton, Va., for a new electron beam (EB) gun system to be used with the electron beam freeform fabrication (EBFFF) process. The movable EB gun will be incorporated in a EBFFF system that will be flown on a microgravity research aircraft and, potentially, in space.

The company, due to the criticality for minimized weight and portability of the system, will work closely with NASA engineers to provide the gun with supporting hardware, such as low- and high-voltage power supplies, controllers, and cables to provide a target weight of 100 lb.

Lincoln Electric Supports Air Show with Welding Classes, Demonstrations

During the recent Experimental Aircraft Association's EAA AirVenture Oshkosh show, Lincoln Electric certified welding instructor Carl Hoes conducted a welding demonstration. More than 1200 show attendees participated in the demonstrations, which followed a one-hour class on best welding practices. They were given hands-on experience with gas metal arc and gas tungsten arc welding machines and instruction on the advantages both provide in aircraft construction and maintenance.

Canada's New Government Launches Apprenticeship Incentive Grant

The Apprenticeship Incentive Grant at Durham College's Skilled Trades Centre in Whitby, Ont., Canada, has been launched by Jim Flaherty, minister of finance and member of Parliament for Whitby-Oshawa, on behalf of Monte Solberg, minister of human resources and social development.

The grant provides $1000 cash per year to registered apprentices who have completed their first or second year in a Red Seal trade program, which offers various positions including welder. The money will help apprentices by offsetting the costs of tuition, travel, and tools. It is estimated that, annually, up to 100,000 apprentices in Canada will be entitled to receive this taxable cash grant.

The grant is one of the measures introduced by Canada's New Government to assist apprentices, tradespeople, and employers in the skilled trades sector. For more information, visit *www.servicecanada.gc.ca*.

Industry Notes

- **Thule Inc.**, Seymour, Conn., a manufacturer of car rack products, has entered into an agreement to purchase United Welding Services and UWS Inc., a manufacturer of aluminum tool boxes and other automotive accessories, for an undisclosed amount.

- **ATI Industrial Automation,** a developer of robotic peripheral equipment, has recently opened a new office in the Detroit, Mich., area. It houses sales, customer service, and training departments along with space for inventory.

- **ASM International**, Materials Park, Ohio, has unveiled a new interactive and customizable Web site for members of the Heat Treating Society at *http://hts.asminternational.org*.

- **Ameriforge Group Inc.**, Houston, Tex., has acquired the business and assets of Prince Industries, a provider of precision machining for large seamless rolled rings and other forgings.

- **Praxair Surface Technologies**, Indianapolis, Ind., has reached an agreement with FMC Technologies to supply thermal spray coatings for gate valve components.

- **Airgas, Inc.**, Radnor, Pa., has acquired the assets and operations of Dantack Corp., a Grand Prairie, Tex.-based safety distributor with branches in Columbus, Ohio, and Richmond, Va.

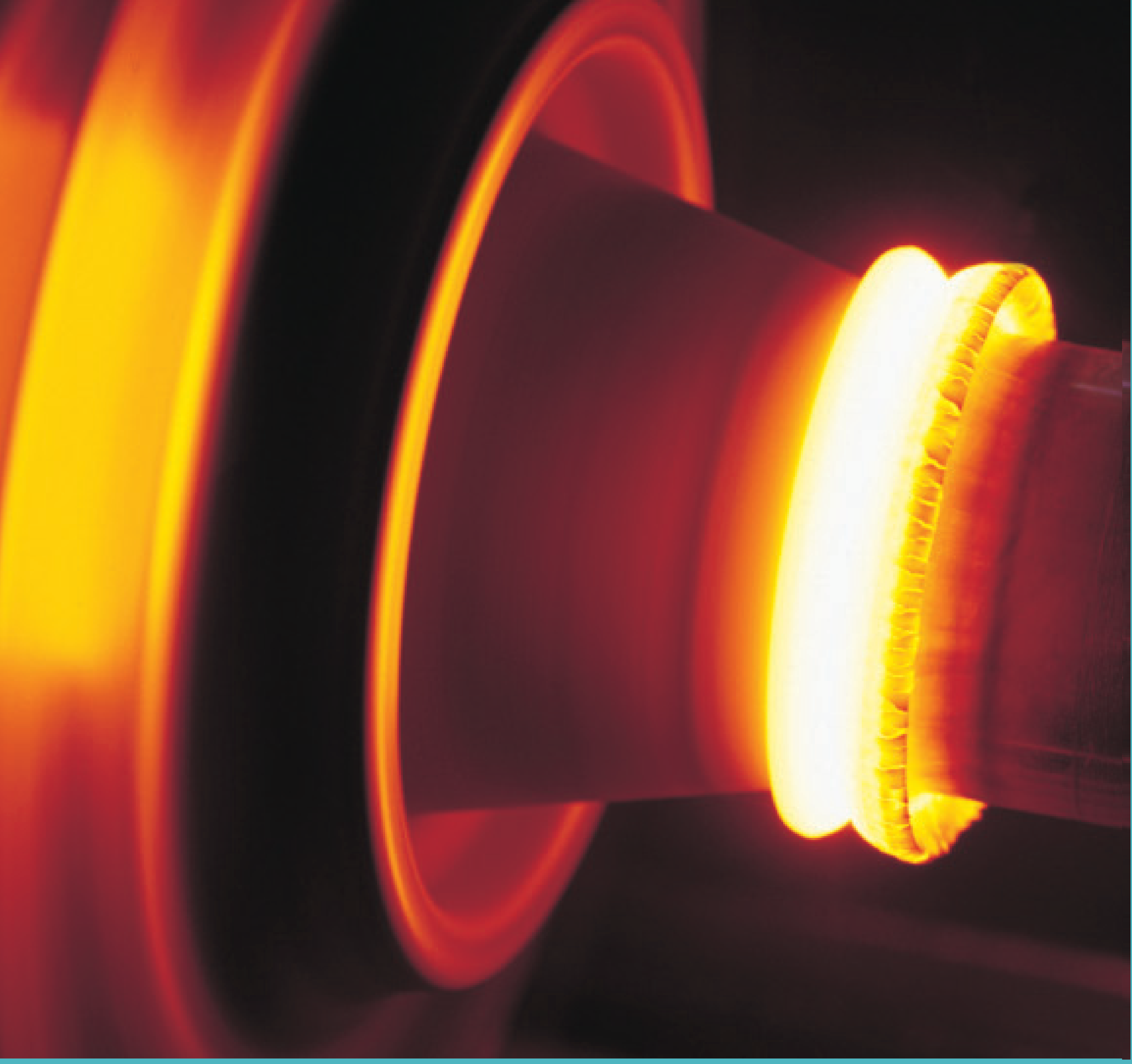
- **Niles Machine and Tool Works, LLC**, Livermore, and **Pacific Production Engineering Consulting, LLC**, Palo Alto, Calif., were merged into one corporate entity as of October 1. The new company is named Integrated Manufacturing Group, LLC.

- **Jet Edge, Inc.**, St. Michael, Minn., has partnered with Saimo Group of Xuzhou in Jiangsu, China, to sell waterjet equipment in China and Australia.

- **KBW Associates, Inc.**, Fargo, N.Dak., a full-service construction firm, has affiliated with VP Buildings, Memphis, Tenn., a manufacturer of metal building systems, as an independent authorized VP Builder.

- **Ansell**, Brussels, has launched its Guardian℠ consulting service to help companies select appropriate work gloves based on increasing safety and productivity, and reducing product cost through extending wear.

- **The NanoSteel® Co.**, Providence, R.I., has been awarded its third R 100 Award for the development of "Hardmetal Alternative Technology: Super Hard Steel® (SHS) 9192 Weld Wire."



Conference on Friction Welding
Chicago • McCormick Place
November 12, 2007

The Four Friction Welding Processes
Daniel Adams, Vice President, Manufacturing Technology, Inc., South Bend, IN, and Tim Haynie, President, Transformation Technologies, Inc. Elkhart, IN

This overall presentation will cover the four main friction welding processes: direct drive friction welding, inertia friction welding, linear friction welding, and friction stir welding. Daniel Adams will discuss the first three processes and Tim Haynie will discuss friction stir welding. The two companies are collaborating on friction stir welding.

Friction Stir Welding at Concurrent Technologies Corporation
Robert W. Semelsberger, Manager, Combat Vehicle Research Program, Concurrent Technologies Corp. Johnstown, PA

Robert Semelsberger will discuss activities at Concurrent Technologies Corp. involving a $1.3 million contract from the U.S. Army Tank Automotive Research, Development and Engineering Center, involving friction stir welding and the use of aluminum-lithium alloys on future lighter tanks and combat vehicles.

New Applications for Friction Stir Welding
Mike Skinner, Business Development Manager, MTS Systems, Inc., Eden Prairie, MN

The aerospace, ground transportation and marine industries have successfully introduced the friction stir welding (FSW) process into series production on 2D/panel welding like applications using the conventional FSW process (fixed pin tools). The focus of this presentation will be on some of the latest production applications utilizing the FSW adjustable and self-reacting process on 3D/complex curvature applications. The following applications will be discussed: fabrication of the Volvo XC-90 aluminum rims, Nippon Shario high-speed trains, and the NASA Constellation Program (Space Shuttle replacement).

Friction Welding of Federal Mogul's Monosteel Pistons
Carmo Ribeiro, Global Technology - Steel Pistons, Federal Mogul Corp., Ann Arbor, MI

Monosteel Piston innovative technology has been created to address the increasing thermal, mechanical, abrasive, and corrosive challenges placed on heavy-duty diesel engines resulting from emissions regulation. Therefore an integration of welding process technology such as friction welding and product design enhancements has been combined to market the idea.

Linear Friction Welding for Aerospace Applications
Martin W. Moffat, Vice-President, Sales and Marketing, The Cyril Bath Company, Monroe, NC

Linear friction welding (LFW) is a relatively new joining technique finding significant value in aerospace turbine engine components and special airframe structures. The focus and value of this technology is with specialty metals such as titanium and certain nickel alloys. By eliminating machining and material loss during processing, LFW can be a valuable technology for joining fan blades to rotating discs. In addition, the use of titanium structures in new commercial aircraft requires new techniques for building various geometric profiles. LFW is a cost effective process to create airframe structure components, while minimizing process yield loss.

Applications for Direct-Drive Friction Welding
Adam Jarzebowski, President, NCT Friction Welding, Newington, CN

Equipped with nine direct-drive friction welding machines, NCT Friction Welding has compiled considerable experience in many different kinds of applications throughout industry, including the welding of dissimilar metals.

Fusion Bonding: Underwater Fastening Without Electricity
Chris Hsu, Director of Engineering, Nelson Stud Welding, Inc., Elyria, OH

In fusion bonding, a lightweight portable air motor device is used to spin a fastener, which is rammed into the workpiece (e.g. hull of a ship) underwater, and the friction heat forms the weld. The process is a safe, fast and economical method to attach studs, bolts, and other fasteners in comparison with alternative methods of welding underwater. This paper outlines a designed experiment (DOE) to characterize the weld performance of fusion bonding. A two-level factorial design with center points is used with 135 welds.

Challenges to Deploying Friction Stir Welding in U. S. Army Weapon Systems
Suhas Vaze, Project Manager, Government Programs Office, Edison Welding Institute, Columbus, OH. Co-authors include Brian Thompson, Tim Stotler, Jeff Bernath, and Tim Trapp

Edison Welding Institute (EWI) has been developing materials joining technologies for the US Army's Future Combat System (FCS) program under the direction of The Army Research Laboratory (ARL). Previous efforts related to the Expeditionary Fighting Vehicle (EFV, formerly AAAV) have shown that friction stir welding can be successfully used in joining 2219/6061 to 2519. This presentation will showcase fabrication of complex aluminum and titanium FCS-like structures, which are technology demonstrators and represent full-scale application of friction stir welding and a step towards deployment of FSW for FCS; and application of VT, UT and RT for inspecting friction stir welded structures.

Conference price is $345 for members of AWS, FMA, SME, or NAM, $480 for nonmembers.To register or to receive a descriptive brochure, call (800) 443-9353 ext. 455, (outside North America, call 305-443-9353), or visit www.aws.org/conferences

Steel to Cover Chernobyl Nuclear Site

The Ukraine government has hired Novarka, a French firm, to build a steel sarcophagus to surround the radioactive site of the world's worst nuclear disaster in Chernobyl.

"The construction of the new 'shelter' facility and a storage for spent nuclear fuel at the Chernobyl nuclear power plant is a global project, which Ukraine and the president (Viktor Yushchenko) view as very important," said Oleksandr Chalyi, deputy chief of staff of the secretariat of the president.

Novarka is a consortium between VINCI Construction and Bouygues Travaux Publics, two French firms that have experience building and dismantling nuclear power plants. Novarka will perform the design and construction duties; a team consisting of representatives of Chernobyl Nuclear Power Plant and a consortium comprised of Bechtel, EDF, and Battelle Memorial Institute will provide project management.

According to Novarka, the prime purpose of the arch-shaped shelter "is to contain the radioactive material, to protect against weather damage to the existing sarcophagus built in 1986, just after the accident, and to allow work to begin on deconstruction of Unit 4 of the Chernobyl power plant."

The structure will weigh 18,000 metric tons and will be 105 m high, 150 m long, and have a span of 257 m. The arch will stand on two concrete beams and will be assembled to the west of the damaged reactor, then slid into place above the existing structure. The existing concrete structure was hastily built following the accident; exposure to weather and poor construction have left it weakened. The reactor still contains 95% of its original nuclear material.

The casing project will take five years to complete at a construction cost of approximately $505 million. The money has come from international donors and the fund is administered by the European Bank for Reconstruction and Development.

A separate deal has also been signed with U.S. firm Holtec to build a storage facility for nuclear waste that has been produced at Chernobyl.

Welding School Launched in Philippines

The JIB Welders Academy recently opened in Davao City, according to the Philippine Information Agency. Joji Iligan Bian, head of the school, said there is a great demand for welders, especially for Philippine welders wanting to work abroad.

The academy is offering a competency-based curriculum. Currently, two courses related to shielded metal arc welding are being offered. Bian said 70 students reserved space in the classes prior to the school's opening. She said that was a good sign that area residents are looking at vocational skills as a good means of becoming employed.

Dutch Welding Company Opens Danish Subsidiary

Valk Welding, Alblasserdam, The Netherlands, plans to open a subsidiary, Valk Welding Danmark, this month to sell automated welding equipment to the Danish market.

The company has been selling robot-based welding equipment in Denmark for seven years.

"Although only a few persons cover the Danish market, sales have been very good," said Marcel Dingemanse, project manager, Valk Welding. "It is therefore with great confidence that we increase our efforts by setting up a subsidiary."

Alstom to Supply High-Speed Trains for Route Linking Helsinki to St. Petersburg

Alstom, Levallois-Perret, France, was recently awarded a contract to supply four high-speed Pendolino trains for the Helsinki, Finland, to St. Petersburg, Russia, rail link. The contract is worth 120 million euros and includes an option for two additional trains.

The trains will be built for Karelian Trains, a joint venture between Russian Railways and Finnish Railways, which will comanage the trains.

The trains are scheduled for delivery in early 2009. They will be based on the 18 Pendolinos that already operate in Finland. They will feature the same front-end and interior fittings and will be adapted to extreme winter conditions. They will be built at Alstom's Savigliano site in Italy.

The new trains will operate on a 450-km, high-speed line at speeds of up to 220 kilometers per hour. The trains will be comprised of seven cars.

Sri Lanka to Establish First Technical University

The first technical educational university in Sri Lanka will be set up under the Ministry of Vocational and Technical Training this year in Ratmalana, according to H. L. Obeyesekera, director general, Dept. of Technical Education and Training.

Previously, technical colleges in the country conducted six-month to one-year certificate courses, but these were inadequate for students to seek good employment, Obeyesekera told the *Sunday Observer*, Sri Lanka's English-language newspaper.

The new university will offer three-year and two-year degrees. Programs will include mechatronics (combining mechanical and electrical engineering), metal technology for all types of welding, boat repairing, manufacturing technology, and food technology.

In addition, the department also plans to set up a construction technology unit to upgrade the existing courses offered at the nation's technical colleges.

Stork Materials Technology Acquires Sheffield Testing Laboratories

Stork Materials Technology recently acquired Sheffield Testing Laboratories, Ltd. (STL). The company will continue to operate from its current facility in Sheffield, England, under the direction of Dr. John Oldfield and David Tame.

Sheffield Testing Laboratories provides materials testing, mechanical testing, corrosion testing, and calibration services to industries through the UK and Europe. The company was established 127 years ago under the name Sheffield Testing & Experimenting Works and its early work consisted of testing for iron, metal, steel, and steel and hemp ropes.

Stork operates laboratories throughout the United States and Europe, conducting materials testing, failure analysis, consulting, product development, and qualification testing for industries such as aerospace and defense, automotive and transportation, construction and architecture, power generation, manufacturing, primary metals, oil, gas, and chemical.

BY DAMIAN J. KOTECKI

Q: What is "sensitization" in a stainless steel weld?

A: *Note: This is a follow-on to my September 2007 Stainless Q+A column that discusses "sugaring." Sensitization is entirely unrelated to sugaring, and it occurs in a different region of the weldment.*

Sensitization in a stainless steel weldment occurs in that part of the weld heat-affected zone (HAZ) that is heated to a peak temperature of between about 900° and 1600°F (480° to 870°C) when there is enough carbon available to produce precipitation of chromium-rich carbides along grain boundaries. Higher peak temperatures than 1600°F either allow chromium to diffuse fast enough to keep up with the carbon in forming carbides, or actually cause the carbides to dissolve. Peak temperatures below about 900°F don't allow enough carbon diffusion to form significant chromium carbides during welding. The carbides have the general formula $M_{23}C_6$, where M is any metallic element, but chromium is by far the most concentrated metallic element in the carbides. The carbon atom is a very small atom that can diffuse rapidly through the stainless steel matrix to the grain boundaries, so that carbon from anywhere in a grain can reach the grain boundary in this temperature range. But the chromium atom is a large atom that diffuses slowly, so that only chromium from very close to the grain boundary participates in formation of the carbides. Formation of the carbides then tends to produce a chromium-depleted zone beside the grain boundary. This chromium-depleted zone, if exposed to a corrosive medium, is preferentially attacked and dissolved. The corrosion follows the chromium-depleted zones beside the grain boundaries and a continuous network of corrosion along grain boundaries causes grains to separate from the weldment.

In order to illustrate sensitization, a 3⁄16-in. (4.8-mm) E309L-17 electrode was used to produce a single bead-on-plate deposit on a ¼-in. (6.4-mm) Type 304 stainless plate. Most 304 stainless produced today can be dual classified as 304L as well. The important feature of this 304 plate is that it is not dual classified as 304L — it actually contains 0.066% carbon, double the 0.03% maximum allowed for 304L. At this carbon level, the weld HAZ is easily sensitized by the bead-on-plate weld. After the weld was deposited, the weldment was sectioned transverse to the welding direction. The cross section was then polished and etched to reveal the chromium carbides along grain boundaries in the HAZ.

Figure 1 shows the HAZ in the region that was heated by the weld to a temperature in the sensitization range. Actually, the carbides have been almost entirely removed by the etching process and only their original locations can be seen in either the optical microscope, or the scanning electron microscope, as microscopic ditches along the austenite grain boundaries.

The damage that can be done to a weldment by exposure of the sensitized HAZ to even a weak corrodent can be very severe. Figure 2 reproduces a frequently published example of a cross section of a weld in a 304 stainless steel pipe that contained hot dilute nitric acid. The dilute

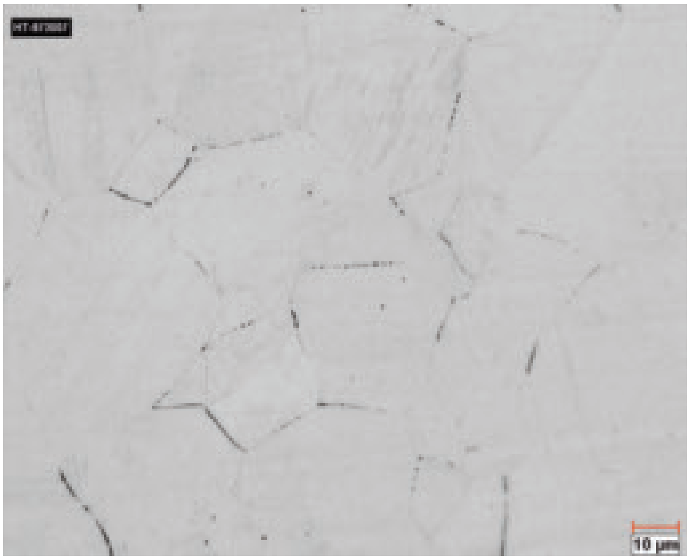


Fig. 1 — Sensitized HAZ of 304 stainless steel plate. Chromium carbides are indicated by chains of dark particles along austenite grain boundaries.

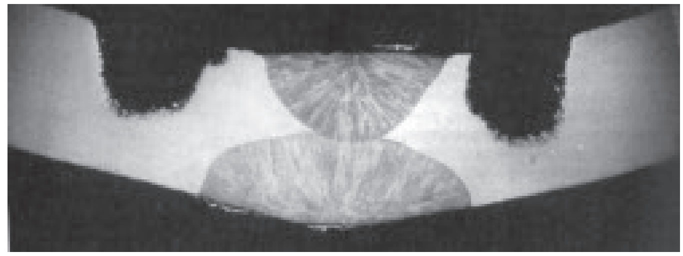


Fig. 2 — Sensitized 304 stainless steel pipe after service in dilute nitric acid. Note that the weld metal and the HAZ closest to the weld metal are unaffected, but the region of the HAZ that reached peak temperatures in the range of 900° to 1600°F (480° to 870°C) is severely attacked. *Photo from* Welding Handbook, *8th Edition, Vol. 4, p. 273.*

acid attacked the sensitized part of the HAZ, dissolving areas around grain boundaries and causing the individual grains of austenite to loosen and be carried off by the dilute acid. But the weld metal, base metal, and hottest part of the HAZ are unaffected by the dilute acid. If one looks carefully at Fig. 2, one can see, along the corroded surface, individual grains that appear separated from the HAZ in this picture but remain in place because they are still partially attached to the HAZ below the visible surface. If the corrosion were allowed to continue, these grains too would detach and be carried away by the dilute acid.

There are two main cures for sensitization. One is to choose a "stabilized" stainless steel base metal, such as Types 321 or 347 stainless steel. These steels are stabilized against chromium carbide precipitation by the addition of alloy elements that have a much stronger tendency to

form carbides than chromium has. Type 321 stainless contains titanium as an alloying element for this purpose, and is otherwise identical in composition to 304. Type 347 contains niobium (columbium) for this purpose and is otherwise identical in composition to 304.

The other main cure, which is most commonly applied today, is to select a low-carbon grade of stainless, such as 304L instead of 304, as the base metal. The low-carbon grades are generally limited to 0.03% carbon maximum. At this low level, continuous networks of carbides generally do not form during welding, so welding does not compromise the corrosion resistance. Today, there is very little cost difference between 304 and 304L stainless, while there is significant cost difference between 304 and 347 or 321 stainless.

There is a third cure for sensitization, which consists of a solution annealing heat treatment after all welding is completed. However, this is costly, involves severe size limitations, and introduces distortion and scaling issues, so it is seldom used.

It should be noted that, while it is possible to also produce chromium carbide precipitation in multiple-pass weld metal by thermal cycles associated with subsequently deposited weld metal, the ordinary stainless steel weld metals that are not low carbon, such as 308 and 316, are not as easily sensitized as their corresponding 304 and 316 base metals. The weld metals generally contain a small amount of ferrite in the otherwise austenitic deposit. The ferrite is richer in chromium than the austenite matrix, and chromium diffuses in ferrite on the order of one hundred times as rapidly as it diffuses in austenite. Chromium carbides that form in ferrite-containing weld metal tend to form at the ferrite-austenite interface, where the ferrite can easily "pump" additional chromium to the precipitation area, thereby usually averting sensitization.

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Technical Note on Hermetic Packaging

BY THOMAS E. SALZER

The same welding technology used to seal semiconductors can be used for other products. Most solid-state products are sealed in clean dry nitrogen gas. Sometimes helium tracer gas is added to facilitate leak testing. Some customers specify argon fill gas that, while more expensive than nitrogen, presents no technical challenge. Essentially, any nonexplosive, noncorrosive, nonpoisonous gas that can be used to fill an environmental chamber can be used as a fill gas. Expensive gases such as xenon are sometimes specified. Hermetric has developed special mini-chambers that can be evacuated and backfilled with these gases with only a few cm^3 gas lost for each part sealed. If one decides not to backfill the part with gas, then one can seal a vacuum inside the minichamber. The procedure is shown in Fig. 1. Many products such as transducers, MEMS, and SAW devices, perform better at low gas pressure. In addition, the dew point temperature can be lowered by sealing at lower pressure. Figure 2 shows a welded vacuum-sealed package containing an electronic device that will not operate at atmospheric pressure.

A characteristic that makes the projection welding process so versatile is the adiabatic nature of the heat-

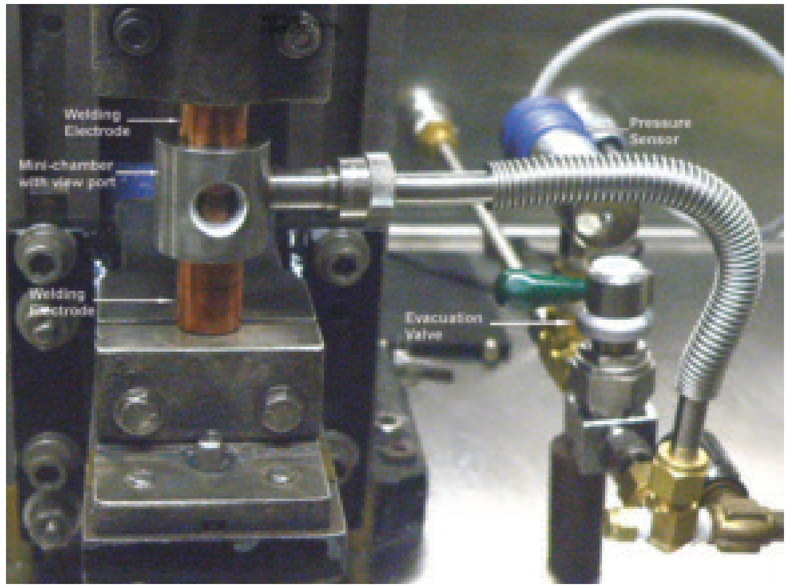


Fig. 1 — Minichamber for vacuum sealing.

Fig. 2 — Vacuum-welded, 0.60-in.-diameter package.

ing. The welding cycle can be so rapid (a few milliseconds) that very little heat transfers to the surroundings. As a result, almost no change in weld parameters is required to seal in different environments. In fact, the process can be so adiabatic that it makes little difference whether the environment is vacuum, gas, or liquid. Because of this, parts can be completely submerged in fluid during the welding process with no change in weld schedule. Some of the fluids sealed into containers include the following:

- Water — for high-pressure applications
- Fluorocarbons — for high-pressure dielectric applications
- Oils — for dielectric applications

Dielectric fluids have been sealed into electronic packages for high-pressure deep-submergence missions. Currently, evaluations are being made for sealing acids into components such as wet tantalum capacitors, electrolytes into batteries, and refrigerants into cooling systems. The ability to seal fluids in containers circumvents the common procedure of sealing a container with gas in it, then replacing the gas with a fluid through a small hole (fill port) in the container, and finally sealing the fill port to contain the fluid. Another advantage of the process is that when evacuating a component from a fill port, the time to evacuate increases as the fill port size becomes smaller. When evacuation occurs prior to sealing, the fill port is not required, and the entire container volume is exposed to the backfill source whether it is vacuum, gas, or liquid. The result is a significant reduction in processing time.

This technique would be difficult or impossible with other joining technologies, and is a direct result of the adiabatic nature of projection welding. The capacity to weld parts with seal perimeters from a small fraction of an inch to as long as ten linear inches is available. The maximum seal perimeter is limited primarily by the current the welding machine can supply. Presently, tabletop-size welding equipment can supply >150,000 A of welding current, and operate from a 120 VAC-10A-1Ø outlet.◆

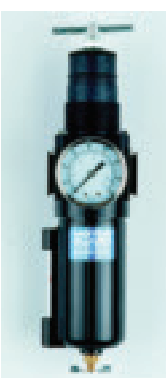
THOMAS E. SALZER (hermetric.inc@verizon.net) *is president, Hermetric, Inc., Burlington, Mass.*

Welding Robot Supports Wide Range of Intelligent Functions

The six-axis ARC Mate 100*i*C intelligent welding robot features a compact design. Also, it offers an integrated welding solution with operation efficiency, speed, high-load capacity, and enhanced performance for welding parts of all shapes and sizes. The robot and R-30*i*A controller can be integrated into a welding system that includes the weld torch cable, wire feeder, and welding power supply. Design enhancements include the following: a cantilevered forearm that is inherently rigid; integrated wire feed control cable with shielding gas hose and welding power cables; an increase in acceleration; a 10-kg payload; slimmer forearm and a size reduction of the robot base to maximize reach in confined areas; multiple mounting positions; and higher motion range. The robot supports intelligent functions such as *i*RVision, a ready-to-use built-in robotic vision package; ROBOGUIDE-WeldPRO simulation package, which easily models the product's dress-out and downloads programs to the robot; Vision Shift, which eliminates the touch-ups and verifications associated with off-line programming or fixture and tool changes; and Collision Guard, which detects robot collisions with external objects. An extra highlight is ArcLink XT™, an Ethernet-based welding network developed in partnership with The Lincoln Electric Co.

FANUC Robotics America, Inc.
www.fanucrobotics.com
(248) 377-7000

Air Preparation Products Useful for Welding Shop Applications



The RG-4520 regulator provides accurate pressure regulation and quick response to changes in supply pressure. Its construction and components deliver reduced set-point creep at high pressure. The unit is rated at 100 ft^3/min of flow, and output pressure range is 0–150 lb/in.^{2}. Included is a high-visibility, scratch- and solvent-proof, glass-faced pressure gauge. In addition, the AC-4525 air control unit combines the precision of the RG-4520 regulator with a water trap and particulate filter. It is rated at a full flow of 100 ft^3/min and 150 lb/in.^{2}. Mounted at the drop before each tool in the shop, a 40-micron-rated sintered bronze element removes dirt and debris, and a metal bowl with manual drain traps moisture.

Motor Guard Corp.
www.motorguardplasma.com
(800) 227-2822

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Thinsulate™ Insulation FR is designed for garments made for the electrical utility and oil and gas workplaces, where momentary, unplanned, or accidental exposure to flames, heat, or electrical arc may occur. This product has thermal weight efficiency making it useful for outdoor environments, so workers can perform jobs in comfort. Made from a blend of aramid, modacrylic, and polyester fibers, the material is designed as a mid-loft product with drape characteristics to aid in garment styling. Plus, the material maintains its flame resistance for the expected life of the garment due to the utilization of inherently fire-resistant fibers.

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Electronic Infrared Thermometer Offered

The IRT-16 infrared thermometer measures temperature accurately through reflected heat emissions. It is for noncontact measurement of welding preheat temperatures. To use, the welder holds the gun, presses the trigger, and aims the gun at the target metal. The temperature immediately appears in °C or °F on the backlit LCD.

Tempil°
www.tempil.com
(800) 757-8301

Automatic Girth Welding Machine Comes with Dual Drive System

The company has added an automatic girth welding machine for tank fabrication applications to its product line. The BGW Series comes standard with a dual drive system. This self-propelled submerged arc welding system can reduce field storage tank welding time as well. The machine is applicable for bottom-up or jack-up constructed single- or double-wall storage tanks inside and outside welding. Features in-

— continued on page 27


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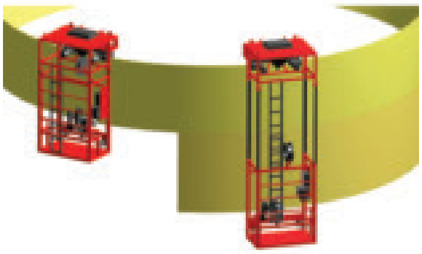


clude a dual motor frequency inverter drive system, power source storage, and heavy-duty flux recovery system.

Bug-O Systems
www.bugo.com
(800) 245-3186

Inverters Monitor All Key Welding Parameters

For use in a mash seam welding application, the company recently announced two high-power WeldVerter™ power supplies with WeldComputer® adaptive weld controls. Each inverter is capable of delivering up to 800 A of continuous welding current at 1 kHz. The system, able to operate in current, voltage, and power feedback modes, is also able to monitor all key welding parameters, detect variations in the process that could be injurious to weld quality, and take preprogrammed action to accommodate the out-of-limits condition.

WeldComputer Corp.
www.weldcomputer.com
(800) 553-9353

Helmet Available with Standard or Ratcheted Suspension

The Radnor® SmoothDome™ slotted cap helmets are tough, lightweight, and com-

fortable. They have received Type 1 (top-impact) safety rating as outlined in ANSI Z89.1-2003 Class E (electrical high voltage). The caps are available in white, blue, gray, yellow, red, Hi-Viz orange, and Hi-Viz yellow/green. Additionally, the helmet is available with a standard or ratchet suspension.

Airgas, Inc.
www.airgas.com
(610) 687-5253

Automatic Door Openers Add Protection to Existing Machinery

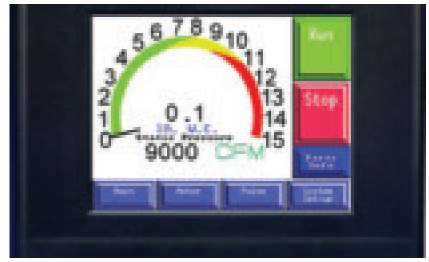
The NT automatic door openers help maintain productivity by automatically opening and closing machine tool doors.

Designed for field retrofit on existing machinery, they are a solution for companies that machine medium to high part volumes. The openers incorporate a preprogrammed control module. Available are several input and output commands that can be wired into the machine's controller to close the door, or an on-off circuit can be used. The openers open single or double doors, have unlimited travel distances, and are self-calibrating.

A & A Mfg. Co., Inc.
www.gortite.com
(262) 786-1500

Dust Collector Control Saves Energy

The company's Intelli-Touch™ energy-savings control panel option is for its entire line of dust collectors. This product reduces



energy consumption with a built-in variable-frequency drive that automatically controls motor rev/min based on ft^3/min needed at the running static pressure. The panel utilizes a soft start and ramp up of motor speed, too. All functions of the dust collector are continually monitored by the panel with a built-in diagnostics feature that tracks pertinent data. This allows the dust collector to operate at maximum efficiency and provide benefits such as longer filter life, reduced compressed air usage, and quieter operation with lower fan speeds.

Micro Air® Clean Air Systems
www.microaironline.com
(866) 566-4276

Coating Process Protects Steel, Aluminum

Through a marketing partnership with Egyptian Coating Co., the company is of-

fering the Thermadep^{SM} one-step, water-based coating process for metal products that require short-term rust protection, coloring, or other aesthetic properties. These protective coatings, available clear and in a variety of colors, are applied by dipping heated parts into a bath of low-VOC, water-based polymer solution. They are effective for protecting castings, forgings, and other heat-treated parts made of any metal substrate, including steel, iron, aluminum, brass, and bronze. The coatings can further be used as a solid film lubrication for fasteners and bearings, a primer and undercoating for metal products, or coating on metal components for processing, drawing, or stamping.

Houghton International, Inc.
www.houghtonintl.com
(610) 666-4000

Work Cell Suits Metal Deposition, Laser Welding

The TetraPORT system is a safe enclosure, modular work cell that can be configured for specific laser application needs. Various models are built for laser applications such as metal deposition, welding, cutting, hardening, and engraving. Also, the metal-deposition system uses a laser to melt metal powder or wire onto a substrate. Applications for this additive process include surface restoration on damaged areas and repair of components.

Alabama Laser Systems
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Reel Features Lower Pull Tension

The LG (Little Giant) series is designed for tubing and air/water applications. It is equipped with a continuous radius grommet style tubing guide constructed of bearing grade, FDA compliant C-PEP™ composite. There are no corners to pinch the tubing, no rollers for the tubing to catch on, and a slick surface for easy glide. The reel features lower pull tension to reduce the chance of stretching tubing. This product mounts to any horizontal or vertical flat surface and weighs 9 to 13 lb depending on the model.

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Nozzle Incorporates Tungsten Alloy Insert

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Thermacut, Inc.
www.thermacut.com
(800) 932-8312

Emergency Response Kit Analyzes Gas Levels Quickly

The Draeger-CMS emergency response kit automatically measures hazardous gases that may be present in any emergency. The CMS unit uses detector tube technology inside a small credit card sized chip and takes a precise air sample of the chemical being measured. With a photo-optical system, the color change is calculated. Gas levels are typically analyzed in about 1 to 2 min. Upon completion, the concentration is indicated on the LCD display. The kit contains the CMS analyzer, the appropriate accessories, and a selection of 10 different chips for response to HazMat or Domestic Preparedness applications.

Draeger Safety, Inc.
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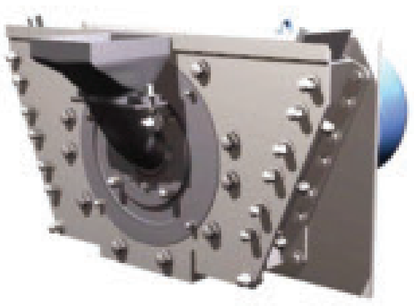
Wheel for Pipe Cleaning Machines Provides Bidirectional Rotation



The Upblast EZEFIT™ wheel is useful for high-production pipe cleaning machines. To maintain a close and consistent distance to the underside portion of the pipe, regardless of the pipe diameter, the wheels mount in the blast cabinet and are positioned under the pipe. This location results in a fast removal of rust, scale, and other contaminants while achieving the mandatory surface profile for effective bonding of the protective coating. The range of pipe sizes cleaned are from 2–120 in. in diameter. The wheel's design offers bidirectional rotation and lower replacement parts inventory through the ability to serve clockwise or counterclockwise wheel applications with a single style wheel.

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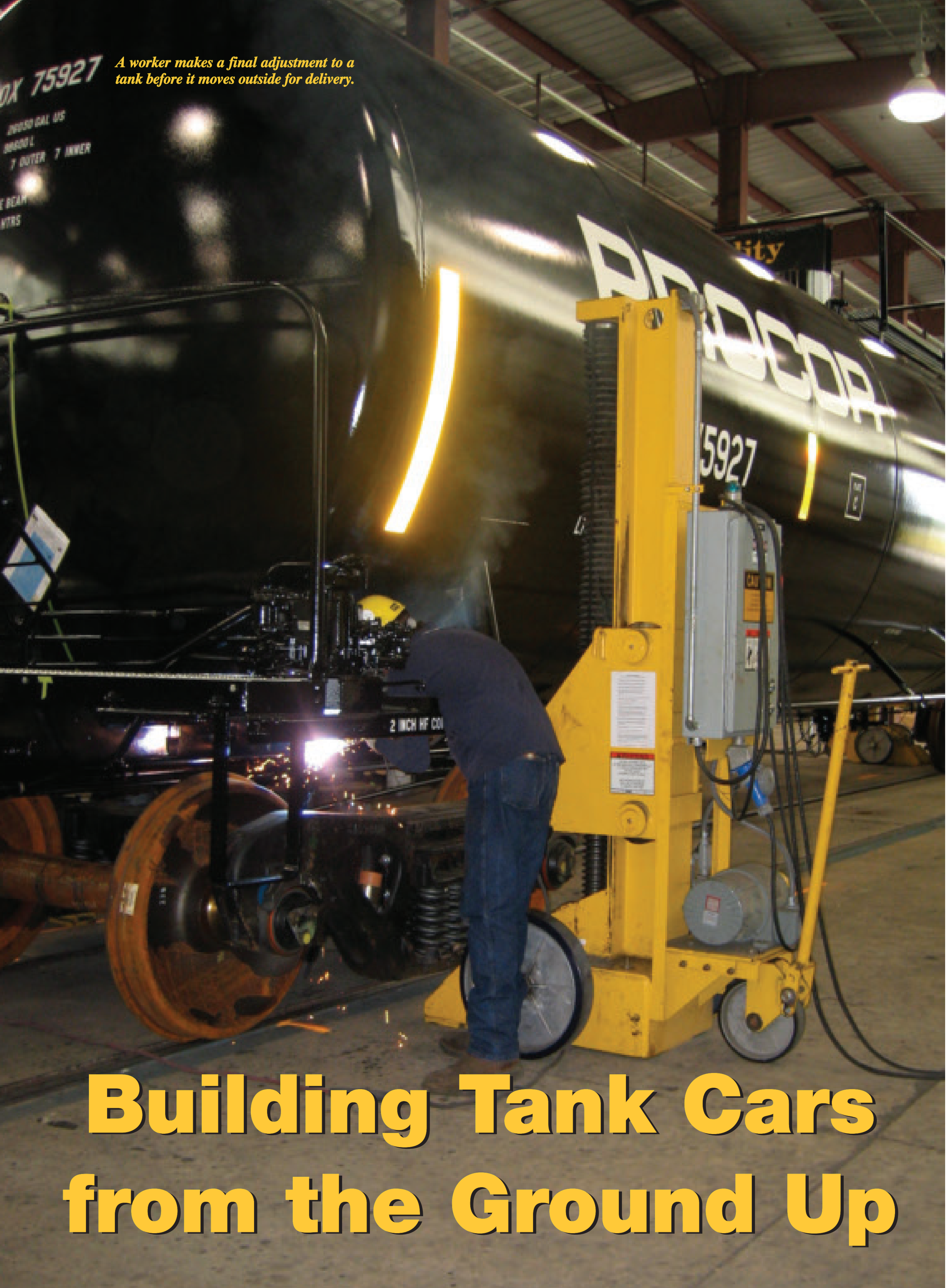

A worker makes a final adjustment to a tank before it moves outside for delivery.

Building Tank Cars from the Ground Up

Union Tank Car's new manufacturing plant in Louisiana represents the latest in tank car manufacturing

BY MARY RUTH JOHNSEN

When Union Tank Car began building a new manufacturing plant in Alexandria, La., it had what some might consider an immodest goal — to construct the most advanced and automated tank car manufacturing facility in the world. Company officials believe it succeeded, and today, less than a year and a half after the first tank car was completed on June 2, 2006, the plant has reached its full production goal of 70 cars per week over two shifts.

"Depending on the type of tank car we're building, we're producing between ten and twelve miles of welds per week," said Bill Casey, manager, Welding Engineering.

The seven-person welding department, which includes Casey, is responsible for "the safety, quality, and efficiency of the welding operations," he said. The tank cars are built and the welds inspected according to the requirements of Association of American Railroads (AAR) M-1002, *Manual of Standards and Recommended Practices Specifications for Tank Cars*, and AWS D15.1, *Railroad Welding Specification — Cars and Locomotives*.

Among other duties, the welding department makes sure the plant's welding operations meet the code requirements, it oversees welder training and qualification, and maintains welding procedure qualification records. Approximately 250 welders work at the plant, most of whom had no previous welding experience before joining the company (see boxed item).

The Facility

UTLX Manufacturing, Inc., is a wholly owned subsidiary of Union Tank Car Co., Chicago, Ill. Union Tank Car examined about a dozen states as potential locales for what was to become UTLX Plant 08 before narrowing the choices to Louisiana, Texas, and Oklahoma. Louisiana Governor Kathleen Blanco led

MARY RUTH JOHNSEN (mjohnsen@aws.org) *is senior editor of the* Welding Journal.

Fig. 1 — A crane picks up the cut-and-blasted steel plate and takes it to be formed into rings (far right).

Fig. 2 — Welders use GMAW-P to tack weld a ring.

Fig. 3 — Automated SAW completes the internal welding to complete the ring.

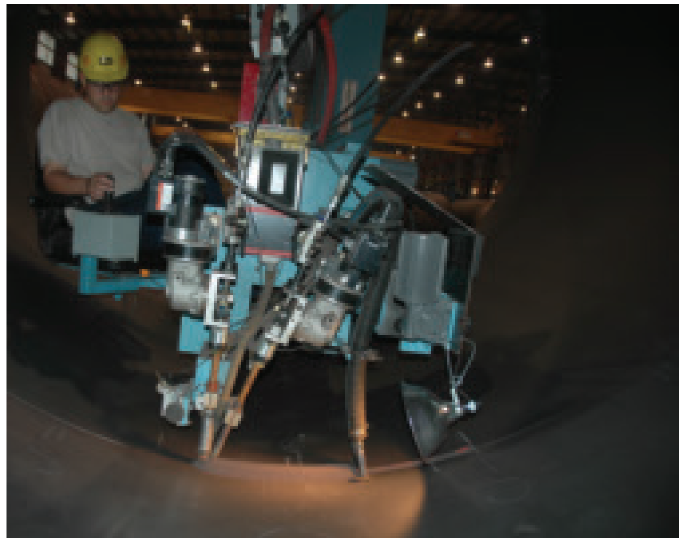

Fig. 4 — Internal welding of the girth weld using SAW in the tandem configuration. The girth weld is one of the main weld joints that joins several rings to construct a tank.

the effort to develop a comprehensive incentive and infrastructure package that would entice UTLX to the state. The Alexandria site was selected in part because of those incentives and because of its location. Alexandria is the crossroads of four major state highways and Interstate 49 runs through it. The site is adjacent to the England Industrial Air Park and Community, which includes the city's airport, and rail service and utilities were already at the property line.

Construction began at the 122-acre greenfield site — a former cotton field — in December 2004. Although Alexandria is in central Louisiana, far enough from the Gulf Coast to avoid the worst hurricane effects, 400,000 yards of soil were brought in to raise the elevation above the 100-year flood plain; the plant now sits 86 ft above sea level. One thousand pilings were driven in to support the four buildings, a 13,345-sq-ft administration building and three manufacturing buildings totaling more than 900,000 sq ft (20.7 acres). In addition, the buildings were designed and constructed to withstand winds of 70 mph. A fire alarm system was also installed throughout the plant. There are four miles of embedded rail inside the plant and three miles outside.

The plant operates on Lean Manufacturing concepts, including self-directed work teams and visual signals for materials replenishment. All materials are placed at point of use; there is no traditional warehouse at the facility.

UTLX officials believe this is the first railcar manufacturing plant anywhere to totally employ an in-line manufacturing process. There are four lines, each divided into seven manufacturing cells. The multiple lines prevent easier-to-assemble tank cars from being delayed by more complicated orders ahead of them. Compared to the company's plant in Sheldon, Tex., the design of the new plant reduces car travel during manufacturing from more than four miles to one mile. Normal cycle time on a two-shift operation will be between 8 and 12 days as compared to up to 40 days, and value-added/nonvalue-added time is 80/20 compared to the typical 50/50. The pace of production flow is set at 4 hours; in other words, they expect to move a car to each new work cell within a 4-h time period.

Fig. 5 — Bolsters such as these are welded to a bolster pad rather than to the tank itself.

Fig. 6 — Using the FCAW process, a welder works on a head shoe. The head shoe is the reinforcement between the tank and the stub sill, which is the device that connects two rail cars.

Creating a New Welding Workforce

Nearly all of the approximately 250 welders now working for UTLX in Alexandria had no welding experience before signing on with the company. "We had to teach them how to put on a welding helmet," said Bill Casey, manager, Welding Engineering.

Recruiting and training were done in conjunction with the Louisiana Department of Labor and the Alexandria campus of Louisiana Technical College. "It was a very successful partnership," Casey said of the company's work with the college.

"Louisiana has a fairly aggressive grant program for training, especially for companies who wish to move into the state," he explained. The Labor Department recruited the workers and sent them to UTLX where they were given a basic mechanical aptitude test. Those who passed began welder training.

UTLX personnel worked with Mike Owens, who heads the industrial training program at Louisiana Technical College, and the other welding instructors there to develop the training the company needed.

"They were taken from the fundamentals to qualification in three to four weeks," Casey said. Twenty to 25 people went through the course approximately every three weeks until UTLX reached the staffing level it needed. Most of the applicants came from the Alexandria area so they did not need to relocate.

They were taught one process, gas shielded flux cored arc welding, because that's the process 80% of the welders use at UTLX. Following the mechanical aptitude testing, UTLX hired them as a welder trainee. Once they passed their qualification tests and proved themselves on the job, they moved up to the position of welder.

"We had about a 90% success rate," Casey said. "However, the 10% who didn't pass usually were hired for other positions, so our hire rate was almost 100%."

About 80% of the applicants for welding positions trained at the college; the rest trained at the plant.

Those who needed to learn gas metal arc welding and submerged arc welding did so at UTLX.

"Finding experienced submerged arc welders is almost impossible," Casey said. "Those with experience, their companies aren't letting them go."

Building the Tank Cars

The Alexandria plant builds both jacketed and nonjacketed nonpressure tank cars. Thus far, the plant has mostly produced general-purpose cars, explained Plant Production Manager Thomas Malo. General-purpose tank cars are rated at no more than 165 lb/in.^{2}. Many of the cars plant workers have built so far have been to transport ethanol. Since currently there are no pipelines for ethanol, it is primarily shipped by rail, Malo said. The Sheldon, Tex., and East Chicago plants build pressure tank cars. Pressure cars are those rated at 300 lb/in.^{2} or greater.

The facility primarily utilizes three welding processes: semiautomatic and automatic submerged arc welding (SAW) using both single and tandem arc configurations, flux cored arc welding (FCAW), and pulsed gas metal arc welding (GMAW-P). A small amount of shielded metal arc welding (SMAW) — mostly for small repair jobs — is also used. With the exception of the SAW power sources, the plant utilizes inverter-type welding machines.

The facility mostly welds ASTM A-516-70 and TC 128, Grade B, steels, and 300 Series stainless steel, which is used for fittings and other items attached to the tank cars. The tank car bodies are constructed in two sections called tubs, Casey explained. Each tub consists of two or more rings and the end cap. The number of rings used depends on the length of the car.

Fig. 7 — Hot water or steam will flow through the coils attached to this car to help liquefy the product it will carry.

The plate arrives at the plant nearly at the size needed, but cutting to the final dimensions is done with a plasma arc cutting table. Both sides are then blasted simultaneously. Once the steel has been blasted, a crane picks it up (Fig. 1) and moves it onto a machine that rolls it into a cylindrical shape. Welders then tack weld the cylindrical sections, known as rings — Fig. 2. Once the tack welds are completed, automated SAW equipment welds the butt joint from the inside — Fig. 3.

The submerged arc process is also used

Fig. 8 — The closed-circuit television system used to monitor employees working inside a tank, which is considered a confined space.

Fig. 9 — The view of the main manufacturing facility from atop one of the platforms workers use instead of ladders to access the top of the tanks.

Fig. 10 — These workers are welding nozzles and repads into the tank car. The weld requires complete joint penetration with ultrasonic NDE requirements, using FCAW. Note the safety harnesses, which are connected to the access platform for fall protection.

Fig. 11 — Jacketed cars receive a wrapping of insulation.

to make the girth welds that join several rings to construct a tank — Fig. 4. The company uses a tandem configuration for the girth welds. UTLX utilizes PowerWave power sources from The Lincoln Electric Co. for all of its SAW applications. Casey said they achieve the weld quality the company needs and are versatile machines since a single power source can operate in several modes. Casey is proud of the accomplishments of his still relatively inexperienced welding operators. "We're close to the point with SAW for zero defect welding," he said. "We should accomplish that sometime this year."

The company recycles the flux and soon will begin recovering the slag. "We're still in the testing phases for recovering slag," he said. The reasons for recycling are twofold: "We can reduce costs and be a good citizen for the environment. It reduces what we send to a landfill."

Inspection occurs throughout the construction process. Welders are expected to be accountable for their own welds, AWS Certified Welding Inspectors perform additional visual inspections, and digital X-ray and ultrasonic phased array equipment is used at various times as dictated by code requirements and/or company policy.

Once the tubs are constructed, workers begin doing the layout and cutting of the holes for inserts such as manways and nozzles. Reinforcements called bolster pads and belly pads are added with a manually welded ¼ to ½ in. fillet weld using FCAW. When using FCAW, the company utilizes E71T1 electrodes with CO_2 shielding gas. The pads increase the structural integrity of the tank and provide a place to attach items to it — Figs. 5, 6. Since tank cars often carry substances potentially harmful to people and the environment, items such as the bolsters upon which the tank rests on the wheels are intentionally not welded to the tank itself. They could then break away from the tank in case of a derailment, explained Malo, lessening the chance of a rupture.

In this step of the construction process, they also attach the series of coils through which steam or hot water travel to help liquefy the product inside a jacketed car — Fig. 7.

Because of the use of CO_2, the inside of the tank is considered a confined space, Malo said. Welders working inside a tank carry with them an oxygen meter, a lower explosive limit (LEL) meter, and a closed-circuit television camera. "This is a system that was designed in-house," Malo said. "With this system, one person can watch eight tanks at the same time instead of having to assign one person for each tank" — Fig. 8.

Another safety measure is to access the top of the tanks using platforms rather than ladders — Fig. 9. When working atop a tank, workers must use safety harnesses for protection from falls — Fig. 10.

Once all the openings are cut, all the attachments are welded on, and inspection requirements completed, the tanks move into one of the plant's two stress-relief ovens.

The stress-relief ovens are the key to the entire operation, Casey said. Because of the expense to operate them, "the whole objective for profitability is to keep the stress ovens loaded and running. If the ovens are not running, we're not shipping tank cars."

Once the cars leave the stress-relief ovens, they undergo hydrostatic testing. Jacketed cars are primed for painting, wrapped with insulation (Fig. 11), then sent to the jacket shop to receive their outer shell made of 9 gauge sheet metal. Four pieces of sheet metal are vacuum formed around the tank, then clamped to hold the pieces in position for welding with GMAW-P. Pulsed gas metal arc welding was selected, Casey said, because it produces less spatter and less distortion. With this process, the company uses metal cored wire and a gas mixture of 90 argon/10 CO_2.

The final major welding step for both jacketed and nonjacketed cars follows. In this cell, fittings such as manways, pipes for air vents, and safety valves; access ladders; and other required safety equipment are welded on — Fig. 10.

Once the interior of the cars are cleaned, they travel to the paint shop. After painting and any final adjustments (see lead photo), the cars move to the outside rails for delivery.

Conclusion

In less than three years, the UTLX plant in Alexandria, La., has gone from literally raising the ground to full production of 70 tank cars a week. Company officials are proud of their modern facility and the accomplishments of their welding staff, most of whom had no welding experience prior to joining the company.◆

Securing Containers of Radioactive Materials

A contractor details how to weld and inspect containers securing hazardous materials

BY GARY R. CANNELL

Fig. 1 — This designed and fabricated fixture supports and aligns the weld head during welding.

The Department of Energy's (DOE) responsibility for the disposition of radioactive materials has given rise to several unique welding applications. Many of these materials require packaging into containers for either interim or long-term storage. It is not uncommon that final container fabrication, i.e., closure welding, is performed with these materials already placed into the container. Closure welding is typically performed remote to the container, and routine postweld testing and nondestructive examination (NDE) are oftentimes not feasible.

Fluor Hanford, prime contractor for DOE at the Hanford Site in Washington, has packaged many such materials in recent years as part of the site's cleanup mission. In lieu of postweld testing and NDE, Fluor's approach has been to establish weld quality through "upfront" development and qualification of welding parameters, and then ensure parameter compliance during production welding. This approach requires a rigor not usually afforded to typical welding development activities, and may involve statistical analysis and nonroutine weld testing, including burst, drop, sensitive leak testing, etc.

This article provides an instructive review of the development and qualification activities associated with the closure of radioactive materials containers, including a brief report on Fluor's welding activities for the closure of research reactor spent nuclear fuel (SNF) overpacks at the Hanford Site.

Technical Approach

Welding development and qualification activities associated with the closure of radioactive materials containers typically require a greater level of effort than for most welding applications. As noted above, this is primarily due to the critical nature of the materials being packaged and the difficulty in performing routine postweld testing and NDE. In addition, this work is performed in a highly regulated environment that is subject to significant review and analysis. The technical basis for development and qualification activities must ensure that requirements are met and that container performance will meet the design service.

The following list of activities should be considered for welding development and qualification for the closure of radioactive materials containers.

- Clearly identify and understand weld requirements and criteria, including container service, performance, and regulatory.
- Based on weld requirements and criteria, select the best-suited welding

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Based on a paper presented during the 2006 FABTECH International & AWS Welding Show held Oct. 31–Nov. 2 in Atlanta, Ga.

Fig. 2 — A pull test of 1.25 times the design lifting load took place on the overpack.

Fig. 3 — Shown are the thermocouple attachment locations and setup.

process; this selection process may include performing a "down-select" or alternative selection review.

- Prepare a written development/qualification plan to include the following:
- Welding trials (including mockup assemblies) to establish suitable parameters. Parameter development should target values that produce desired (optimum) weld characteristics, such as bead penetration, bead shape, deposition rate, etc.
- Qualification testing to include that specified by the applicable code(s) and/or regulatory body(s) and any additional testing necessary to establish required confidence in the process and parameters. Test and examination may include NDE, mechanical testing (burst, drop, tensile, bend), metallography, etc.
- Demonstration or validation testing.
- Procure or design a suitable data-acquisition system (DAS) to be used to capture production weld data for weld parameter, compliance verification.

Results/Discussion

Fluor has successfully completed several radioactive materials packaging campaigns, including those for plutonium-bearing special nuclear materials (SNM) (Ref. 1) and spent nuclear fuel (SNF) (Ref. 2). The following provides a brief review of the activities for the development and qualification of a gas tungsten arc welding (GTAW) process for closure of overpacks containing TRIGA®[1] research reactor SNF.

Requirements and Criteria

The overpack was designed to provide confinement of the packaged materials against release to the environment during interim storage over a 40-year design life. The materials of construction, heads, shell, and miscellaneous pieces are Type 304L. Qualification of the welding process, procedure, and welding operators met requirements of ASME *Section IX — Welding and Brazing Qualifications*. In addition, storage-facility criteria required the welded overpack to be leaktight per ANSI N14.5 ($\leq 1 \times 10^{-7}$ atm cc/s air).

Welding Process Selection and Description of Equipment

The GTAW process, machine-welding mode, was selected for this application. Equipment included a full-function, microprocessor-controlled system (Gold Track V) manufactured by Liburdi Dimetrics®[2]. Welding was performed remote to the overpack with the aid of a video console and cameras at the weld head. A fixture to support and align the weld head, with respect to the overpack closure, during welding was designed and fabricated — Fig. 1.

Welding Trials

Design of the production weld joint called for a 3⁄16-in. (4.8-mm) fillet to be welded in the horizontal or 2G position. Initial welding trials were made on flat plate test coupons, representative of the overpack weld joint with regard to material type, thickness, weld joint design, and welding position. These were followed by trials on round sections, simulating the actual overpack.

One of the constraints considered during parameter development was weld joint fitup, i.e., the potential for a gap at the shell/head interface. Per the design drawing, the gap could range from 0 to 3⁄32 in. (2.4 mm). To ensure the welding parameters/process would accommodate fitup within this range, several test coupons were welded in which gaps varied from 0 to 5⁄32 in. (4 mm). It was determined that a 3⁄32-in. (2.4-mm) gap could be successfully welded.

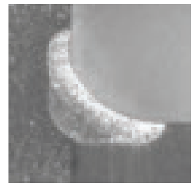
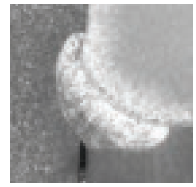
Qualification Testing

With the nominal set of welding parameters selected, a simple statistical experiment was designed to evaluate bounding limits for two of the welding parameters — primary welding current and pri-

1. TRIGA (Training, Research, Isotopes, General Atomics) is a registered trademark of General Atomics.

2. Liburdi Dimetrics is a registered trademark of Liburdi Dimetrics Corp.

Table 1 — Test Results and Photomicrographs from Three Weld Sections, Representing the Low, High, and Nominal Heat-Input Settings

Test ID	VT	PT	LT	Metallography		
SW-1-1	Accept	Accept	Accept	Accept	Accept	Accept
SW-1-2	No	No	Leak Rate:	SW-1-1 (Low Heat)	SW-1-4 (High Heat)	SW-1-6 (Nominal Heat)
SW-1-3	Indications	Indications	$< 1 \times 10^{-7}$ atm-cc/s	210 A/4 in./min	270 A/3.2 in./min	240 A/3.6 in./min
SW-1-4						
SW-1-5						
SW-1-6						
SW-1-7						
SW-1-8						

mary travel speed. These parameters were judged to be of key importance in determining weld bead shape, weld pool control, and fusion at the root of the joint.

The purpose of the experiment was to identify a suitable/acceptable range for the critical parameters. Bounding values were set at the welding engineers' discretion to bracket anticipated variability of the welding and measuring equipment, and to accommodate potential upset conditions.

The experiment, a two-factor, two-level factorial with replication at high and low limit values, was performed on an actual production overpack. Welds were subjected to visual inspection (VT), liquid penetrant examination (PT), helium leak testing (LT), and metallographic evaluation. Table 1 provides test results and photomicrographs from three (of the eight) weld sections, representing the low, high, and nominal heat-input settings.

One additional production overpack closure was completed in which the entire weld was deposited using the nominal heat input parameters. Finally, ASME Section IX welding procedure testing was performed. All qualification testing met specified requirements.

3. Fluent is a registered trademark of Fluent Inc.

Additional Testing and Evaluation

Integrated Proof Testing

A production overpack in which both heads were fitted with lifting lugs (in production only the top head receives these lugs) was welded using the qualified process. This overpack was subjected to a pull test of 1.25 times the design lifting load — Fig. 2. The tested overpack was visually examined and liquid penetrant tested for damage, and one of the head-to-shell welds was helium leak tested. All testing met specified requirements.

Maximum Overpack Temperature

To understand the impact the heat of closure welding may have on the overpack contents, a temperature calculation, using the computer code FLUENT™[3], was performed. The maximum overpack temperature, at approximately three inches from the weld (on the shell), was calculated to be 153°C (307°F). Testing to measure actual maximum temperatures, via thermocouples attached to the final qualification overpack weld, was performed. Temperature values were recorded using a vendor-calibrated data logger; thermocouple attachment locations and setup are shown in Fig. 3. A comparison of the calculated value at three inches from the weld (on the shell) to the measured value at the same location confirmed the conservative nature of the calculation — that is, 153°C (307°F) and 80°C (176°F) for the calculated vs. the measured values, respectively.

Discussion

In addition to the ASME Section IX certifications, the welding operators scheduled for production welding were those who performed the development work. This provided the opportunity to become thoroughly familiar with the process and the specific technique developed. The "machine-welding" mode relies, to a degree, on the skill of the welding operator. The overall strategy for providing high confidence in overpack closure welding includes both the development qualification activities and the skill of the qualified welding operators.

Conclusion

Fluor has successfully closure welded many radioactive materials packages. As nuclear site cleanup activities continue, there will be an opportunity and need to develop and qualify additional closure-welding processes. The above-outlined approach provides a template to consider when preparing/planning for these activities.◆

References

1. Cannell, G. R., Daugherty, W. L., and Stokes, M. W. 2002. Welds safeguard plutonium-bearing containers. *Welding Journal* 81(7): 42–46.

2. Cannell, G. R., and Ruth, R. P. 2003. Closing spent nuclear fuel canisters with GTAW. *Welding Journal* 82(12): 28–32.

Decisions to Make before Automating

There are many factors to assess before a decision to implement automation is made

BY DIANE STEADHAM

In a society where technology is advancing on a daily basis, many industries are faced with the question of whether or not to replace manual laborers with machines. In the welding and fabrication industry, several recent advances have been made to allow the transition to automation to occur, but there are several factors that need to be considered first. It is important for anyone wishing to use automation to consider the overall investment when making the decision to convert to automation, and how that investment affects things such as your facility, equipment, training, personnel, and support.

Evaluate the Facility

The first aspect of the investment that needs to be considered is the facility. It is important to understand that many existing facilities will require changes and improvements to accommodate welding automation. While incredibly efficient, often times doubling output, both fixed automation and robotics use more space due to size of machines and the room needed for the flow of raw materials once production increases. There likely will be requirements for additional power sources and ventilation. Additionally, an obvious decision will need to be made on the type of equipment. Will you be using robotics or fixed/hard automation? There may also be an investment of personnel involved. In some instances, workers may need to be trained to operate the automation system, and in others, training may not be logical and new employees brought in.

Automation Advantages

Along with automation comes a multitude of cost-saving opportunities. Automation will provide faster setup, which will result in less downtime and increased production. Since the automated system will be set up for repeatability and will involve less downtime, there will be less of an opportunity for outside variables to affect the equipment resulting in longer equipment life and improved consumable usage. The ultimate consistency and repeatability of automation will in most cases prevent a need for human touch up or clean up.

What Really Is the Payback?

In addition to immediate cost savings, those wishing to transition one or all of their applications to automation usually ask about the payback. While some of the larger weld shops in the industry, specifically the big three automakers, have the ability to begin profiting from automation within a year, most will take one to two full years to see the initial returns. The average shop can expect a return of about $100,000 within two years of substituting one person with automation. A smaller shop could require up to four years and the substitution of two persons in order to see that kind of return on their investment, so it is extremely important to consider all the economic factors involved.

Choosing the Automation

The final part of the decision process is to determine whether you will be using fixed/hard automation (Fig. 1) or robotics — Fig. 2. The majority of manufacturers will provide a thorough cost analysis including process recommendations and the projected cost for each. If what is needed is a variety of welds and processes, then robotics is more than likely going to be the recommendation. Most robotic cells are capable of storing a variety of programs making them extremely versatile. However, if you wish to replace just a few applications, fixed or hard automation would be the most efficient investment and fixed systems can almost always be customized to fit your specific needs. It may also be helpful to look forward to the future as well to determine future costs of parts as well as whether or not you

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Fig. 1 — An example of hard automation where the welding gun is clamped in a fixed position.

Fig. 2 — Typical robotic weld cell.

have intentions of adding additional automated applications.

When the Decision Is Made

Once a decision is made to automate, it will be time to revisit earlier steps beginning with the facility. At that point you will need to determine if you have adequate space. There will need to be space for the equipment and also increased space for incoming materials and finished product once the automation increases output.

Despite decreasing the need for manual labor when switching to automation, the effect on personnel is very positive. The addition of automation can provide the opportunity for advancement and technicians could be needed to monitor the automation equipment. There will also be opportunities in training as well. Not only will there need to be trainers hired but the existing employees may have the opportunity to learn more about and how to operate the new technology. The automation systems will also reengage and involve employees as they work to come up with and test the improved automation processes.

Cooling the Equipment

Another extremely important aspect to consider during the equipment selection process is whether your automation system will be air cooled or water cooled. Duty cycle, amperage, wire size, and shielding gases are all important factors in making this decision in order to keep the highest level of safety possible. Any systems with a duty cycle of 80% or above or amperage higher than 250–300 A normally will be water cooled. Additional guidelines for a water-cooled system would be any system using wire sizes larger than ¹⁄₁₆ in. or high concentration of shielding gasses.

Auxiliary Equipment and Technology

There are several other smaller issues and options to consider once you have made the decision to go with automation. The first is that a wide variety of automated accessories and peripherals are available to help further increase the efficiency of your automation system. A nozzle cleaner, wire trimmer, and antispatter mist applicator are all available as well as an alignment fixture and tool center point (TCP) verification tool. Each of these automated accessories helps reduce downtime, increase the life of equipment, and enable continuing repeatability.

Next, there are all kinds of specialized technologies available, especially for robotic systems. The various technologies, almost all of which are tied to improving repeatability and production, include nozzle sense, touch sense, TCP, emergency stop, and compact cables and storage. There are many more as well.

A common concern is that because of the new equipment, you may have to bring in a new separate line of consumables. However, if addressed up front, manufacturers can work with you to consolidate as much consumable use as possible such as contact tips, gas diffusers, nozzles, and conduit/liners. It will also be important to connect with your robotics manufacturer and welding supplier to increase efficiency in areas such as training, programming, maintenance, and process changes.

Remember Technical Support

Finally, you will want to make sure that there is always support in place. Ongoing training for employees will help them handle most issues that may arise and will help them to become more efficient in daily operational tasks. For the instances when issues cannot be handled internally, you will want to make sure there is technical support provided by your manufacturer. Also be well aware of equipment availability to further help you quickly respond to any issues or problems that may come up. Since the whole reason for automating was to increase production, you want to be sure you are prepared to handle any emergency situations in an efficient manner.

Be Informed

By considering the guidelines I have laid out, I hope the automation process has become a little clearer. It is important not to jump into making decisions such as transitioning to automation without knowing all the facts and details. It is hoped you can now make a well-informed decision about automation and how it can help advance your business.◆

AWS Adds Two-Run Option for Flux-Electrode Classification

Important revisions to AWS filler metal specification A5.23 are explained in detail

BY DENNIS D. CROCKETT

The submerged arc welding process has been used for many years by manufacturers seeking to improve quality, increase productivity, reduce costs, and enhance welder comfort. This automated arc welding process utilizes continuous solid or cored (composite) electrodes with a granular welding flux. The flux's main function is to shield the molten weld pool from the atmosphere. The flux is deposited along the weld joint ahead of the welding arc(s). The high current-carrying capacity of the electrodes and the ability to utilize welding procedures employing multiple electrodes make the submerged arc process a good choice for downhill welding applications requiring deep penetration, high deposition rates, fast travel speed, or some combination thereof.

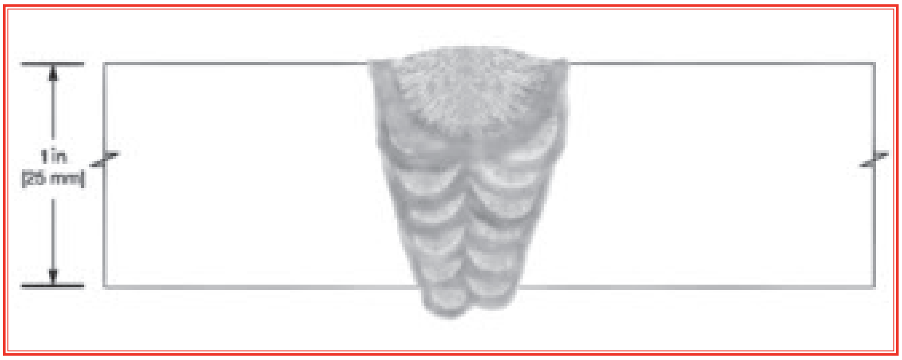

Fig. 1 — Cross section of multiple pass flux-electrode classification weld.

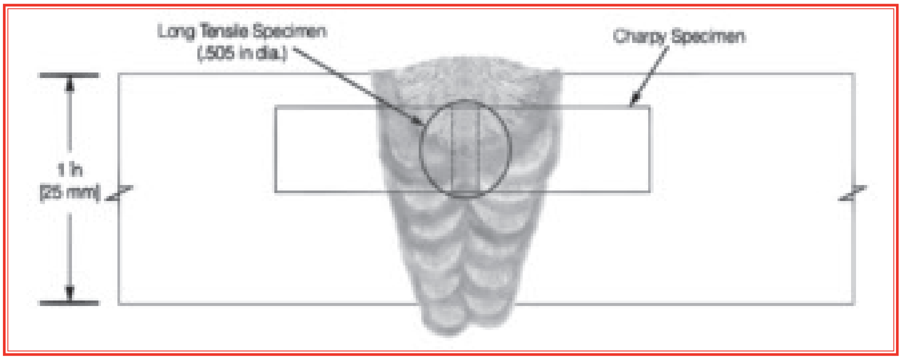

Fig. 2 — Charpy and tensile specimen locations for multiple pass classification test.

The A5.17 and A5.23 Specifications

The American Welding Society classifies carbon and low-alloy submerged arc electrodes and fluxes with two specifications. These are AWS A5.17/A5.17M, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding,* and AWS A5.23/A5.23M, *Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding.* These specifications make use of both U.S. Customary Units and the International System of Units [SI]. Solid electrodes under both specifications are classified based upon their chemical compositions. Tubular (composite) electrodes are classified based upon the weld deposit composition developed with the electrode and a particular flux. Fluxes are not classified independently but are classified with an electrode of a specific classification based upon the mechanical properties of the weld metal deposited in a 1 in [25 mm] thick groove joint with the flux-electrode combination. The test groove joint typically requires 12 to 15 weld passes to complete. The A5.23/A5.23M low-alloy specification also has specific requirements for weld deposit composition. The A5.17/A5.17M carbon steel specification does not.

Revisions to A5.23/A5.23M Specification

The 2007 editions of both the AWS A5.17/A5.17M carbon steel and AWS A5.23/A5.23M low-alloy steel submerged arc specifications have been published this year. The A5.17/A5.17M-97 (R2007) edition is simply a reaffirmation of the

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ANSI/AWS A5.17/A5.17M-97 specification issued in 1997. No technical changes were made to that specification. However, major changes have been incorporated into the A5.23/A5.23M:2007 low-alloy specification. The most noteworthy of these changes is the addition of a two-run classification system. The AWS A5B Subcommittee on Carbon and Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding has added a two-run classification option in recognition of the fact that mechanical properties obtained on a two-run and other limited-pass welds with a given flux-electrode combination can be significantly different than the mechanical properties obtained on multiple pass welds using the same flux-electrode combination.

Two-Run and Multiple Pass Welds

The differences in the mechanical properties obtained on multiple pass welds from those developed on two-run and other limited pass welds can be attributed in great part to their respective microstructures. In multiple pass welding, the reheating of each weld pass by the subsequent weld pass has the effect of refining the grain structure of that pass. As a result, the completed multiple pass weld consists of a network of fine grain regions that serve to enhance the Charpy V-notch properties of the weld — Figs. 1, 2. The use of higher-basicity fluxes can further improve the V-notch properties of multiple pass welds by reducing the grain boundary oxygen (oxide) inclusion levels. Also, any adverse effect from admixture with the base plate is minimized due to the low dilution factor.

On two-run (limited-pass) welds, the grain refinement mechanism described above for multiple pass welds is minimal. The second pass of a two-run weld consists entirely of as-deposited microstructure that is not conducive typically to developing good weld metal V-notch properties — Fig. 3. In addition, the base plate dilution factor of limited pass welds can exceed 50%. As a result, the mechanical properties obtained with any flux-electrode combination on a limited pass weld can be expected to vary with the base plate composition. The approaches taken to develop good Charpy V-notch properties on limited-pass welds are of necessity different than those used for multiple pass welds. These include, for example, the design of special fluxes that promote finer grain weld structures and the use of electrodes alloyed with molybdenum, titanium, and/or boron to promote a fine acicular ferrite structure and to retard the growth of grain boundary ferrite.

Limitation of Existing Classification

The existing multiple pass flux-electrode classification provides users a reasonable basis for identifying candidate flux-electrode combinations to meet their multiple pass application requirements. However, for limited pass applications such as the fabrication of structural steel shapes, pipe for oil and gas transmission, and wind towers the usefulness of multiple pass flux-electrode classifications for identifying candidate flux-electrode combinations that meet their application requirements is questionable. It is for this reason that a two-run flux-electrode classification option has been added to the AWS A5.23/A5.23M specification. The low-alloy A5.23/A5.23M specification was selected as the residence document for the two-run classification because (1) low-alloy electrodes classified under this specification are commonly used to develop good mechanical properties on limited pass welds, and (2) the strength level requirements in this document are higher than those found in the A5.17/A5.17M carbon steel specification and better meet the requirements of commercial practice.

The two-run weld test assembly is a nominal 1/2 in [12 mm] thick butt joint weld which is welded with one pass on each side. The base plate material and welding conditions are defined in the specification. Full-size Charpy V-notch impact specimens and a 0.250 in diameter longitudinal tensile test specimen are machined from the completed weldment and tested to determine conformance to mechanical property requirements — Fig. 4. The two-run flux-electrode classification has no weld metal composition requirement.

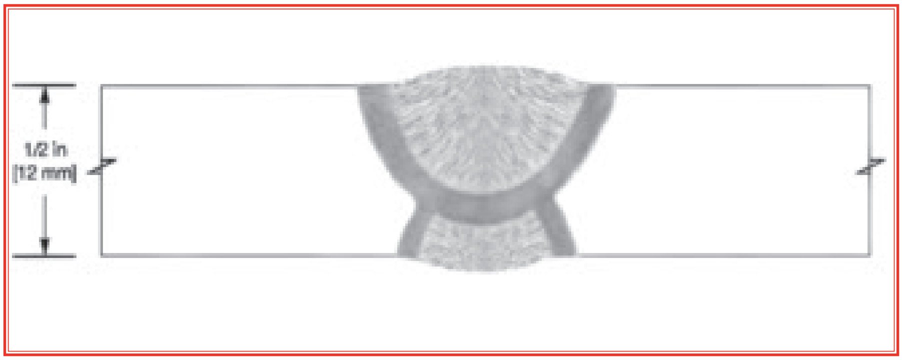


Fig. 3 — Cross section of two-run flux-electrode classification weld.

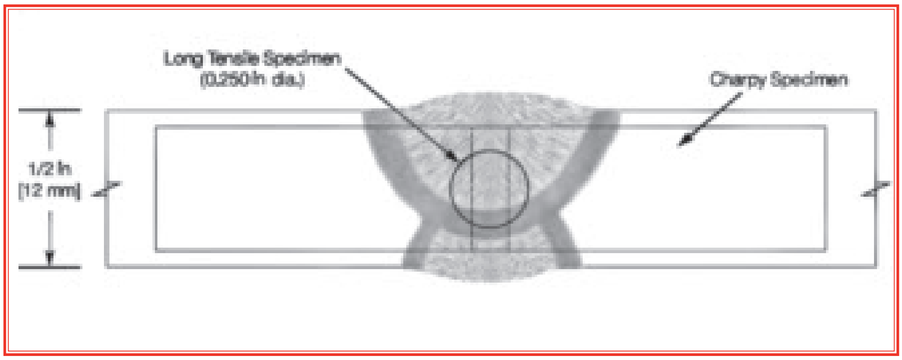


Fig. 4 — Charpy and tensile specimen location for two-run classification test.

The Classification System Outlined

The classification system is outlined as follows.

FXTXXG – EXX – HX, where,

- The letter **F** indicates a submerged arc welding flux.
- The letters **XT** indicate the minimum tensile strength on a two-run classification.
- The **X** in the fourth position indicates the condition of heat treatment, if any.
- The **X** in the fifth position indicates Charpy V-notch properties.
- The **G**, when present, indicates that the test joint was not constructed from one of the steels prescribed in the specification but from another steel as agreed to between purchaser and supplier.
- The **EXX** indicates the classification of electrode used in producing the weld.
- The **HX** is an optional, supplemental hydrogen designator. This designator is optional and does not constitute part of the flux-electrode classification.

Two examples of flux-electrode two-run classifications are given below. The examples shown are in U.S. Customary Units.

Example 1. **F7TA4-EM12K** is a complete designation for a flux-electrode two-run classification. It refers to a flux that, when used with an EM12K electrode to weld the base plate prescribed in accordance with the two-run welding conditions called for in the AWS A5.23/A5.23M:2007 specification, will produce weld metal in the as-welded condition having a minimum tensile strength of 70,000 psi and Charpy V-notch impact strength of at least 20 ft·lbf at –40°F.

Example 2. **F8TA2G-EA1** is a complete designation for a flux-electrode two-run classification. It refers to a flux that, when used with an EA1 electrode to weld the test plate in accordance with the two-run welding conditions called for in the AWS A5.23/A5.23M:2007 specification, will produce weld metal in the as-welded condition having a minimum tensile strength of 80,000 psi and Charpy V-notch impact strength of at least 20 ft·lbf at –20°F. The **G** in the classification indicates that the base steel used is not one of the test steels prescribed in the specification but is some other steel (such as an API 5LX70 pipe steel) as agreed between purchaser and supplier.

Additional Changes to A5.23

In addition to the two-run classification, higher classification strength levels have been added to the AWS A5.23/A5.23M:2007 revision to reflect the use of higher-strength steels in practice today. Changes were also made to composition requirements for EB9 electrodes and B9 weld deposits, as well as changes to the diameter tolerance for composite electrodes. This revision includes new classifications EA1TiB and EA2TiB, that are titanium-boron-containing electrodes useful in developing improved Charpy V-notch impact properties on single-pass welds.◆

FABTECH International & AWS Welding Show
General Attendance Information

Convention Center
McCormick Place
2301 South Lake Shore Drive
Chicago, IL 60616

Show Hours
Sunday, November 11
11:00 a.m.–4:00 p.m.

Monday, November 12
9:00 a.m.–5:00 p.m.

Tuesday, November 13
9:00 a.m.–5:00 p.m.

Wednesday, November 14
9:00 a.m.–3:00 p.m.

Registration Hours
Sunday, November 11
9:30 a.m.–3:00 p.m.

Monday, November 12
8:00 a.m.–4:00 p.m.

Tuesday, November 13
8:00 a.m.–4:00 p.m.

Wednesday, November 14
8:00 a.m.–2:00 p.m.

Show Visitor Age Requirements
The FABTECH International & AWS Welding Show is a trade event and open only to industry professionals. No one under 16 will be admitted.

Student Registration
Technical students are welcome at the Exposition. Guidelines for instructors and students can be found on the Web at www.fmafabtech.com/Attendees/Student-Attendance.cfm
Questions about student registration should be directed to the show's registrar:
Lori Poole
(313) 425-3147
FAX: (313) 425-3407
Email: lpoole@sme.org

Transportation from Chicago O'Hare International Airport
There are a number of ways to get to and from O'Hare International Airport, which is located just 17 miles northwest of downtown Chicago. Most ground transportation access areas are located at the main entrance for each terminal.

Taxi—Taxicabs are available on a first-come, first-served basis from the lower level curbfront of all terminals. Shared ride service is available. There are no flat rates because all taxicabs run on meters. Expect to spend approximately $35 to $40 for a taxicab ride to downtown Chicago. For wheelchair-accessible vehicles, please call United Dispatch at (800) 281-4466.

Limo Services—Approximate cost is $100 to downtown Chicago.

Airport Express Shuttle Service—Provides transportation to/from the Hyatt Regency McCormick Place Hotel (which is connected to the convention center) at a service fee. For more information please contact Airport Express at (888) 284-3826 or on the Web at www.airportexpress.com.

RTA—The Regional Transportation Authority (RTA) manages the 3 public transit operations in northeastern Illinois: The Chicago Transit (CTA), Metra commuter rail, and Pace suburban bus. For information on routes and schedules, contact the RTA via its Website at www.rtachicago.org or call the Transit Information Hotline at (312) 836-7000.

Parking
McCormick Place has two parking garages, one located near the South Building and one located in Lakeside Center. The current charge is $16 per day regardless of the length of stay. The Hyatt Regency McCormick Place Hotel, which is connected to the convention center, also has a parking garage with an hourly rate. You may contact them at (312) 567-1234 for details. Handicap-accessible parking is available in Lot A (located on Martin Luther King Drive), Lot C (located underground in Lakeside Center), and the Hyatt Regency McCormick Place parking garage.

Hotel Information
The Chicago Hilton & Towers has been selected as the AWS Headquarters for the 2007 FABTECH International & AWS Welding Show.
Below are all participating hotels. Shuttle service between the hotels and the convention center will be available only from these hotels.

Hotels
Free shuttle service between the hotels and the convention center will be available only from these hotels.
Best Western Inn Chicago
Conrad Chicago
Courtyard by Marriott Downtown
Courtyard by Marriott Chicago Mag. Mile
Embassy Suites Chicago Downtown
Embassy Suites Lakefront
Essex Inn
Fairmont Hotel
Hard Rock Hotel
Hilton Chicago
Hilton Garden Inn
Hyatt Regency Chicago
Hyatt Regency McCormick
Intercontinental Chicago
Marriott Downtown Mag. Mile
Palmer House Hilton
Sheraton Chicago
Wyndham Chicago
Make hotel reservations online from any of the show sponsors' Web sites, or call the FABTECH International & AWS Welding Show housing agency at (800) 974-9833 or (847) 282-2529 (outside the U.S.) Monday–Friday, 8:00 AM – 5:00 PM CST.

Directions to McCormick Place (Parking Lot A)

FROM O'HARE INTERNATIONAL AIRPORT, NORTHWEST OR THE NORTH:
Follow I-190 East to I-90 East. This turns into I-90/94 East (Dan Ryan Expressway). Keeping to the right, follow to I-55 North (Stevenson Expressway). Exit at Martin L. King Drive (Exit #293D) and follow signs to Lot A.

FROM THE WEST: Take I-290 East (Eisenhower Expressway) to I-94 East (Dan Ryan Expressway). Keeping to the right, follow to I-55 North (Stevenson Expressway). Exit at Martin L. King Drive (Exit #293D) and follow signs to Lot A.

FROM MIDWAY AIRPORT OR SOUTHWEST: Take I-55 North (Stevenson Expressway). Exit at Martin L. King Drive (Exit #293D) and follow signs to Lot A.

FROM THE SOUTH OR INDIANA via I-80/94: From I-80/94, exit at I-94 West (Bishop Ford Expressway) and proceed on I-94 West (Dan Ryan Expressway). Follow to I-55 North (Stevenson Expressway). Exit at Martin L. King Drive (Exit #293D) and follow signs to Lot A.

FROM INDIANA-SKYWAY: Take I-90 West (Indiana Tollway turns into the Chicago Skyway). Merge onto I-90/94 West (Dan Ryan Expressway). Exit at I-55 North (Stevenson Expressway). Exit at Martin L. King Drive (Exit #293D) and follow signs to Lot A.

FROM NORTH LAKE SHORE DRIVE (US-41): From Lake Shore Drive, exit at 31st St. and turn right (West). Turn right again on Martin L. King Drive and follow signs to Lot A.

FROM SOUTH LAKE SHORE DRIVE (US-41): From Lake Shore Drive, exit at 31st St. and turn left (West). Turn right on Martin L. King Drive and follow signs to Lot A.

FROM CONGRESS PARKWAY: From Congress Parkway, turn right onto Michigan Ave. Proceed South to Cermak Rd. (E. 22nd St.). Turn left on Cermak Rd. Then turn right immediately onto Prairie Av. and follow signs to Lot A.

See Chicago

After show hours, enjoy your stay in Chicago, a world-class destination that offers something for every taste and every budget, whether it's spectacular live theatre, energetic nightclubs, or awe-inspiring architecture. For information on what to see and do in Chicago, log on to www.meetinchicago.com.

AWS Special Events

Sunday, November 11
11:00 a.m.

FABTECH INTERNATIONAL & AWS WELDING SHOW OPENING CEREMONY

A short, symbolic ceremony opens the FABTECH International & AWS Welding Show, the largest trade show and educational conference for the metal forming, fabricating, and welding industries.

AWS PROFESSIONAL WELDERS COMPETITION

Competition Hours:
Monday, November 12
9:30 a.m.–12:30 p.m. and 1:30 p.m.–4:30 p.m.

Tuesday, November 13
9:30 a.m.–12:30 p.m. and 1:30 p.m.–4:30 p.m.
Show Floor of North Building

Awards Ceremony
Wednesday, November 14
10:00 a.m. **Booth 39051**

Winners will be announced at the awards ceremony. (Winners need not be present.)

The Professional Welders Competition Committee sponsors the competiion, and welcomes the assistance of Indiana Section 27.

Professional welders will compete on the show floor for a grand prize of $2,500, as well as a $1,000 second prize and a $500 third prize. The welding procedure involves welding a 3 x 3 x 3/8-inch angle to a 1/4 x 6 x 6-inch horizontal plate using shielded metal arc welding (SMAW). Each participant will set his/her own current and voltage prior to welding and must clean the weldment following welding to prepare for the inspection process. Competitors will have five minutes to create a single-pass 5/16-inch fillet weld using 5/32-inch E7018 electrode on low-carbon steel. The contest will be judged by a team of AWS Certified Welding Inspectors using the criteria in AWS D1.1, Structural Welding Code — Steel, and verified using automated inspection equipment.

Competitors must be at least 19 years old, sign a form stating that they are professional welders, and pay a $10 entry fee. You may bring your own helmet, protective clothing, earplugs, etc., or use those provided at the competition site. Registration will take place at the Professional Welders Competition booth on the show floor in the North Building between 12:30 and 4:30 PM on Sunday, November 11, or Monday and Tuesday, November 12 and 13, during the competition. Note: Registration for the exposition is required to gain admittance to the show floor.

For more information about the Professional Welders Competition, including complete competition rules and safety rules, please visit www.aws.org/competition.

Monday-Tuesday, November 12-13
9:00 a.m. – 5:00 p.m.
Co-sponsored by SME and FMA
North Building • Free • Registration Code: J1

JOB FAIR AND WORKFORCE DEVELOPMENT PAVILION

Whether you're a veteran professional or a student just entering the workforce, the Job Fair & Workforce Development Pavilion will give you an excellent opportunity to meet with representatives of companies seeking prospective employees. Learn about the jobs these companies offer, and perhaps even have a personal interview. When you visit the pavilion, please dress appropriately and bring your résumé.

While at the pavilion, you'll also want to visit employment service providers who will be on hand to offer their support and assistance in workforce development and other employment-related opportunities.

Monday, November 12
8:00 a.m. – 9:00 a.m.

LEADERSHIP SUMMIT: ADDRESSING THE SHORTAGE OF SKILLED WORKERS IN U.S. MANUFACTURING

The shortage of skilled workers has been a cause for stress for businesses across America and in many parts of the world. A retiring workforce that makes up about half of the industry today, coupled with a lack of young people entering the fabrication and welding fields, has created an extremely challenging production environment for manufacturers. Media reports across the country document regional shortages that are forcing employers to take unprecedented measures to complete projects. Consequences of the skills shortage can be severe operationally and are already emerging across several critical industries where fabrication and welding employees are integral to the manufacturing and construction fields. This provocative summit will join together, for the first time, key representatives from our nation's capital and manufacturing sector, who will reveal relevant strategies and long-term approaches to building a competitive manufacturing workforce in a challenging recruiting environment. This is a must-attend event for anyone involved with operations or production in the manufacturing industry.

Moderator: David Hanson,Commissioner, Mayor's Office of Workforce Development, Chicago

Since 2005, David Hanson has served as Commissioner of the City of Chicago Mayor's Office of Workforce Development. He also serves as co-chair of the Chicago Manufacturing Renaissance Council (CMRC), has worked on initiatives to help provide businesses with assessment of workforce needs, to expand training beyond conventional city college programs toward more industry-specific certifications, and has brought about an alignment of local education and training.

Panelist: Anthony Swoope, Administrator, Office of Apprenticeship Employment and Training Administration, U.S. Department of Labor

Anthony Swoope became Administrator of the Office of Apprenticeship in 1999 with the reorganization of the Employment and Training Administration. He has held positions as the Director of the Bureau of Apprenticeship and Training, Ohio State Director, as an Apprenticeship and Training Representative, an Apprenticeship Instructor at Owens Technical College, and Director of the Akron Urban League's Apprenticeship Outreach Program. A native of Akron, Ohio, Anthony graduated from the Sheet Metal Apprenticeship Program and received his formal education from the University of Akron and the University of Toledo.

Panelist: Dan Swinney, Executive Director, Chicago Manufacturing Renaissance Council

Dan worked for 13 years as a machinist in the Chicago area. He organized Steelworker Local 8787 at G+W Taylor Forge in Cicero, Illinois, and served as vice president. In 1982 he founded the Center for Labor and Community Research (CLCR), a not-for-profit consulting and research organization that specializes in developing innovative and effective approaches to community and business development, industrial job retention, and workforce education. Dan also directs the Chicago Manufacturing Renaissance Council (CMRC), a federation of business, labor, educational, and governmental leadership that provides oversight and coordination of a variety of manufacturing workforce projects. In addition, Dan serves as Project Manager for Chicago's Austin Polytech Academy. Dan earned his B.A. degree from the University of Wisconsin.

Panelist: Jim Reeb, Director of Manufacturing R & D, Caterpillar

Over his 33-year career, Jim has managed all functions within Operations, Logistics and Procurement and managed product engineering groups who design powertrain components. Currently he is responsible for the development and deployment of Manufacturing Processes and Technology. Jim is also the Global Process Owner for Manufacturing Engineering, Manufacturing Production Execution, and Manufacturing Support Process. He has completed a 4-year manufacturing apprentice program and earned a bachelor's degree from the University of St. Francis, and an MBA from Governors State University.

9:00 a.m.

AWS OPENING SESSION & ANNUAL BUSINESS MEETING

During the AWS Opening Session and 88th Annual Business Meeting, 2007 AWS President Gerald D. Uttrachi will give the Presidential Report and Gene E. Lawson will be inducted as AWS President for 2008. Following the induction, the 2007 Class of AWS Counselors and Fellows will also be introduced. This meeting is open to all AWS Members and Show registrants.

10:30 a.m. – 11:30 a.m.

COMFORT A. ADAMS LECTURE — Room S404

A New Path to Probe Weld Microstructure Evolution Using Synchrotron Radiation

Dr. John W. Elmer, Acting Program Element Leader, Stockpile Materials and Joining in the Chemistry & Materials Science Directorate of Lawrence Livermore National Laboratory, is this year's Adams Lecturer. The Comfort A. Adams Lecture is named after the Founder and First President of AWS. This annual lecture is made by an outstanding scientist or engineer, honored by the AWS Board of Directors.

11:15 a.m.

IMAGE OF WELDING AWARD CEREMONY — Room S504 a, b, c

Join the Image of Welding Committee (a subcommittee of the Welding Equipment Manufacturers Committee) and special guests as they recognize the individuals and organizations that have excelled in promoting the image of welding in their communities. Invitation only.

6:30 p.m. – 8:00 p.m.
Chicago Hilton & Towers Hotel International Ballroom

AWS OFFICERS/PRESIDENT'S/COUNTERPARTS RECEPTION

This reception is held annually during the Show and is open to all registrants. Take advantage of this opportunity to meet the AWS Officers, and network with members and prospects. A complimentary hors d'oeuvres buffet is included, along with a cash bar. Evening business attire, please.

Tuesday, November 13

2:00 p.m. – 3:00 p.m.

AWS NATIONAL NOMINATING COMMITTEE – OPEN MEETING — Room S504 b, c

AWS Members are requested to submit their recommendations for National Officers to serve during 2009. Nominations must be accompanied by 16 copies of biographical material on each candidate, including a written statement by the candidate as to his/her willingness and ability to serve if nominated and elected.

9:00 a.m. – 11:00 a.m.
Free • Registration Code: W88

END USER FORUM — Room S504 b, c

Speakers: John Matthews, Senior Welding Engineer, Welding and QA Technology, CB&I, Plainfield, Ill.; Guy Mulee, Manufacturing Engineering Manager, Baldor Dodge Reliance, Clio, S.C.; Mark Combs, President, Combs Welding Design, Inc., Winter Haven, Fla.

Like most welding professionals, most of your time is spent dealing with the "big picture": aligning company goals, motivating and keeping staff, and meeting customer needs. Every once in a while, it's important to step away from the daily routine and get rejuvenated through exposure to new thinking and dialogue with your peers.

This forum has been created to bring together the end-user welding community for a one-of-a-kind, content-rich productivity learning experience. The session will allow you to engage in provocative discussions with your peers, away from the office or shop floor.

Presenters will cover real-life productivity issues, including:

- Mechanizing field welding procedures and the use of incentives to enhance welding productivity for field construction.
- Overview of a contracting strategy for new construction and maintenance work at a large manufacturing and research facility as it transitions from a self-performing to a majority contracting organization.

• What one welding shop has done to increase its throughput and efficiency.

• How contractors are qualified, HSE requirements, quality control, and project management.

• What a small job shop has done to eliminate its reliance on suppliers, to be more competitive and responsive to its customers.

11:00 a.m. – Noon

FREE

GLOBAL IMPROVEMENT OF LIFE THROUGH WELDING

Room S504 b, c

Chris Smallbone, president of IIW (International Institute of Welding), will address IIW's vision of improving human conditions worldwide through welding technology, as well as the need for international bodies to cooperate for the benefit of developing nations, nations with economies in transition, and developed nations. Successful models used in various countries, particularly for technology diffusion, education and training, the use of appropriate technologies, and conformity assessment, will be shown to be of benefit in meeting global challenges.

Noon–1:30 p.m.
Price: $30 for members and nonmembers
AWS AWARDS/AWS FOUNDATION RECOGNITION CEREMONY AND LUNCHEON **Room S503 b**

The first AWS award, the Samuel Wyllie Miller Memorial Medal, was presented to Comfort A. Adams in 1927. As the Society and the industry it serves have grown, so has the need to recognize outstanding scientists, engineers, educators, and researchers. Join an assembly of distinguished award presenters, recipients, and guests for a well-paced ceremony and a delicious lunch. The cost for attending the ceremony and luncheon is $30, and it is open to all registrants. You must register for this event separately from the full Show program. Tickets will also be available at the door.

1:00 p.m. – 5:00 p.m.
Registration Code: W89
INTRODUCTION TO THERMAL SPRAY COATING PROCESSES **Room S404 b, c**

Thermal Spray Seminar

Instructors: Frank Hermanek and Ed Simonds
From the application of zinc and aluminum to steel structures and the protection of welds on galvanized and aluminized steel, to the application of stainless steel to pump and valve components that will see chemical exposure, thermal spray has broad application in protecting a range of substrates from corrosion.
The seminar will present a three-part overview of these thermal spray coating processes:

• Molten metal flame spraying
• Powder flame spraying
• Wire flame spraying
• Ceramic rod flame spraying
• Detonation flame spraying
• High velocity oxyfuel spraying (HVOF)
• Cold spraying
• Plasma spraying
• Electric arc spraying
• RF plasma spraying

Wednesday, November 14
7:45 a.m.– 8:45 a.m.
PRAYER BREAKFAST **Room S503 a**

Lift your spirits with fellowship, a good breakfast, and a prayer in this nondenominational gathering. The cost for attending the breakfast is $20, and is open to all registrants. For advance reservations, register online at www.aws.org/show and click on the "Register" button. You must register for this event separately from the full Show program. Tickets will also be available at the door.

10:00 a.m.
R. D. THOMAS, JR., INTERNATIONAL LECTURE

Room S404 b, c

(American Council of IIW meeting immediately following lecture at 10:30)

The Need for Common Standards in a Global Economy

Dr. David Shackleton, Chair of IIW Select Committee on Standardization, and President, ISO3834.com Ltd., is this year's lecturer. The R. D. Thomas, Jr., International Lecture award was created to honor R. D. Thomas, Jr., for his participation in IIW/ISO activities and is presented by AWS to an individual who is also involved in IIW/ISO international activities. The recipient is invited to deliver a lecture that illustrates the incorporation of global studies in the standardization of welding technology during the AWS Welding Show and at the Annual Assembly of the IIW.

Society Free Events

All free events. Plummer Lecture is part of the full Education Program on the registration form, but there is no charge.

Monday, November 12

10:30 a.m. – 11:30 a.m. **Room S404**

Comfort A. Adams Lecture

A New Path to Probe Weld Microstructure Evolution Using Synchrotron Radiation

Tuesday, November 13
10:00 a.m. – 11:30 a.m. **Room S404 a**
Plummer Memorial Education Lecture
Observations from 40 Years of Welding Training

11:00 a.m. – Noon **Room S504 b, c**
Global Improvement of Life through Welding

Wednesday, November 14
10:00 a.m. – 10:30 a.m. **Room S404 b, c**
R. D. Thomas, Jr., International Lecture
The Need for Common Standards in a Global Economy

10:30 a.m. (immediately following R. D. Thomas , Jr. Lecture) **Room S404 b, c**

American Council of IIW Meeting

Show Events

	SUNDAY, NOV. 11 *Show hours 11 am–4 pm*	MONDAY, NOV. 12 *Show hours 9 am–5 pm*
CONFERENCES		FRICTION WELDING CONFERENCE
SEMINARS *Continuing education programs to enhance your career*		INSPECTION TO NEW D1.1 ROADMAP THROUGH D1.1 PRICING & PROFITABILITY WHY & HOW OF WELDING PROCEDURE SPECIFICATIONS
PROFESSIONAL PROGRAM *State-of-the-art technical presentations*		AUTOMOTIVE APPLICATIONS COATINGS TECHNOLOGIES MODELING 1 CONSUMABLES DESIGN WELD SENSING & CONTROL FITNESS FOR SERVICE, RESIDUAL STRESSES & NDE
	POSTER SESSION	POSTER SESSION
RWMA SCHOOL		
EDUCATION SESSIONS *Free programs for welding educators*		PROFESSIONAL WELDERS COMPETITION
SOCIETY SPECIAL EVENTS *Mostly free volunteer and networking events for people who want to get more involved*	SHOW OPENING AWS FOUNDATION DISTRICTS COUNCIL	LEADERSHIP SUMMIT: SHORTAGE OF SKILLED WORKERS AWS ANNUAL BUSINESS MEETING ADAMS LECTURE IMAGE OF WELDING AWARD CEREMONY OFFICERS & COUNTERPARTS RECEPTION JOB FAIR AND WORKFORCE DEVELOPMENT PAVILION

FABTECH TECHNICAL SESSIONS

The Fabricators and Manufacturers Association Int'l and the Society of Manufacturing Engineers have scheduled more than 40 FABTECH Technical Sessions in 10 technology areas.

Technology Areas	*9:30 – 11:30 am*	*1:30 – 3:30 pm*
Management	R&D Tax Credit (F10)	Lean Accounting (F20) Basic Management for Emerging Team Leaders (F21)
Operations/Lean	Lean 101–Principles of Lean Manufacturing (F11)	Lean 202–Advanced Value Stream Mapping (F22)
Automation		
Cutting	Comparative Cutting with Tech Tour (F12)	Waterjet Cutting Advancements (F23)
Lasers		Laser 101 (F24)
Fabricating/Forming	Roll Forming (F13)	Roll Forming for Construction Industry (F25)
Materials, Processes	Adding Powder Capabilities to the Job Shop (F14)	Tool Steel Friction Management (F26)
Safety	Safety & Health Concerns for Management/Business Owners (F15)	Laser Safety in Manufacturing (F27)
Stamping	Introduction to Metal Formability (F16)	Understanding Sheet Metal Stamping Springback (F28)
Tube & Pipe	Tube & Pipe Production (F17)	Hydroforming Today (F29)
Other Show Events	**12:00 – 1:00 pm** **Free Business Seminar: Selecting Lean Building Blocks** (B1)	

at a Glance

Register with form on page 71 or at www.aws.org/show

TUESDAY, NOV. 13 *Show hours 9 am–5 pm*	WEDNESDAY, NOV. 14 *Show hours 9 am–3 pm*
HOT WIRE WELDING & CLADDING CONFERENCE	
WELDING OF STAINLESS STEELS	WELDING OF STAINLESS STEELS
VISUAL INSPECTION WORKSHOP	METALLURGY APPLIED TO EVERYDAY LIFE
	INTRODUCTION TO MT, PT, UT & RT
WELDING & JOINING IN SCANDANAVIA	WELDING IN KOREA
OPTIMIZATION IN ARC WELDING	ELECTRON BEAM WELDING
RESEARCH IN GERMANY	LASER BEAM WELDING
MODELING 2	NAVY-SPONSORED FRICTION STIR WELDING
WELDABILITY OF MATERIALS	WELDING METALLURGY
NAVY-SPONSORED ARC WELDING	ADVANCES IN FRICTION STIR WELDING
MANAGEMENT & TRAINING	ARC WELDING TECHNOLOGIES
POSTER SESSION	POSTER SESSION
RWMA RESISTANCE WELDING SCHOOL	RWMA RESISTANCE WELDING SCHOOL
PROFESSIONAL WELDERS COMPETITION	PROFESSIONAL WELDERS AWARDS CEREMONY
PLUMMER EDUCATION LECTURE	HIGHER EDUCATION WELDING UPDATE
NAT'L SCIENCE FOUNDATION GRANT: NAT'L CENTER OF EXCELLENCE IN WELDING EDUCATION & TRAINING	
INT'L BRAZING & SOLDERING SYMPOSIUM	PRAYER BREAKFAST
END USER FORUM	THOMAS LECTURE
GLOBAL IMPROVEMENT OF LIFE THROUGH WELDING	
AWS AWARDS/FOUNDATION RECOGNITION LUNCHEON	
INTRODUCTION TO THERMAL SPRAY COATING PROCESSES	
JOB FAIR AND WORKFORCE DEVELOPMENT PAVILION	

9:30 – 11:30 am	*1:30 – 3:30 pm*	*9:30 – 11:30 am*
High-Powered Lean Teams (F30)	Assessing Your Company for Growth & Investment (F40)	Strategic Planning for Job Shop Owners (F50)
		Leading Technical Professionals (F51)
Lean 203–5S Workplace Organization and Standardization (F31)	Total Productive Maintenance for the Fabrication Job Shop (F41)	Optimizing High Variation Operations: Lessons for Fabricators and Specialty Manufacturers (F52)
Demand Pull in the Fabrication Job Shop (F32)		
Automated Non-contact & Vision with Tech Tour (F33)	Productive Robotics with Tech Tour (F42)	Business Software (F53)
Laser Cutting Technology (F33)	Plasma Plate & Structural Cutting (F43)	
Precision Laser Applications (F35)	Laser Part Design & Identification (F44)	Breakthroughs in Laser Technology (F54)
Coil Processing (F36)	Press Brakes with Tech Tour (F45)	
Tool Steel for the Non-metallurgist (F37)	Fabricating of Stainless Steel (F46)	
Risk Control: Substance Abuse Screening (F38)	Machine Safeguarding without Compromising Production (F47)	Elements of a Comprehensive Safety & Health Program (F55)
Lean Tool & Die Shop Solutions (F39)	Solutions for Stamping Press Operations & Set-up (F48)	
	Tube Bending (F49)	Tube Production (F56)
8:00 – 9:30 am **Executive Forum Breakfast: Finding Growth in the New Economy** (F1)	**12:00 – 1:00 pm** **Free Business Seminar: Job Shop Marketing** (B2)	**12:00 – 1:00 pm** **Free Business Seminar: Workforce Performance Improvement** (B3)

The 2007 FABTECH International & AWS Welding Show is packed with technical sessions, conferences, and seminars. If you are interested in the latest happenings in the research world, friction welding, hot wire welding, resistance welding, the D1.1 *Structural Welding Code — Steel*, visual inspection, welding stainless steel, welding procedure specifications, brazing and soldering, and education and training, to name a few, you are in the right place. Take a look at all the offerings below, and sign up today to improve your knowledge and productivity. It is a rare opportunity to have so much variety available in one place. Take advantage of it now.

Welding Show 2007 Professional Program

Pick and choose between concurrent sessions for the latest in welding research and commercial developments. Pay by the day or attend the entire three-day program, with special discounts for students and members of AWS, SME, FMA, or NAM. On-site registration will be available at the event meeting room.

3-day Complete Professional Program; for Member of AWS/FMA/SME/NAM: $225; Nonmember: $360 (Code W84)
3-day Student Professional Program; for Member of AWS/FMA/SME/NAM: $75; Nonmember: $90 (Code W85)
1-day Professional Program (Monday [W81], Tuesday [W82] or Wednesday [W83] only); for Member of AWS/FMA/SME/NAM: $150; Nonmember: $285

Monday, November 12
8:00 a.m.–5:00 p.m.

Session 1 — Room S501a
AUTOMOTIVE WELDING AND JOINING APPLICATIONS

A. 8:00 a.m. **"Panel Distortion Using Low-Heat MIG Braze Welding Process"** by C. Tsai and C. Kim, Ohio State University, Columbus, Ohio, and J. McClure and M. Garnett, DaimlerChrysler Corporation, Auburn Hills, Mich.

B. 8:30 a.m. **"Modeling of High Frequency Induction Heating"** by J. Cadman, J. Swenson, Y. Adonyi, and R. Warke, LeTourneau University, Longview, Tex.

C. 9:00 a.m. **"Comparison of Welding Processes and Base Metals for Automotive Applications"** by E. Surian, National University of Lomas de Zamora, and National Technological University Buenos Aires, Argentina, H. Svoboda, National University of Buenos Aires, Buenos Aires, Argentina, A. Scotti and V. A. Ferraresi, University of Uberlandia

D. 9:30 a.m. **"New Arc Welding and Brazing Processes and Their Benefits in Auto Body Assembly"** by Y. Cho, Hyundai Motor Company, Hwaseong-si, Korea

E. 10:00 a.m. **"Distortion Control of Resistance Spot Welding of Steel Sheets"** by K. Hou, L. Liu, and H. Wu, Chang Gung University, Taoyuan, Taiwan

Session 2: — Room S501b, c
INDUSTRIAL TECHNOLOGY 1: COATINGS TECHNOLOGIES

A. 8:00 a.m. **"Do All Paths Lead To The Same Coating?"** by D. Moody, Plasma Powders & Systems, Inc., The Villages, Fla.

B. 8:30 a.m. **"Cold Spray, A New Solid-State Material Spraying Technology"** by J. Villafuerte, Windsor, Canada

C. 9:00 a.m. **"Reliable and Simple Twin Wire Arc Spray Process for On-line Re-Coating from a Tubeweld Seam"** by F. Van Rodijnen, Sulzer Metco OSU GmbH, Duisburg, Germany

D. 9:30 a.m. **"Overlay: Welding vs. Thermal Spray"** by P. Sahoo, ASM, LLC, Houston, Tex.

E. 10:00 a.m. **"Industrial Application of Magnetic Pulse Welding for Dissimilar and Similar Metals"** by M. Blakely, Hirotec America, Auburn Hills, Mich.

Session 3: — Room S501d
MODELING OF WELDING AND JOINING PROCESSES 1

A. 8:00 a.m. **"Weld Pool Behavior in Arc Welding at High Current"** by P.F. Mendez, Colorado School of Mines, Golden, Colo.

B. 8:30 a.m. **"Predicting Susceptibility of Aluminum Welds to Liquation Cracking"** by C. Huang, Taiwan Semiconductor Manufacturing Company, Hsin-Chu, Taiwan and G. Cao and S. Kou, University of Wisconsin, Madison, Wis.

C. 9:00 a.m **"Transformation Shears and Residual Stress in Constrained Welds"** by S. Kundu and H.K.D.H. Bhadeshia, University of Cambridge, Cambridge, United Kingdom

D. 9:30 a.m. **"Simulation Based Design of Hybrid Laser Welding Processes"** by D.F. Farson, M.H. Cho and Y.C. Lim, The Ohio State University, Columbus, Ohio

E. 10:00 a.m. **"Heat Transfer and Fluid Flow During Keyhole Mode Laser Welding of Tantalum, Ti-6Al-4V, 304 Stainless Steel and Vanadium"** by R. Rai, J.W. Elmer, T.A. Palmer and

T. DebRoy, The Pennsylvania State University, University Park, Pa.

Session 4: Room S501a
RECENT DEVELOPMENT IN CONSUMABLES DESIGN

A. 1:00 p.m. **"Effect of Fluoride Additions on the Diffusible Hydrogen Content in Steel Weld Metal"**
by Y. Murakami, JFE Steel Corporation, Golden, Colo, and S. Liu, Colorado School of Mines, Golden, Colo.

B. 1:30 p.m. **"SMAW Consumable Trials for Strain-Based Design Requirements"**
by M. D. Crawford, G. J. Atkins, D.B. Lillig and J. Sleigh, ExxonMobil Development Company, Houston, Tex.

C. 2:00 p.m. **"Welding High-Strength Steel with Reduced Heat Input and Improved Productivity"**
by K. Li and Y. Zhang, University of Kentucky, Lexington, Ky., and P. Xu, Link-Belt Construction Equipment Company, Lexington, Ky.

D. 2:30 p.m. **"Novel Tools for Alloy and Welding Consumable Development"**
by B. T. Alexandrov and J. C. Lippold, Ohio State University, Columbus, Ohio and N. E. Nissley, ExxonMobil, Houston, Tex. and S.J. Norton, BP America, Houston, Tex.

E. 3:00 p.m. **"Development of a Ni-Cu Consumable for Reduction of Hexavalent-Cr Emissions When Welding Stainless Steels"**
by J. W. Sowards, Boian T. Alexandrov, G. S. Frankel, D. Liang and J. C. Lippold, The Ohio State University, Columbus, Ohio

F. 3:30 p.m. **"New Method to Design Consumables for Welding High Strength Pipe Steels"**
by J.C. Madeni, D. Tordonato, M. Lopetegui, S. Liu, and P. Mendez, Colorado School of Mines, Golden, Colo.

G. 4:00 p.m. **"Influence of Ti and C Additions on the Microstructure of Fe-Al-Cr Weld Overlay Coatings"**
by K.D. Adams and J.N. DuPont, Lehigh University, Bethlehem, Pa.

H. 4:30 p.m. **"Porosity Formation and Mitigation in Underwater Wet Welding"**
by F. Perez and S. Liu, Colorado School of Mines, Golden, Colo.

Session 5: Room S501b,c
WELDING WELD SENSING & CONTROL

A. 1:00 p.m. **"Machine Vision Recognition of Three-Dimensional GTA Weld Pool Surface"**
by H. Song, and Y. Zhang, University of Kentucky, Lexington, Ky.

B. 1:30 p.m. **"Vision-Based Welding Pool Sensing and Control of Aluminum Alloy Pulsed GMA Welding"**
by Y. Shi, C. Xue, D. Fan and J. Chen, Clanzhou University of Technology, Lanzhou, China

C. 2:00 p.m. **"Sensor Development for Shipbuilding and Offshore Application"**
by H.S. Moon, Y.B. Kim, J.G. Kim and I.W. Park, Hyundai Heavy Industries Co., Ltd., Ulsan, Korea

D. 2:30 p.m. **"Automatic Detection and Identification of Contaminants during Welding"**
by G. Schwab, T. Vincent and J. Steele, Colorado School of Mines, Golden, Colo.

E. 3:00 p.m. **"Analysis of Pulse Arc Characteristics and Application of Arc Sensor in Tandem Pulse Welding Process"**
by S.H. Ko, H.S. Moon, J.C. Kim and Y.B. Kim, Hyundai Heavy Industries Co., Ltd., Ulsan, Korea

F. 3:30 p.m. **"Direct Welding Arc Observation without Harsh Flicker"**
by B. Hillers and A. Gräser, Institute of Automation/University of Bremen, Bremen, Germany

G. 4:00 p.m. **"Weld Penetration at High Velocity in GTAW"**
by U. Duman and P.F. Mendez, Colorado School of Mines, Golden, Colo.

Session 6: Room S501d
FITNESS FOR SERVICE, RESIDUAL STRESSES AND MODERN NDE

A. 1:00 p.m. **"FFS Assessment of Crack-Like Flaws in Spherical Vessel"**
by S. Han and K. Park, Korea Gas Safety Corporation, Kong-Do, Korea, and D.S. Kim, Shell Global Solutions, Houston, TX, and C.L. Tsai, The Ohio State University, Columbus, Ohio

B. 1:30 p.m. **"Weld Distortion Mitigation by Automated Thermal Forming"**
by J.E. Jones, V. Rhoades and P. Tarnow, Native American Technologies Company, Golden, CO, G. Turner, Northrop-Grumman Ship Systems, Pascagoula, MS, and J. McMahon, Bollinger Lockport, LLC, Lockport, La.

C. 2:00 p.m. **"Residual Stress Evaluation of Thermal Barrier Coating with Cold Sprayed CoNiCrAlY Bond Coating"**
by K. Ogawa, T. Nike, and T. Shoji, Tohoku University, Sendai, Japan

D. 2:30 p.m. **"In-Plane Shrinkage on Welding Distortion in Thin-Wall Structures"**
by W. Cheng, ExxonMobil Upstream Research Company, and C.L. Tsai, Ohio State University, Columbus, Ohio

E. 3:00 p.m. **"Laser Ultrasonic NDE of Small Component Braze & Weld Joints"**
by G.A. Knorovsky, Sandia National Laboratories, Albuquerque, NM, and M. Klein and T. Sidekick, Intelligent Optical Systems, Torrance, Calif.

F. 3:30 p.m. **"Hydrogen Induced Cracking and Advanced NDE of Creep Resistant Steel Welds"**
by P.S. Patel, M. Lose and R. Spencer, EWI, Columbus, Ohio, and J.C. Lippold and B.T. Alexandrov, The Ohio State University, Columbus, Ohio

G. 4:00 p.m. **"Advanced Electromagnetic Techniques for Hydrogen Content Assessment in Steel Elements"**
by A.N. Lassoing-Jackson, T. Stewart and D. McCaskey, National Institute of Standards and Technology, Boulder, Colo., and J. Jackson and D. Olson, Colorado School of Mines, Golden, Colo.

H. 4:30 p.m. **"Protecting and Improving the Performance of Rotating Components by the Use of a Strain-Tolerant Ceramic Coating"**
by A. Weatherill, ITSA, Lincoln, United Kingdom

Tuesday, November 13
8:00 a.m.–5:00 p.m.

PLENARY PRESENTATION Room S502b

8:00 a.m. – 9:00 a.m. **"Welding & Joining in Scandinavia"**
Prof. Odd M. Asleep, Sinter Materials & Chemistry, Norway

Session 7: Room S501a
OPTIMIZATION IN ARC WELDING PROCESS

A. 9:00 a.m. **"Consumable Double-Electrode Gas Metal Arc Welding Process and Control"**
by K. Li and Y. Zhang, University of Kentucky, Lexington, Ky.

B. 9:30 a.m. **"Study of Weld Bead Formation in Double-Sided Arc Welding"**
by J. Chen and Y. Zhang, University of Kentucky, Lexington, Ky., and J. Emerson, Magnates Limited Partnership, East Granby, Conn., and M. Ludwig, Bath Iron Works, East Granby, Conn., and L. G. Kvidahl, Northrop Grumman Corporation Ship Systems

C. 10:00 a.m. **"Dual Bypass GMAW of Aluminum Rings"**
by X. Liu, Y. Shi and Y. Zhang, University of Kentucky, Ky., and M. Johnson, Los Alamos National Laboratory, Los Alamos, N.M.

D. 10:30 a.m. **"Undercutting and Humping Flaw Formation during Autogenous Plasma Transferred Arc Welding"**
by M. Yarmuch, Alberta Research Council, Edmonton, Canada, and B. Patchett, MaglynEngineering, Chemainus, Canada, and D. Ivey, University of Alberta, Edmonton, Canada

E.11:00 a.m. **"Effect of Heat Transfer on Electrode Extension and Droplet Formation in GMAW"**
by E.J. Soderstrom and P.F. Mendez, Colorado School of Mines, Golden, Colo.

F. 11:30 a.m. **"Effects of Input Parameter Variation on Robotic Out-of-Position (Downhill) GMAW"**
by J. Steele, Colorado School of Mines, Golden, Colo.

G. 12:00 p.m. **"Design of Experiments for the Optimization of Submerged Arc Welding Process"**
by A. Tiwari

Session 8: Room S501b, c
STATE-OF-THE-ART RESEARCH IN WELDING & JOINING IN GERMANY

A. 9:00 a.m. **"Microstructures and Properties of Friction Spot Welds in a 2-mm-Thick Alclad"**
by J.F. dos Santos, GKSS, Geesthacht, Germany

B. 9:30 a.m. **"Effect of Hydrogen on Aluminum Weldability"**
by C.E. Cross and N. Coniglio, BAM, Berlin, Germany

C. 10:00 a.m. **"Computer-Aided Development of the Crack-Free Laser Welding Processes"**
by V. Ploshikhin, Neue Materialien, Bayreuth, Germany

D. 10:30 a.m. **"Determining and Avoiding HIC for Specific Welding Conditions"**
by G. Huismann, Helmut Schmidt University, Hamburg, Germany

E. 11:00 a.m. **"New Concepts for Low Temperature Joining"**
by J.P. Bergmann, Tech. Univ. Llmenau, Llmenau, Germany

F. 11:30 a.m. **"Simulation of the Welding Distortions in Large Welded Structures"**
by N. Doynov, Tech. Univ. Brandenburg, Cottbus, Germany

G. 12:00 p.m. **"Innovation in Joining Technology: Processes and Products for the Future"**
by H. Herold, Univ. Magdeburg, Magdeburg, Germany

Session 9: Room S501d
MODELING OF WELDING AND JOINING PROCESSES 2

A. 9:00 a.m. **"Nanoparticle Coalescence and Sintering: Molecular Dynamics Simulation"**
by N. Wang, S.I. Rokhlin, J. Chen and D.F. Farson, The Ohio State University, Ohio

B. 9:30 a.m. **"In-Situ Neutron Diffraction Measurement of Temperature and Stress Fields in Friction Stir Welding of an Al Alloy"**
by Z. Feng, X.L. Wang, K. An, C. Hubbard and S.A. David, Oak Ridge National Laboratory, Oak Ridge, Tenn. and W. Woo and H. Choo, University of Tennessee, Knoxville, Tenn., and D.W. Brown and B. Clausen, Los Alamos National Laboratory, Los Alamos, N.M.

C. 10:00 a.m. **"Heat Transfer, Fluid Flow and Solidified Surface Profile of Various Fillet Joint Configurations and Welding Positions during GMAW"**
by A. Kumar, ExxonMobil Upstream Research Company, Houston, Tex., and T. Debroy, The Pennsylvania State University, University Park, Pa.

D. 10:30 a.m. **"Automatic Weld Modeling Based On Finite Element Analysis and High Performance Computing Architecture"**
by W. Zhang, S. Khurana and W. Gan, Edison Welding Institute Inc., Columbus, Ohio

E. 11:00 a.m. **"Bonding Mechanisms for Ultrasonic Consolidation Through Numeric Simulations"**
by C. Zhang and L. Li, Utah State University, Logan, Utah.

F. 11:30 a.m. **"Development of Microalloyed Welding Consumables Using a Computational Thermodynamics Approach"**
by D.S. Tordonato, J.C. Madeni, S. Liu and P. Mendez, Colorado School of Mines, Golden, Colo.

Session 10: Room S501a
WELDABILITY OF MATERIALS

A. 1:00 p.m. **"The Influence of Gd and B on the Solidification and Weldability of a Ni-Cr-Mo Alloy"**
by J.N. DuPont and T.D. Anderson, Lehigh University, Bethlehem, Pa., and C.V. Robino, Sandia National Laboratory, Albuquerque, N.Mex.

B. 1:30 p.m. **"Macrosegregation in Dissimilar-Filler Welds"**
by Y. Yang and S. Kou, University of Wisconsin, Madison, Wis.

C. 2:00 p.m. **"Elevated Temperature Cracking in Alloy C22"**
by M. Gallagher and J.C. Lippold, The Ohio State University, Columbus, Ohio.

D. 2:30 p.m. **"Microstructural Insights into Ductility Dip Cracking in Ni Based Filler Metals"**
by F.F. Noecker II and J.N. DuPont, Lehigh University, Bethlehem, Pa., and G. A. Young Jr., Lockheed Martin, Schenectady, N.Y.

E. 3:00 p.m. **"Development and Application of Ternary Solidification Models for Understanding Weldability Phenomena in Engineering Alloys"**
by J.N. DuPont, Lehigh University, Bethlehem, Pa.

F. 3:30 p.m. **"Effect of Microstructure on Reheat Cracking in the HAZ of Type 347 Stainless Steel"**
by I. Phung-on and J.C. Lippold, The Ohio State University, Columbus, Ohio.

G. 4:00 p.m. **"Liquation Tendency of Al and Mg Alloys in Friction-Stir Spot Welding"**
by Y. Yang and H. Dong, University of Wisconsin, Madison, Wis.

H. 4:30 p.m. **"Resistance Sealing and Parting of Stainless Steel Tubing for Nuclear Waste Applications"**
by L. Zirker, Idaho National Laboratory, Idaho Falls, Idaho and RT. Chiarcos, CenterLine (Windsor) Ltd, Windsor, Canada

Session 11: Room S501b, c
NAVY-SPONSORED SESSION OF ARC WELDING PROCESSES

A. 1:00 p.m. **"Development of Laser-Arc Hybrid Welding Technology for Ship Construction"**
by R. P. Martukanitz and S. M. Kelly, Pennsylvania State University, State College, Pa., and T. D. Huang and L. Kvidahl, Northrop Grumman Ship Systems, New Orleans, La., and Pascagoula, Miss., and T. DebRoy, Pennsylvania State University, University Park, Pa.

B. 1:30 p.m. **"An Investigation into Cracking on Aluminum Superstructures"**
by K.N. Tran, W. Goins and E. Murcko, Naval Surface Warfare Center, West Bethesda, Md. and Philadelphia, Pa.

C. 2:00 p.m. **"Joining AL6XNTM Superaustenitic Stainless Steel by GMAW-P, PAW, and Hybrid LBW"**
by P.J. Konkol and M.F. Mruczek, Concurrent Technologies Corp., Pittsburgh, Pa.

D. 2:30 p.m. **"Reducing Mn Fumes during FCAW of High-Strength Steels"**
by S. Ferree and M. Sierdzinski, ESAB Welding and Cutting Products, Hanover, Pa., and M. F. Mruczek and P. J. Konkol, Concurrent Technologies Corp., Pittsburgh, Pa.

E. 3:00 p.m. **"Tandem Gas Metal Arc Welding for Out-of-Position High Strength Steel Erection Joints"**
by N. Porter, Edison Welding Institute, Columbus, Ohio

F. 3:30 p.m. **"Cold-Wire-Feed Submerged Arc Welding"**
by P.J. Konkol and M.F. Mruczek, Concurrent Technologies Corp., Pittsburgh, Pa.

G. 4:00 p.m. **"High-Speed Tandem Submerged Arc Welding of Thin Steel Panels for Naval Surface Combatants"**
by N. Porter, Edison Welding Institute, Columbus, Ohio

Session 12: Room S501d
INDUSTRIAL TECHNOLOGY 2: MANAGEMENT AND TRAINING

A. 1:00 p.m. **"Total Welding Management"**
by J. R. Barckhoff, Barckhoff Welding Management Corp., Victoria, Minn.

B. 1:30 p.m. **"What Contract Managers Need to Know About Welding Code Requirements in Their Projects"**
by A. Petroski, Atema, Inc., Chicago, Ill.

C. 2:00 p.m. **"CS WAVE: Virtual Reality for Welders' Training"**
by L. Da Dalto, CS Communications & Systems, Toulouse Cedex 6, France; D. Steib and D. Mellet-d'Huart, AFPA, Venissieux Cedex, France

D. 2:30 p.m. **"Cracked Workmanship Sample Blocks Solve Unique Inspection Problems"**
by L. Zirker and J. Dowallo, Idaho National Laboratory, Idaho Falls, Idaho

E. 3:00 p.m. **"Saving Time and Money with Simulation Resistance Welding Software"**
by K. Chan, Huys Industries Limited, Weston, Canada

F. 3:30 p.m. **"Sensors in Welding Cells…Ten Iron-Clad Methods for Reducing Downtime, Increasing Productivity and Increasing Profitability"**
by D. Bird, Balluff, Inc., Florence, Ky.

G. 4:00 p.m. **"Fusion Bonding: Underwater Fastening Without Electricity"**
by C. Hsu, J. Thomas and B. Rak, Nelson Stud Welding, Inc., Elyria, Ohio

H. 4:30 p.m. **"New Advances in Induction Brazing"**
by K. Spain, Radyne Corporation, Milwaukee, Wis.

Wednesday, November 14
8:00 a.m.–5:00 p.m.

PLENARY PRESENTATION — Room S502b

8:00 a.m. – 9:00 a.m. **"Welding and Joining in Korea"**

Dr. Jeong-han Kim, Executive Director, KiTech Incheon Research Center, Korea

Session 13: Room S501a
ELECTRON BEAM WELDING

A. 9:00 a.m. **"Coupling CNC Part Motion with High-Speed EB Pulsing Helps Enhance Hole Drilling Capabilities"**
by G.G. Schubert, J. Dowd and D. Powers, PTR-Precision Technologies, Inc., Enfield, Conn.

B. 9:30 a.m. **"Megahertz Beam Deflection Capability Broadens EB Usage Spectrum"**
by G.R. LaFlamme, J.Rugh and D. Powers, PTR-Precision Technologies, Inc., Enfield, Conn.

C. 10:00 a.m. **"Vacuum Effects Electron Beam Welding"**
by P. Burgardt, Los Alamos National Laboratory, Los Alamos, N.M.

D. 10:30 a.m. **"Low-Voltage EB Welders Using Enhanced Diagnostics"**
by K.W. Lachenberg, Sciaky Incorporated, Chicago, Ill., and T.A. Palmer, A.T. Teruya and J.W. Elmer, Lawrence Livermore National Laboratory, Livermore, Calif.

E. 11:00 a.m. **"Engineering Microstructures and Properties of EB Welds to Join Thick-Section HSLA-100 Steel"**
by M. Johnson, A. Duffield and P. Burgardt, Los Alamos National Lab, Los Alamos, N.Mex.

F. 11:30 a.m. **"A Comparison of Pulsed, Out of Focus and Circle Deflection Electron Beam Welding of Stainless Steel: Morphology and Microstructure"**
by P. Hochanadel, D. Kautz and J. Martinez, Los Alamos National Lab, Los Alamos, N.Mex.

Session 14: Room S501b, c
LASER BEAM WELDING

A. 9:00 a.m. **"Nonlinear Identification of Diode Laser Welding Process"**
by X. Na, Y. Zhang and B.L. Walcott, University or Kentucky, Lexington, Ky.

B. 9:30 a.m. **"Laser Beam Welding of Haynes 230"**
by P. Burgardt and T.J. Lienert, Los Alamos National Lab, Los Alamos, N.Mex.

C. 10:00 a.m. **"Evaluating Keyhole Mode Laser Welds via High Speed Imaging"**
by J. Norris, C.V. Robino, M. Perricone, K. Fuerschbach and M. Martinez, Sandia National Laboratories, Albuquerque, N.Mex.

D. 10:30 a.m. **"Hybrid Laser Arc Welding of HY-80 Steel"**
by C. Roepke, Colorado School of Mines, Golden, Colo.

E. 11:00 a.m. **"Time-Resolved Energy Absorption in Laser Spot Welds"**
by J. Norris, C.V. Robino and M. Perricone, Sandia National Laboratories, Albuquerque, N.Mex.

F. 11:30 a.m. **"Correction and Simulation of Post-Weld-Shift by Laser Hammering for Laser Diode Module Packaging"**
by K.Hou, L. Liu and Y. Shih, Chang Gung University, Taoyuan, Taiwan

G. 12:00 p.m. **"Distortion of Laser-Welded Thin Planar Microcomponents"**
by D. MacCallum, G.A. Knorovsky and C.V. Robino, Sandia National Laboratories, Albuquerque, N.M.

Session 15: Room S501d
NAVY-SPONSORED SESSION ON FRICTION STIR WELDING

A. 9:00 a.m. **"Friction Stir Welding of Ti-5111"**
by J. Nguyen, Naval Surface Warfare Center, West Bethesda, Md and L. Salamanca-Riba, University of Maryland, College Park, Md.

B. 9:30 a.m. **"Materials Selection Information on Friction Stir Welds for LHA-6"**
by C. Davis, M. Posada and J. DeLoach, Naval Surface Warfare Center, West Bethesda, Md.

C. 10:00 a.m. **"Aluminum Friction Stir Welds for Naval Structures"**
by M. Posada, J. DeLoach and C. Davis, Naval Surface Warfare Center, West Bethesda, Md.

D. 10:30 a.m. **"Nondestructive Inspection Requirements for Friction Stir Welds"**

by K. Lipetzky and N. Trepal, Naval Surface Warfare Center, West Bethesda, Md., R. Kok, Naval Sea Systems Command, Washington, D.C.

E. 11:00 a.m. **"Corrosion Evaluation of Friction Stir Processed Nickel Aluminum Bronze"**
by J. Nguyen and R. Park, Naval Surface Warfare Center, West Bethesda, Md., and M. Krupa and E. Lemieux, Naval Research Laboratory, Key West, Fla.

Session 16: Room S501a
WELDING METALLURGY

A. 1:00 p.m. **"Laser Weld Repair of Single Crystal Superalloys"**
by T. Anderson and J.N. DuPont, Lehigh University, Bethlehem, Pa.

B. 1:30 p.m. **"Heat Treatment Optimization of High-Alloy Stainless Steel"**
by J. Farren and J.N. DuPont, Lehigh University, Bethlehem, Pa.

C. 2:00 p.m. **"Materials Properties Evaluation of Alloy 605 Base and Weld Metal"**
by J. Shingledecker and R. Miller, Oak Ridge National Laboratory, Oak Ridge, Tenn.

D. 2:30 p.m. **"Fusion Welding of High-Mo Austenitic Stainless Steels — An Overview"**
by J.N. DuPont, T.D. Anderson, M.J. Perricone and S.W. Banovic, Lehigh University, Bethlehem, Pa.

E. 3:00 p.m. **"Applying 36Ni Alloy to Cryogenic Pipelines"**
by B.D. Newbury, D.B. Lillig and P.M. Sommerfield, Exxon Mobil Development Company, Houston, Tex.

F. 3:30 p.m. **"Repair of the U.S. Capitol Dome"**
by T. Siewert, NIST, Boulder, Colo., K. Hildebrand, Architect of the Capitol, Washington, D.C., R. Bushey, ESAB Welding and Cutting Products, Hanover, Pa.

G. 4:00 p.m. **"Composite-Like Engineered Welds for Achieving Multiple Improved Properties"**
by J. Jackson, E. Soderstrom, P.F. Mendez and D.L. Olson, Colorado School of Mines, Golden, Colo. and A.N. Lasseigne-Jackson, NIST, Boulder, Colo.

Session 17: Room S501b, c
ADVANCES IN FRICTION STIR WELDING

A. 1:00 p.m. **"Novel Nuclear Fuel Plate Fabrication Using the Friction Stir Weld Process"**
by N.P. Hallinan, D.E. Burkes, J. Wight, M.D. Chapple and C.R. Clark, Idaho National Laboratory, Idaho Falls, Idaho

B. 1:30 p.m. **"Thermal Stir Welding — A New Solid-State Welding Process"**
by J. Ding, NASA, Huntsville, Ala., and B.H. Walker, Port St. Lucie, Fla.

C. 2:00 p.m. **"Processing and Tensile Properties of Immersed Friction Stir Welding of AA606l-T6"**
by T.S. Bloodworth III, P.A. Fleming, D.H. Lammlein, T.J. Prater and G.E. Cook, Vanderbilt University, Clarksville, Tenn.

D. 2:30 p.m. **"Finite Element Modeling of Friction Stir Welding"**
by Y. Mao and R.B. Madigan, Montana Tech of the University of Montana, Butte, Mont. and T.J. Lienert, Los Alamos National Lab, Los Alamos, N.Mex.

E. 3:00 p.m. **"A Linear Variable Shoulder Pressure in Pin Tapered Reduction for Closure Friction Stir Welding"**
by D. Lammlein, D. DeLapp, A. Strauss, P. Fleming, Vanderbilt University, Nashville, Tenn., and T. J. Lienert, Los Alamos National Lab, Los Alamos, N.Mex.

F. 3:30 p.m. **"Control of Normal Tool Stress during Friction Stir Welding"**
by R.B. Madigan, B.J. Shubert, Y. Mao, Montana Tech of the University of Montana, Butte, Mont. and T.J. Lienert, Los Alamos National Lab, Los Alamos, N.Mex.

G. 4:00 p.m. **"Fault Detection in Friction Stir Welding of Lap Welds in Aluminum"**
by P. Fleming, M. Wilkes, G.E. Cook and T. Bloodworth, Vanderbilt University, Nashville, Tenn., and T.J. Lienert, Los Alamos National Lab, Los Alamos, N.Mex.

Session 18: Room S501d
INDUSTRIAL TECHNOLOGY 3: ARC WELDING TECHNOLOGIES

A. 1:00 p.m. **"New Applications for Gas Metal Arc Welding"**
by N. Kapustka, C. Conrardy and N. Porter, EWI, Columbus, Ohio

B. 1:30 p.m. **"Process Optimization of 3/8" ATC Short Cycle Stud Welding in Plate Vertical Position"**
by C. Hsu, J. Mumaw and J. Thomas, Nelson Stud Welding, Inc., Elyria, Ohio

C. 2:00 p.m. **"Comparison of TOPTIG and GMAW Weld Processes for Robotic Welding"**
by L. Rimano, Air Liquide Canada Inc., Montreal, Quebec, Canada

D. 2:30 p.m. **"Shaping of Pulsed Wave Form for TIG Welding for Sheet Metal"**
by G.R.N. Tagore, I.A.K. Reddy and P. Sammaiah, Dept. of Mech. Eng., National Institute of Technology, Warangal, India

E. 3:00 p.m. **"TARC Process; Robust Single-Sided Metal Stamping Fastener Welding without Fixture"**
by C. Hsu and J. Mumaw, Nelson Stud Welding, Inc., Elyria, Ohio

F. 3:30 p.m. **"Welding Automation"**
by Z. Marnell, Orbitform Group, Jackson, Mich.

G. 4:00 p.m. **"Pulsed Arc Welding for Sheet Metal Work"**
by G.R.N. Tagore, Dept. of Mech. Eng. National Institute of Technology, Warangal, India

Friction Welding Conference

This conference will be packed with a number of short presentations on various facets of conventional friction welding, linear friction welding, and friction stir welding. Some of the versions of these processes are capable of welding practically any metal, and to do it without creating fumes.

Monday, November 12
8:50 a.m.–2:35 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W70 Room S401a

8:50 a.m.–9:00 a.m.
Welcome and Introduction
Chairman: Bob Irving
Co-Chairman: Suhas Vaze

9:00 a.m.–9:40 a.m.
The Four Friction Welding Processes

Daniel Adams, Vice President, Manufacturing Technology, Inc., South Bend, Ind.; and Tim Haynie, President, Transformation Technologies, Inc., Elkhart, Ind.

This overall presentation will cover the four main friction welding processes—direct-drive friction welding, inertia friction welding, linear friction welding, and friction stir welding. Daniel Adams will discuss the first three processes and Tim Haynie will discuss friction stir welding. The two companies are collaborating on friction stir welding.

9:40 a.m.–10:20 a.m.
Friction Stir Welding at Concurrent Technologies Corporation

Robert W. Semelsberger, Manager, Combat Vehicle Research Program, Concurrent Technologies Corp., Johnstown, Pa.

Robert Semelsberger will discuss activities involving a $1.3 million contract from the U.S. Army Tank Automotive Research, Development and Engineering Center, involving friction stir welding and the use of aluminum-lithium alloys on future lighter tanks and combat vehicles.

10:20 a.m.–10:40 a.m.
New Applications for Friction Stir Welding

Mike Skinner, Business Development Manager, MTS Systems, Inc., Eden Prairie, Minn.

The aerospace, ground transportation, and marine industries have successfully introduced the friction stir welding (FSW) process into series production on 2-D panel welding applications using the conventional FSW process (fixed pin tools). The focus of this presentation will be on some of the latest production applications utilizing the FSW adjustable and self-reacting process on 3-D complex curvature applications. The following applications will be discussed: fabrication of Volvo XC-90 aluminum rims, Nippon Shario high-speed trains, and the NASA Constellation Program (Space Shuttle replacement).

10:40 a.m.–11:00 a.m. Refreshment Break

11:00 a.m.–11:40 a.m.
Friction Welding of Federal Mogul's Monosteel Pistons

Carmo Ribeiro, Global Technology–Steel Pistons, Federal Mogul Corp., Ann Arbor, Mich.

Monosteel Piston innovative technology has been created to address the increasing thermal, mechanical, abrasive, and corrosive challenges placed on heavy-duty diesel engines resulting from emissions regulation. Therefore, an integration of welding process technology (such as friction welding) and product design enhancements has been combined to market the idea.

11:40 a.m.–12:30 p.m.
Linear Friction Welding for Aerospace Applications

Martin W. Moffat, Vice-President, Sales and Marketing, The Cyril Bath Company, Monroe, N.C.

Linear friction welding (LFW) is a relatively new joining technique finding significant value in aerospace turbine engine components and special airframe structures. The focus and value of this technology is with specialty metals such as titanium and certain nickel alloys. By eliminating machining and material loss during processing, LFW can be a valuable technology for joining fan blades to rotating discs. In addition, the use of titanium structures in new commercial aircraft requires new techniques for building various geometric profiles. LFW is a cost-effective process to create airframe structure components, while minimizing process yield loss.

12:30 p.m.–1:30 p.m. Lunch

1:30 p.m.–1:45 p.m.
Applications for Direct-Drive Friction Welding

Adam Jarzebowski, President, NCT Friction Welding, Newington, Conn.

Equipped with nine direct-drive friction welding machines, NCT Friction Welding has compiled considerable experience in many different kinds of applications throughout industry, including the welding of dissimilar metals.

1:45 p.m.–1:55 p.m.
Fusion Bonding: Underwater Fastening without Electricity

Chris Hsu, Director of Engineering, Nelson Stud Welding, Inc., Elyria, Ohio.

In fusion bonding, a lightweight portable air motor device is used to spin a fastener, which is rammed into the workpiece (e.g., hull of a ship) underwater, and the friction heat forms the weld. The process is a safe, fast, and economical method to attach studs, bolts, and other fasteners, in comparison with alternative methods of welding underwater. This presentation outlines a designed experiment to characterize the weld performance of fusion bonding.

1:55 p.m. – 2:35 p.m.
Challenges to Deploying Friction Stir Welding in U.S. Army Weapon Systems

Suhas Vaze, Project Manager, Government Programs Office, Edison Welding Institute, Columbus, Ohio (Co-authors include Brian Thompson, Tim Stotler, Jeff Bernath, and Tim Trapp)

Edison Welding Institute (EWI) has been developing materials joining technologies for the US Army's Future Combat System (FCS) program under the direction of the Army Research Laboratory (ARL). Previous efforts related to the Expeditionary Fighting Vehicle (EFV, formerly AAAV) have shown that friction stir welding can be successfully used in joining 2219/6061 to 2519. This presentation will showcase fabrication of complex aluminum and titanium FCS-like structures, which are technology demonstrators and represent full-scale application of friction stir welding and a step toward deployment of FSW for FCS; and application of VT, UT, and RT for inspecting friction stir welded structures.

2:35 p.m. – Adjournment

Hot Wire Welding and Cladding Conference

There is a great deal of revived interest in hot wire welding and cladding. One version or the other is already being used by participants in the oil and gas industry, by the Navy, and by builders of aircraft engines. Presentations on both hot wire GTAW and hot wire plasma processes will be on the agenda. One topic will be the popular use of hot wire gas tungsten arc cladding of tube and piping for the offshore oil and gas industries. In another presentation, hot wire GTA "narrow groove" welding will be shown to have performed well on titanium. Advantages are increased deposition rates and faster travel speeds.

Tuesday, November 13
8:50 a.m.–3:15 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W75 Room S401b, c

8:50 a.m.–9:00 a.m.
Welcome and Introduction

Chairman: Bob Irving
Co-Chairman: Tom Rankin

9:00 a.m. - 9:40 a.m.
Hot Wire Gas Tungsten Arc Welding — An Overview of Process Applications and Capabilities

Jonathan T. Salkin, President, Arc Applications, Inc., York, Pa.

The hot wire gas tungsten arc welding process has found increasing use over a wide range of groove welding, buildup, and cladding operations. Commercially available and specialized hot wire equipment continues to promote application of the process for producing high-quality welds in industries including nuclear, power generation, pressure vessel, and offshore oil. Applications will be presented to show the process capabilities, characteristics, benefits, and limitations. Examples of process control and variations to consider will be discussed based on welding requirements, materials, process variables, weld design, and inspection.

9:40 a.m.–10:20 a.m.
Hot Wire Narrow Groove Welding and Cladding with Nickel-Based Alloys

Jeff M. Kikel, Manager, Weld Engineering, BWX Technologies, Inc., Nuclear Operations Division, Barberton, Ohio

Where a considerable amount of work is directed toward pressure vessel fabrication, hot wire gas tungsten arc welding is used extensively for the narrow groove welding of nickel-based alloys. The hot wire process is also used for buildup, buttering, and cladding of high-strength low-alloy steel.

10:20 a.m.–10:40 a.m.
Hot Wire GTAW—Practical Considerations and Applications

Tom Rankin, Vice President and General Manager, ITW Jetline Engineering, Irvine, Calif.

This talk will cover the early development of the process along with basic theory and important variables. Justification for the use of hot wire process and equipment requirements will be presented. Application examples of successful cladding, joining, and deep groove using stainless and Inconel® will be presented.

10:40 a.m.—11:00 a.m. Refreshment Break

11:00 a.m.—11:40 a.m.
New Advances in Hot Wire Cladding Applications

Daniel Allford, President, ARC Specialties, Houston, Tex.

This presentation will be a discussion of recent advances in plasma, variable polarity, as well as new configurations for automatic cladding. New programming techniques for bore cladding will also be discussed.

11:40 a.m.—12:30 a.m.
Wire Surface Condition Impacts Hot Wire Weld Quality

Harry Wehr, Technical Director, Arcos Industries, LLC, Mt. Carmel, Pa.

The surface condition of the welding wire used to make hot wire overlay deposits can impact the quality and integrity of the weld in several ways. A detailed study of 625 welding wire used for hot wire applications has shown that there are three major areas where wire surface condition can impact deposit integrity: surface roughness, residual contaminants, and wire cast. If the weld deposit must be clean and defect-free, each of these areas must be addressed.

12:30 p.m.–1:30 p.m. Lunch

Note: There will be no afternoon refreshment break; however, refreshments will be available in the back of the room.

1:30 p.m–1:45 p.m
Observations from Gus Manz, Inventor of Hot Wire Welding

Gus Manz, President, A. F. Manz Associates, Union, N.J.

Hear from the inventor himself, who was awarded a patent on the hot wire welding process on February 25, 1964.

1:45 p.m–1:55 p.m
Observations from Fritz Saenger, Member of the Original Hot Wire Welding Research Team

Fritz Saenger, Consultant, Columbus, Ohio

Listen to the observations of Saenger, who was a member of the original research team for the hot wire welding process.

1:55 p.m–2:35 p.m
Welding and Cladding in the Oil and Gas Industry

Don Schwemmer, President, AMET Inc., Rexburg, Idaho; and Galen Wright, President, Arc Innovations Inc., Edmonton, AB, Canada

In response to some of the requirements by the oil and gas industry in Canada, the presenter talks of narrow groove welding 1-1/2 to 2 in. thick 2205 duplex stainless steel, and cladding 625 Inconel® tubulars.

2:35 p.m–3:15 p.m
The Benefits of Hot Wire GTAW in the Orbital Welding Industry

Rob Pistor, Managing Director, Liburdi Engineering, Dundas, ON, Canada

In this presentation, several applications will be discussed. Included are narrow groove welding, cladding, nuclear canister closure welding, and 1G vs. 5G parameters.

3:15 p.m – Adjournment

SEMINARS

Monday, November 12
8:30 a.m.–4:30 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W71 Room S401b, c

ROAD MAP THROUGH THE D1.1/D1.1M:2006 STRUCTURAL WELDING CODE—STEEL

This one-day program provides a comprehensive overview of AWS D1.1:2006, *Structural Welding Code — Steel*. Each code section, including General Requirements, Design of Welded Connections, Prequalification, Qualification, Fabrication, Inspection, Stud Welding, and Strengthening and Repair of Existing Structures, will be summarized with emphasis on their interrelationships and usage. In addition, the role of mandatory and nonmandatory annexes will be reviewed, along with tips on using the code Commentary. This program will benefit managers, engineers, supervisors, inspectors, and other decision-makers who need comprehensive understanding of what is, and what is not, covered by AWS D1.1:2006 to improve their job effectiveness.

Attendees must bring their own copy of D1.1:2006, *Structural Welding Code — Steel*. Order it online at http://www.awspubs.com or contact the AWS Store at (888) 935-3464.

Monday, November 12
8:30 a.m.–4:30 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W72 Room S401d

PRICING AND PROFITABILITY— CONTROLLING THE COSTS OF WELDING

If you're responsible for estimating the cost of welding and determining which process and selection of weld joints is required, then you'll want to attend this course.

This program will provide a value-added experience for estimators, small job shops, and owner operators. Topics to be covered include responsible weld design, weldment cost elements, welding process efficiencies, deposition efficiencies, and Weld Cost Express.

You'll learn how to compare costs associated with use of different weld joint geometries, processes, and filler metal combinations; application of code and standards documents when generating an estimate; how to document welding variables and the costs associated with them; and how economic order lot quantities affect the weld estimate.

Monday, November 12
8:30 a.m.–4:30 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W73 Room S402a

INSPECTION TO THE 2006 D1.1 STRUCTURAL WELDING CODE — STEEL

This one-day course is devoted to inspection of structural steel welds. Inspector qualifications and the responsibilities of inspectors and contractors will be covered. Inspection procedures and techniques are highlighted as a prelude to a detailed review of the inspection acceptance standards. Test method fundamentals will be covered, where necessary, to understand the more in-depth tables and criteria, along with tips on what to look for in inspection reports.

Supervisors, engineers, inspectors, and auditors will gain a better understanding of weld quality from this presentation.

Attendees must bring their own copy of D1.1:2006, *Structural Welding Code — Steel*. Order it online at http://www.awspubs.com or contact the AWS Store at (888) 935-3464.

Monday, November 12
8:30 a.m.–4:30 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W74 Room S402b

THE WHY AND HOW OF WELDING PROCEDURE SPECIFICATIONS

If you are responsible for planning a welding operation, which of the following items are most critical: base metal, welding process, filler metal, current and range, voltage and travel speed, joint design tolerances, joint and surface preparation, tack welding, welding position, preheat and interpass temperature, or shielding gas? This course provides the answers.

This program will benefit owners, managers, engineers, and supervisors who must qualify, write, or revise their own welding procedure specifications to satisfy codes and contract documents.

Topics covered:

- Proper preparation and qualification of welding procedure specifications
- Selecting and documenting welding variables
- Documenting standard procedure qualification testing for commonly used processes for joining ferrous plate and pipe materials.

You can learn how to:

- Specify essential and nonessential variables commonly used in sample AWS, ASME, and API code formats
- Use standards when preparing procedures
- Document welding variables and qualification tests
- Avoid the pitfalls in revising previously qualified procedures.

Tuesday, November 13
8:30 a.m.–4:30 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W76 Room S401d

VISUAL INSPECTION WOKSHOP

This workshop provides eight hours of expert instruction that includes approximately three hours of instruction in the use of inspection tools, followed by "hands-on" learning for the balance of the workshop. This hands-on training incorporates plastic replicas of welds and also includes a sample practical examination to prepare test candidates for the CWI practical exam.

By attending, you can learn:

- How to use weld measuring instruments
- Compliance to a specific code
- Dos and don'ts of documentation
- When a discontinuity is OK
- When a defect is rejectable
- Why visual inspection can be the most effective NDE technique.

Tuesday and Wednesday, Novemer 13–14
8:30 a.m.–4:30 p.m.
Member of AWS/FMA/SME/NAM: $550, Nonmember: $685
Registration Code: W79 Room S401a

WELDING OF STAINLESS STEELS (BASICS AND AVOIDING WELD DEFECTS)

The two-day program focuses on the basic weldability of all types of stainless steels. If you need a comprehensive look at the weldability of stainless steels, particularly the 300 series, this course is for you.

Topics covered:

- Why alloys are "stainless"
- Stainless-steel differences
- Selecting a stainless for use
- Mechanical properties
- Properties after welding
- Heat treatment factors
- Selecting filler metals
- Gas vs. flux shielding
- Code requirements

You'll learn:

- Five stainless-steel types
- The effects of welding on all types of stainless steels
- Why some stainless steels require preheat and others prohibit it
- Answers to your questions about selecting and welding stainless steels.

Wednesday, November 14
8:30 a.m.–4:30 p.m.
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W77 Room S401b, c

METALLURGY APPLIED TO EVERYDAY WELDING

Metallurgy of welds in carbon and low alloy-steels doesn't need to be complicated. This short course will help you understand how welding affects the properties of base materials, and how weld defects occur.

Owners, inspectors, engineers, and supervisors who specify welding and need to understand the interaction of base, filler, and welding processes should attend.

Wednesday, November 14
8:30 AM–4:30 PM
Member of AWS/FMA/SME/NAM: $345, Nonmember: $480
Registration Code: W78

INTRODUCTION TO MT, PT, UT AND RT

The morning session (8:30 a.m.–Noon) will introduce the non-destructive methods of magnetic particle (MT) and liquid penetrant (PT) testing, and explain inspection techniques and operating principles for visible and fluorescent MT and PT. The discussion will cover basic principles of magnetic particle testing, with emphasis on the characteristics of longitudinal and circular magnetism, and will summarize the use of MT equipment such as yokes, prods, central conductors, and coils. The liquid penetrant testing discussion will include solvent-removable, water-washable, and post-emulsifiable penetrant testing methods.

The afternoon session (1 p.m.–4:30 p.m.) will introduce and review the fundamentals of ultrasonic and radiographic testing. Specific topics will include the principles and physics of each method, equipment, measurement techniques, and each method's advantages and disadvantages. A special section on weld inspection using ultrasonics with AWS D1.1:2006, Structural Welding Code–Steel will be included.

Who Should Attend: Inspectors, welders, production personnel, and students whose responsibilities include the application of quality in welding, and individuals seeking certification in PT and MT from the American Society for Non-destructive Testing.

Resistance Welding School

This two-day resistance welding school is sponsored by the American Welding Society and the Resistance Welding Manufacturing Alliance (RWMA), and conducted by industry specialists with extensive resistance welding experience. The basics of resistance welding and real-life application of the process are covered. Each participant may learn at his/her own pace, and discuss specific welding concerns with the instructors. You are invited to bring your own samples for discussion.

Please plan to be present for both days of the school. The program is limited to 100 students. The registration fee includes a copy of the Resistance Welding Manual*, Revised Fourth Edition (a $125 value) and a course binder containing all instructor presentations. Participants will also receive a certificate of completion. In addition, there will be a tabletop reception following the first day of classes, demonstrating the latest resistance welding products offered by RWMA-member companies.*

The following processes will be covered:

Resistance Spot Welding
Projection Welding
Cross Wire Resistance Welding
Upset Resistance Welding
Flash Butt Welding
Resistance Butt Welding
Resistance Seam Welding
Resistance Mash Seam Welding
Roll Spot Resistance Welding
Resistance Welder Electrodes and Tooling
Resistance Welder Controls
Resistance Welder Equipment Selection and Setup
Resistance Welder Power Systems
Resistance Welder Maintenance and Troubleshooting

Tuesday, November 13
7:45 a.m.–5:00 p.m.
5:00 p.m.–6:30 p.m. (Tabletop Exhibit and Reception)
Room S402b

Wednesday, November 14
8:00 a.m.–3:30 p.m.
Member AWS/FMA/SME/NAM: $425, Nonmember: $660
Registration Code: W80 Room S402a

Tuesday, November 13

7:45 a.m.– 8:00 a.m. **"Welcome and Introduction to Resistance Welding"**

Bill Brafford, Technical Liaison Manager; Tuffaloy Products, Inc., Greer, S.C.

8:00 a.m.– 8:30 a.m. **"Basics of Resistance Welding Video–Part 1"**

8:30 a.m.– 11:00 a.m. **"Electrodes and Tooling**

Bill Brafford, Technical Liaison Manager, Tuffaloy Products, Inc., Greer, S.C.

Focus on the classification, selection and maintenance of electrodes and fixtures as they pertain to numerous applications. By revealing some problem-solving techniques and suggestions, Bill will familiarize you with some powerful problem/evaluation/solution techniques that will keep your production process running longer– and operation more efficient.

11:10 a.m. – 12:15 p.m. **"Welding Controls"**

Don Sorenson, Director of Engineering, ENTRON Controls, Inc., Greer, S.C.

This discussion focuses on the selection, descriptions, and applications of welding timers, contactors, and accessories. Packed with a punch, Don drives home H = I2 RT in a way you'll never forget. He shows you how this invaluable formula is used in every resistance welding application– every day–every cycle–all the time!

12:15 p.m. – 1:15 p.m.
Lunch Served

1:15 p.m. – 2:15 p.m. **"Welding Controls" (continued…)**

Don Sorenson, Director of Engineering, ENTRON Controls, Inc., Greer, S.C.

Continuation of discussion on the selection, descriptions, and applications of welding timers, contactors, and accessories.

2:30 p.m.– "Electrical Power Systems"
5:00 p.m.

Mark Siehling, Vice-President-Engineering, RoMan Engineering Services, Grand Rapids, Mich.

This session reviews the descriptions and maintenance of electrical power components and conductors from the weld control to the electrode. This lively presentation has something for everybody. Utilizing several small demonstrations, Mark helps you understand this very important part of the resistance welding process which will keep you on the edge of your seat!

5:00 p.m. – 6:30 p.m.
Tabletop Exhibits and Reception

Wednesday, November 14

8:00 a.m. – 10:00 a.m. **"Welding Processes and Machines"**

Tim Foley, Sr. Applications Engineer, Automation International, Inc., Danville, Ill.

This session will reinforce the very essence of how the resistance welding process works and how the process relates to each of the four resistance welding processes. This session will be full of application examples from each process and how machinery utilizes the individual components and elements illustrated in the other sessions.

10:15 a.m.– 10:45 a.m. **"Basics of Resistance Welding Video – Part 2**
10:45 a.m. – 12:00 p.m. **"Troubleshooting and Maintenance"**

Bruce Kelly, President, Kelly Welding Solutions, Grand Ledge, Mich.

With over 30 years' experience in the auto industry, specifying, installing and troubleshooting resistance welding systems, Bruce will give you tips on how to find the reasons why welds don't turn out the way you would like. This presentation is filled with real-life examples of problems that baffled maintenance persons.

12:00 p.m. – 1:15 p.m.
Lunch Served

1:15 p.m. – 3:15 p.m. **"Initial Machine Set-Up"**

Robert Matteson, Director-Product Development, Taylor–Winfield, Inc., Brookfield, Ohio

Robert takes you through the selection and maintenance procedures of proper weld schedules and preventive maintenance programs designed to make your resistance welding operations profitable. Hands-on demonstrations peak this presentation

3:15 p.m. – 3:30 p.m.
Question and Answer Session

Education Sessions

PLUMMER MEMORIAL EDUCATION LECTURE

Tuesday, November 13
10:00 a.m. – 11:30 a.m.
Observations from 40 Years of Welding Training
FREE

The Plummer Memorial Education Lecture Award has been established by the American Welding Society to recognize an outstanding individual who has made significant contributions to welding education and training, and to recognize Fred L. Plummer's service to the Society as President from 1952 to 1954 and Executive Director from 1957 to1969. The recipient of this award will deliver a lecture and receive this educational distinction.

This year's presenter is Mr. Andy Godley, Director of Training, Southern Company. Mr. Godley has devoted his entire life to welding education. From teaching and consulting in 1967 to presently working for Southern Company, as well as serving on the National SkillsUSA Welding Technical Committee and the AWS Education Committee, if it's been done in welding education, Andy's done it. Attend and enjoy a straightforward presentation as observed from over 40 years of welding education.

Tuesday, November 13
1:00 p.m. – 4:00 p.m.
Registration Code: W86 **Room S404a**

NATIONAL SCIENCE FOUNDATION GRANT FOR NATIONAL CENTER OF EXCELLENCE IN WELDING EDUCATION AND TRAINING

The National Center for Welding Education and Training (NCWET) was created in July 2007 to increase the number of science and engineering welding technicians to meet workforce demands. The Center furthers comprehensive reform in welding education by providing technologically current educational materials and professional development opportunities to two-year colleges and other educational institutions.

Presentations in this session will discuss the formation of NCWET, the roles of the Center's partners and the initial plans for operation of the Center. Also to be discussed are industry training needs and expectations as well as the use of Workforce Skills Panels in providing input to Center planning and operations.

Session 1:
NATIONAL CENTER OF EXCELLENCE IN WELDING EDUCATION AND TRAINING

Ken Smith, Lorain County Community College, and Jim Key, AWS Past President

Session 2:
INDUSTRY INPUT AND EXPECTATIONS

Ernest Levert, Senior Staff Manufacturing Engineer, Lockheed Martin

Session 3:
PRESENTATION ON WORKFORCE SKILLS PANELS

Robert Visdos, Workforce Institute

HIGHER EDUCATION WELDING UPDATE

Wednesday, November 14
10:00 a.m. – 2:00 p.m.
Registration Code: W86

Experience the new technology and delivery methods that higher education is using to advance our students to new heights. Attend and find out how these educational institutions are preparing tomorrow's workforce, today!

10:00 a.m. – 11:00 a.m.

Session 1:
Ferris State University

Jeffrey Carney, Assistant Professor

11:15 a.m. – Noon
Session 2:
Pennsylvania College of Technology

Dave Cotner, Welding Instructor

1:00 p.m. – 2:00 p.m.
Session 3:
Montana Tech of the University of Montana

Mr. R. Bruce Madigan, PhD, P.E., Associate Professor

International Brazing & Soldering Symposium

Free expert panel discussions on current and emerging technologies and developments in brazing and soldering.

The 36th Annual Brazing and Soldering Symposium is a must-attend event if you work in the field of brazing and soldering or have an interest in research and applications, as well as networking with industry experts.

Tuesday, November 13
8:30 a.m. – 4:40 p.m.
Free • Registration Code: W87 **Room S403b**

8:30 a.m. **"Case Study: Failure Analysis of Solder Joints on a Connector Assembly** by P. Vianco, A. Kilgo, G. Zender, and P. Hlava (Sandia National Laboratories, Albuquerque, N.Mex.)

8:50 a.m. **"Development and Characterization of Amorphous Filler Metals for Joining of Magnesium Alloys"** by Silke Muecklich, Gudrun Fritsche, Bernhard Wielage (Institute of Composite Materials and Surface Technology, University of Technology, Chemnitz, Germany)

9:10 a.m. **"Effect of Ce on Property and Microstructure of Sn-Ag-Cu Solder"** by Xue Songbai, Wan Jiangsin, Han Zongjie (College of Materials Science and Technology, Nanjing University of Aeronautics, Nanjing, China); Gu Liyiong, Gu Wenhua (Changshu Huayin Filler Metals Co., Ltd, Changshu, China)

9:30 a.m. **"Laser Soldering with Lead-Free Solder Alloy for Electronic Packaging"** by Yu Shenglin (Nanjing Research Institute of Electronics Technology and College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing, China); Xue Songbai, Han Zongjie, Wang Jianxin ,and Zhang Xin (College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing, China)

9:50 a.m. **"Solderability Testing of Pb-Free Solder Alloys Versus Sn-37Pb Eutectic Solder for High-Reliability Applications"** by Edwin P. Lopez, and Paul Vianco (Sandia National Laboratories, Albuquerque, N.Mex.)

10:10 a.m. **"Advances in Brazing and Soldering with Reactive Multilayer Foil Applications"** by A. Duckham, Y. Xun, D. Deger, and T. P. Weihs (Reactive Nano Technologies, Inc., Hunt Valley, Md.)

10:30 a.m. **"Joining of High Strength Aluminum-Based Lightweight Materials"** **by Tin Based MMC Solders** by Bernhard Wielage, Ina. Hoyer, and Sebastian Weis (University of Technology, Chemnitz, Germany)

10:50 a.m. **"Ultrasonic Soldering and Brazing"** by T. Frech, K. Graf, and D. Hauser (Edison Welding Institute, Columbus, Ohio)

11:10 a.m. **"The Arc Spray Application of Braze Material to Copper/Brass Heat Exchangers"** by P. Kutsopias (Praxair Surface Technologies, Grapevine, Tex.)

11:30 a.m. **"Ultrasonic Imaging and Quantitative Analysis of Defects in Ag-Cu-Zr Active Braze Joints"** by D. F. Susan, D. R. Garcia, D. B. Appel, S. Younghouse, C. A. Walker, and M. Senkow (Sandia National Laboratories, Albuquerque, N.Mex.)

11:50 a.m. **"Fundamental Studies for Joining Yttria Stabilized Zirconia (YSZ) to Croffer22-APU by Reactive Brazing"** by O. A. Quintana and J. E. Indacochea (Department of Civil and Materials Engineering, University of Illinois at Chicago, Chicago, Ill.)

1:00 p.m. **"Corrosion Testing of BNi-3 Brazed Surfaces on Type 347 Stainless Steel for the Space Station Internal Cooling System"** by M. J. Pohlman and C. S. Jeffcoate (Honeywell Aerospace, Torrance, Calif.)

1:20 p.m **"Safety in Cutting, Brazing & Welding with Acetylene & Oxygen"** by Jesse A. Grantham (Welding & Joining Management Group, Westminster, Colo.)

1:40 p.m. **"Brazing & Forming Technology Produce Economical High-Temperature Oven Trays"** by William J. Powers (HiTech Metal Group, Cleveland, Ohio)

2:00 p.m. **"Fluoride Ion Cleaning as a Pre-Braze Process"** by Robert E. Kornfeld (High-Tech Furnace System, Inc., Shelby Township, Mich.)

2:20 p.m. **"Innovations for the Manufacture of Industrial Heat Exchangers"** by S. Rangaswamy and D. Fortuna (Sulzer Metco [US] Inc., Troy, Mich.)

2:40 p.m. **"Virtual Reality to Speed Up the Certification Process of Brazing"** by C. Choquet and O. LisotteCaron (123certification, Inc., Montreal, QC, Canada)

3:00 p.m. **"Advantages of Flux-Cored Braze Materials for Open Air Brazing"** by Creed Darling (Lucas-Milhaupt, Inc., Cudahy, Wis.)

3:20 p.m. **"Brazing of Copper with Cu-Base Brazing Filler Metals"**
by E. Vanegas and T. Oyama (WESGO Metals, Hayward, Calif.)

3:40 p.m **"Comparison of Metal-Ceramic Brazing Methods"**
by C. A. Walker and V.C. Hodges (Sandia National Laboratories, Albuquerque, N.Mex.)

4:00 p.m. **"High-Strength, Ductile Braze Repairs for Stationary Gas Turbine Components"**
by Warren Miglietti (University of Pretoria and GE Aviation) and Prof. Madeline Du Toit (University of Pretoria)

4:20 p.m. **"Study on the Wetting of Glass-to-Metal Joining"**
by C.-P. Chou, K.-H. Tseng, H.-Y. Huang, H.-D. Chen (National Chiao Tung University, Hsinchu, Taiwan; and Metal Industries Research & Development Center, Kaosiung, Taiwan)

AWS POSTER SESSION

Sunday – Wednesday, November 11–14
9:00 a.m. – 5:00 p.m. Sunday,
and show hours on Monday – Wednesday
FREE

The AWS Poster Session is an integral part of the Professional Program. Graphic displays of technical achievements are presented for close, first-hand examination in the Poster Session. Posters present welding results and related material, which are best communicated visually, as well as research results that call for close study of photomicrographs, tables, systems architecture, or other illustrative materials. Posters are presented in five categories: Students in a High School Welding Program, Students in a Two-Year College or Certificate Program, Undergraduate Students, Graduate Students, and Professionals. Be sure to stop by and observe this year's entries.

2-YEAR DEGREE OR CERTIFICATE STUDENT LEVEL

Effects of Different Shielding Gases on Bead Shape
by Frank Starnes, Cy-Fair College, Houston, Tex.

4-YEAR DEGREE STUDENT LEVEL

Joining of Aluminum to Non-Ferrous Metals
by J. Sammons, K. Izor and M. Carney, The Ohio State University, Columbus, Ohio

Heat-Affected-Zone Cracking Mechanisms
by N. Erchak, J. Will and E. Ash, The Ohio State University, Columbus, Ohio

Weldability of Hastelloy X and Haynes 230
by K. McCulloch, J. Seaman and M. Triplett, The Ohio State University, Columbus, Ohio

Empirical Formulae for Extended Stick-out Strip Cladding
by R. Neal, A. Guethlein, and M. Myers, The Ohio State University, Columbus, Ohio

HAZ Study of SAW Welds on High-Strength Steel
by M. Barrett, B. Hammond, and D. Straub

Evaluating the Effect that Core Wire Alloy Content
by W.T. Gunning IV, B. Navarre and O. Onwuama, The Ohio State University, Columbus, Ohio

Deformation Resistance Welding
by D. Failla, C. Huber and E. Galbreath, The Ohio State University, Columbus, Ohio

Effect of Welding Power Supply Type on E9015-B9 SMAW Weld Deposits
by W.J. Christy, K. Thomas and W.H. Thompson

Through-Transmission Laser Welding of Polypropylene Clay Nancoomposites
by P. Gurnani, D. Han and D. Foster, The Ohio State University, Columbus, Ohio

Ultrasonic Weldability of Advanced Metals
by H. Khan, C. Kramer and J. Ocasio, The Ohio State University, Columbus, Ohio

Joining of Aluminum to Ferrous Materials
by S.A. Brooke, K.A. Craver and J. Robillard, The Ohio State University, Columbus, Ohio

GRADUATE DEGREE STUDENT LEVEL

Thermit Welding of Heat Exchanger Tubes
by J. Nickell, Colorado School of Mines, Golden, Colo.

PROFESSIONAL/COMMERCIAL

Application of Robotic Arc Welding Technology
by V. Pintos, and I.V. Crespo, AIMEN, Pontevedra, Spain, and S. Barreras, AISTER, Pontevedra, Spain

In-Process Quality Assurance for Titanium GMAW
by D.A. Hartman, M.J. Cola and V.R. Dave, Beyond6-Sigma, Sante Fe, N.Mex.

Characterization of Friction Stir Welded and Superplastically Formed – Friction Stir Welded Titanium 6Al-4V Alloy
by D.G. Sanders and P. Edwards, The Boeing Company, Seattle, WA and M. Ramulu, University of Washington, Seattle, WA

AWS COMMITTEES

Open-to-the-public meetings of the volunteer committees and board of the American Welding Society.

Events	Date	Time	Room
AWS Foundation	Sunday, November 11	7:45 a.m. – noon	S503a (C)
Districts Council	Sunday, November 11	1:30 p.m.	S502b (C)
C7B Subcommittee on Electron Beam Welding and Cutting	Sunday, November 11	2:00 p.m. – 5:00 p.m.	N226 (C)
C7 Committee on High Energy Beam Welding and Cutting	Sunday, November 11	5:00 p.m. – 6:00 p.m.	N226 (C)
A5H Subcommittee on Filler Metals and Fluxes for Brazing	Monday, November 12	8:00 p.m. – noon	N227a (C)
D17 Committee on Welding in the Aircraft and Aerospace Industries and D17 Subcommittees	Monday, November 12	8:00 a.m. – 5:00 p.m.	N226 (C)
C3 Committee on Brazing and Soldering and C3 Subcommittees	Monday, November 12	8:00 a.m. – 5:00 p.m.	N227a (C)
Opening Session & Annual AWS Business Meeting	Monday, November 12	9:00 a.m.	S404 (C)
C1 Committee on Resistance Welding	Monday, November 12	1:00 p.m. – 4:00 p.m.	N229 (C)
D14G Subcommittee on Welding of Rotating Equipment	Monday, November 12	1:00 p.m. – 5:00 p.m.	N227b (C)
Educational Scholarship Committee	Monday, November 12	3:00 p.m.	(H)
D16 Committee on Robotic and Automatic Welding	Tuesday, November 13	7:30 a.m. – 9:00 a.m.	N227a (C)
D17 Committee on Welding in the Aircraft and Aerospace Industries and D17 Subcommittees	Tuesday, November 13	8:00 a.m. – 5:00 p.m.	N226 (C)
J1 Committee on Resistance Welding Equipment	Tuesday, November 13	9:00 a.m. – 12:00 p.m.	N229 (C)
PACWI/POCWA	Tuesday, November 13	10:00 a.m.	S503a (C)
G2C Subcommittee on Nickel Alloys (tentative)	Tuesday, November 13	10:00 a.m. – 11:30 a.m.	N227a (C)
B1 Committee on Methods of Inspection	Tuesday, November 13	1:00 p.m. – 5:00 p.m.	N227b (C)
D18 Committee on Sanitary Applications	Tuesday, November 13	1:00 p.m. – 5:00 p.m.	N229 (C)
C3 Committee on Brazing and Soldering and C3 Subcommittees	Wednesday, November 14	8:00 a.m. – 5:00 p.m.	N227a (C)
D15C Subcommittee on Track Welding (tentative)	Wednesday, November 14	8:00 a.m. – 5:00 p.m.	N226 (C)
American Council of the IIW	Wednesday, November 14	10:30 a.m.	S404b, c (C)
Preceded by Thomas Lecture at	Wednesday, November 14	10:00 a.m.	S404b, c (C)
Standards Council	Wednesday, November 14		(H)
Professional Development Council	Wednesday, November 14		(H)
Communications Council	Wednesday, November 14		(H)
Role and Missions Committee	Wednesday, November 14		(H)
Board of Directors – Day 1 2:00 p.m. – 7:30 p.m. (rolling meeting format)	Wednesday, November 14		(H)
Board of Directors – Day 2	Thursday, November 15	8:00 a.m.	(H)
C6 Committee on Friction Welding	Thursday, November 15	8:00 a.m. – 12:00 p.m.	(H)

Key:
(H) = Chicago Hilton & Towers
(C) = McCormick Center

Don't Miss the Action in the North Hall

Looking for that special spark to shift your career and business into overdrive? Well, look no further than the North Hall at the FABTECH International & AWS Welding Show in Chicago. With offerings from interactive welding displays to networking opportunities, the North Hall promises to deliver an exciting and valuable experience. Here are some highlights.

Visit the booths of the associations and other groups who support these dynamic and changing industries. These important contacts include the American Welding Society, Society of Manufacturing Engineers, Fabricators and Manufacturers Association, Resistance Welding Manufacturing Alliance, Welding Equipment Manufacturers Committee, and Chinese Mechanical Engineering Society.

How about a chance to win a free trip to Las Vegas? To enter the drawing, visit Booth #35070 and simply scan your show badge. Multiple drawings will take place daily and 14 lucky winners will be selected over the course of four days. With an allowance of one entry per day, per person, you will have several chances to win. Representatives from Las Vegas will be at the booth to discuss next year's FABTECH Internationa & AWS Welding show, Oct. 6–8, at the Las Vegas Convention Center.

The North Hall will also feature the Job Fair & Workforce Development Pavilion. Whether you are a veteran professional or student just entering the workforce, this comprehensive career expo will give you the opportunity to meet company representatives on the hunt for prospective employees.

In the North Hall, you can also find out solutions to some of industry's biggest problems.

A retiring workforce that makes up about half of today's welding industry, coupled with a lack of young people entering this field, has created an extremely challenging production environment for manufacturers. Consequences of this skills shortage can be severe. At the Leadership Summit on Addressing the Shortage of Skilled Workers in U.S. Manufacturing, key representatives from government and the manufacturing sector will reveal strategies and long-term approaches to building a competitive manufacturing workforce. This free event should interest anyone involved with manufacturing operations or production.

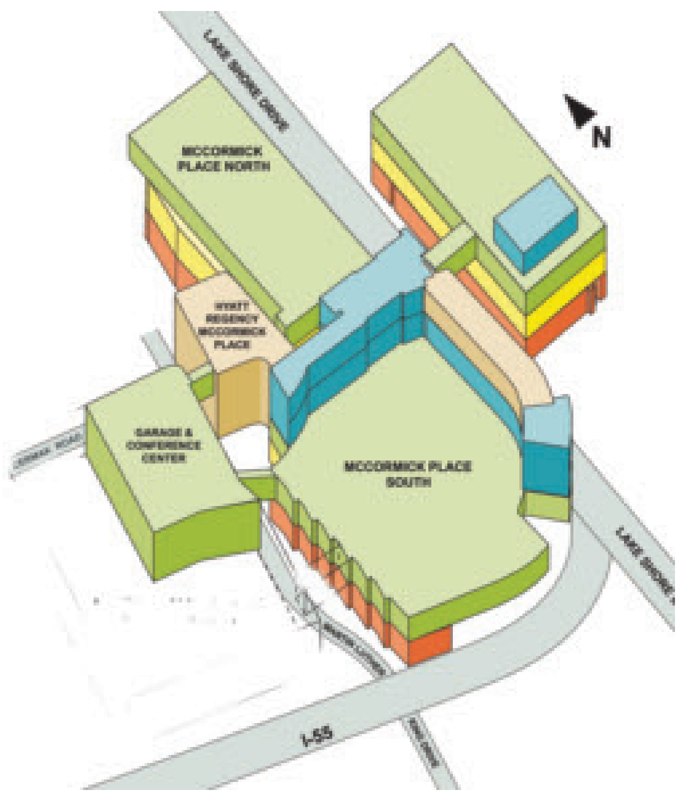
Scared of a little competition? If so, be very afraid of the North Hall. It will house this year's Professional Welders Competition. You can participate or watch by the sidelines as these pros fight for a $2500 grand prize as they undergo a rigorous challenge to make the perfect simulated beam-to-column connection. A $1000 second prize and a $500 third prize will also be awarded, and the top 12 competitors will win an AWS duffel bag. Each participant will receive an AWS Professional Welders Competition T-shirt. For more information about the competition, including complete competition rules and safety rules, visit *www.aws.org/competition*.

The North Hall is home to the popular Innovation Theater, where new products and solutions come to life. The theater will feature 27 exhibitors who will hold free technology sessions every 30 minutes, each day of the show.

Stop by ESAB's Solutions Demo Trailer. There, you will learn from the experts on how to save time and money, get the most out of your welding and cutting equipment, and achieve better end results. Watch practical, hands-on demonstrations from the ESAB crew.

Also rolling into town will be the Miller Electric Welding and Cutting Road Show™. This 62-ft-long semi is equipped with the latest welding power sources and systems. Not only will you be able to see Miller's products in action, you will have an opportunity to test them out yourself.

While we have covered a few of the North Hall highlights, we just can't capture all of the opportunities it has to offer. Visit the North Hall this year and take a journey into new territories.



SHOW REGISTRATION FORM

FABTECH INTERNATIONAL & AWS WELDING SHOW

November 11 – 14, 2007
McCormick Place,
Chicago, Illinois, USA
www.aws.org/show

SHOW HOURS
Sun., Nov. 11: 11 am – 4 pm
Mon., Nov. 12: 9 am – 5 pm
Tues., Nov. 13: 9 am – 5 pm
Wed., Nov. 14: 9 am – 3 pm

- **Online registrants will receive an immediate e-mail confirmation. Fax/Mail-in registrants will receive a confirmation within 3 business days.**
- **Students: DO NOT use this form to register. Please call (800) 733-4763 for assistance.**
- **No one under 16 years of age admitted.**

2 EASY WAYS TO REGISTER:

ONLINE: www.aws.org/show
FAX: (708) 344-4444
MAIL TO:
FABTECH/AWS Welding Show 2007
Compusystems
P.O. Box 541
Brookfield, IL 60513-0541 USA
If you register online or via fax, DO NOT mail this form.
Photocopy this form for additional registrants.

1. Check if you are a member of:

A ☐ AWS B ☐ FMA C ☐ SME D ☐ Nonmember E ☐ NAM

2. Check your ONE primary job function:

1 ☐ Job Shop Owner
2 ☐ Corporate Executive
3 ☐ Manufacturing Engineering
4 ☐ Manufacturing Production
5 ☐ Welding Management
6 ☐ Welding Engineer
7 ☐ Welder, Welding Operator
8 ☐ Welding Distributor
9 ☐ Inspector/Tester
10 ☐ Product Design & Development
11 ☐ Purchasing
12 ☐ Sales/Marketing
13 ☐ Educator/Student
14 ☐ Other

3. Check the number of employees at your facility:

0 ☐ Less than 20
1 ☐ 20–49
2 ☐ 50–99
3 ☐ 100–249
4 ☐ 250–499
5 ☐ 500–999
6 ☐ 1,000–2,499
7 ☐ 2,500 and Over

4. Indicate the products or services you plan to evaluate at the show:

A ☐ Arc Welding
B ☐ Assembly
C ☐ Bending & Forming
D ☐ Brazing & Soldering
E ☐ Business Services
F ☐ Coil Processing
G ☐ Cutting
H ☐ Fastening & Joining
I ☐ Finishing
J ☐ Gases & Gas Equipment
K ☐ Hydroforming
L ☐ Inspection & Testing
M ☐ Job Shop/Contract Mfg.
N ☐ Lasers
O ☐ Lubrication
P ☐ Maintenance & Repair
Q ☐ Material Handling
R ☐ Metal Suppliers
S ☐ Plate & Structural Fabricating
T ☐ Press Brakes
U ☐ Punching
V ☐ Resistance Welding
W ☐ Robotics
X ☐ Safety & Environmental
Y ☐ Saws
Z ☐ Software, Machine Controls
AA ☐ Stamping
BB ☐ Thermal Spraying
CC ☐ Tooling
DD ☐ Tube & Pipe Fabricating or Welding
EE ☐ Tube & Pipe Producing
FF ☐ Welding Consumables
GG ☐ Other Welding Machines
HH ☐ Workholding/Positioners

5. Indicate your company's total budget for these products or services during the next 12 months:

A ☐ Up to $20,000
B ☐ $20,001–$50,000
C ☐ $50,001–$200,000
D ☐ $200,001–$500,000
E ☐ $500,001–$1,000,000
F ☐ $1,000,001–$5,000,000
G ☐ Over $5,000,000

6. Indicate your purchasing authority:

A ☐ Evaluate/Recommend B ☐ Specify C ☐ Approve D ☐ No Role

7. Check the primary industry your company serves:

A ☐ Agriculture/Landscaping Equipment
B ☐ Aircraft/Aerospace
C ☐ Automotive
D ☐ Rail
E ☐ Shipbuilding/Marine
F ☐ Other Transportation
G ☐ Architectural Engineering
H ☐ Construction
I ☐ HVAC
J ☐ Appliance
K ☐ Consumer Products
L ☐ Electronics/Computers
M ☐ Furniture
N ☐ Chemical & Petroleum
O ☐ Government/Military
P ☐ Industrial/Commercial Machinery
Q ☐ Mining/Utilities
R ☐ Fabricated Metal/Stampings
S ☐ Other Manufacturing
T ☐ Education
U ☐ Non-Manufacturing

CODE: W02

☐ Mr. ☐ Ms. ☐ Mrs. ☐ Dr.

PLEASE PRINT - One Form per person

Name ____________________________________

Title ____________________________________

BUSINESS ADDRESS REQUIRED:

Company ____________________________________

Address ____________________________________

Address ____________________________________

City/State/Zip ____________________________________

Postal Code/Country ____________________________________

Phone________________________ Ext. ____________

Fax ____________________________________

E-mail ____________________________________

☐ Please do not use my e-mail for communications outside of the FABTECH Int'l & AWS Welding Show.

Free Special Events

FREE AWS Programs

☐ (W86) AWS Education Program *Tues., Nov. 13–Wed., Nov. 14*
☐ (W87) Int'l Brazing & Soldering Symposium *Tues., Nov. 13*
☐ (W88) End User Forum *Tues., Nov. 13*
☐ (W89) Introduction to Thermal Spray *Tues., Nov. 13*
☐ (S1) Leadership Summit *Mon., Nov. 12*
☐ (J1) Job Fair *Mon.–Tues., Nov. 13–14*

FREE Business Seminars

☐ (B1) Selecting Lean Building Blocks *Mon., Nov. 12*
☐ (B2) Job Shop Marketing *Tues., Nov. 13*
☐ (B3) Workforce Performance Improvement *Wed., Nov. 14*

Some events require separate registration. To compete in the **Professional Welder Competition**, register onsite on Sunday afternoon or during the competition. To reserve for the **Image of Welding Awards Ceremony**, RSVP to azalkind@aws.org or (800) 443-9353 ext. 416. To register for the **AWS Awards/AWS Foundation Recognition Ceremony & Luncheon**, visit www.aws.org/show. To register for the ***Prayer Breakfast***, visit www.aws.org/show or pay at the door.

Please call (800) 733-4763 if you require special assistance.

November 11–14, 2007 • McCormick Place, Chicago

PAID PROGRAMS REGISTRATION FORM

Entry into the exposition is included in paid-event fee.

If faxing this form to register, please fax both sides of page.

Please indicate your name and member number (if any) to receive full pricing benefits.

CODE: W02

Name____

Company____

I am a member of: ☐ AWS ☐ FMA ☐ SME ☐ NAM ☐ Nonmember Member Number ________________________

AWS PROGRAMS

Conferences
*AWS/FMA/SME/NAM Member $345; Nonmember $480**

Friction Welding Conference
☐ (W70) Mon., Nov. 12

Hot Wire Welding and Cladding Conference
☐ (W75) Tues., Nov. 13

RWMA Resistance Welding School
*AWS/FMA/SME/NAM Member $425; Nonmember $660**

☐ (W80) Tues. & Wed., Nov. 13-14

2-Day Stainless Steel Seminar
*AWS/FMA/SME/NAM Member $550; Nonmember $685**

Welding of Stainless Steels
☐ (W79) Tues. & Wed., Nov. 13-14

1-Day Seminars
*AWS/FMA/SME/NAM Member $345; Nonmember $480**

Road Map through the D1.1
☐ (W71) Mon., Nov. 12

Pricing and Profitability
☐ (W72) Mon., Nov. 12

Inspection to the 2006 D1.1
☐ (W73) Mon., Nov. 12

Why & How of Welding Procedure Specification
☐ (W74) Mon., Nov. 12

Visual Inspection Workshop
☐ (W76) Tues., Nov. 13

Metallurgy Applied to Everyday Welding
☐ (W77) Wed., Nov. 14

Introduction to MT, PT, UT and RT
☐ (W78) Wed., Nov 14

3-Day Professional Program***
*AWS/FMA/SME/NAM Member $225; Nonmember $360**

☐ (W84) Mon.-Wed., Nov. 12-14

3-Day Student Professional Program***
*AWS/FMA/SME/NAM Member $75; Nonmember $90***

☐ (W85) Mon.-Wed., Nov. 12-14

1 Day of Professional Program***
*AWS/FMA/SME/NAM Member $150; Nonmember $285**

☐ (W81) Mon., Nov. 12
☐ (W82) Tues., Nov 13
☐ (W83) Wed., Nov 14

FABTECH TECHNICAL SESSIONS

☐ 1 Session *FMA/AWS/SME/NAM Member $165; Nonmember $195*
☐ 2 Sessions *FMA/AWS/SME/NAM Member $295; Nonmember $345*
☐ 3 Sessions *FMA/AWS/SME/NAM Member $395; Nonmember $465*
☐ 4-5 Sessions *FMA/AWS/SME/NAM Member $655; Nonmember $765*

Please select the FABTECH Technical Sessions below you would like to attend. The price for a multiple session purchase is noted at left, and is not combinable with AWS programs above. Do not register for more than one session in each time slot each day as sessions run concurrently. After Oct. 26 and on-site, add $25 to the purchase price of FABTECH Technical Sessions only.

Monday, November 12	Tuesday, November 13	Wednesday, November 14
AM Sessions – 9:30-11:30 am	**AM Sessions – 9:30-11:30 am**	**AM Sessions – 9:30-11:30 am**
☐(F10) ☐(F11) ☐(F12) ☐(F13)	☐(F30) ☐(F31) ☐(F32) ☐(F33) ☐(F34)	☐(F50) ☐(F51) ☐(F52) ☐(F53)
☐(F14) ☐(F15) ☐(F16) ☐(F17)	☐(F35) ☐(F36) ☐(F37) ☐(F38) ☐(F39)	☐(F54) ☐(F55) ☐(F56)
PM Sessions – 1:30-3:30 pm	**PM Sessions – 1:30-3:30 pm**	
☐(F20) ☐(F21) ☐(F22) ☐(F23) ☐(F24)	☐(F40) ☐(F41) ☐(F42) ☐(F43) ☐(F44)	
☐(F25) ☐(F26) ☐(F27) ☐(F28) ☐(F29)	☐(F45) ☐(F46) ☐(F47) ☐(F48) ☐(F49)	

☐ EXHIBITS ONLY
Free if pre-registered. ($50 on-site.) Complete the form on the next page or visit www.aws.org/show and register online.

AWS PROGRAMS SUBTOTAL: $______________

FABTECH SESSIONS SUBTOTAL: $______________

TOTAL FEES $______________

Full payment must accompany your registration.

Payment

Forms received without payment will not be processed. Payment due in U.S. Funds.

☐ Check enclosed (checks payable to SME) Total amount due $_________

☐ Authorize charge to my credit account (Complete credit card information below)

CHECK ONE: ☐ VISA ☐ American Express ☐ MasterCard ☐ Discover

____
Name (Please print)

____
Signature

☐☐☐☐-☐☐☐☐-☐☐☐☐-☐☐☐☐
Credit Card Number

☐☐-☐☐
Expiration Date

*Nonmember price for AWS Sessions includes a two-year AWS Individual Membership. Member benefits include a subscription to the *Welding Journal*, a 25% discount on AWS publications, membership in a local section, and more.

**Nonmember Student Professional Program price includes a one-year AWS Student Membership.

***Professional Program fee includes one copy of the Professional Program Abstracts. Additional copies are available to the public at the AWS Publications Booth (North Building, #38011) for $75.

Cancellation Policy
Cancellations must be made in writing and **faxed** to Attn: FABTECH International & AWS Welding Show Conference Cancellation at (313)425-3407 no later than October 26, 2007 to receive a full refund. Cancellations received after this date are non-refundable.


www.genstartech.com
WELDING & CUTTING AUTOMATION SOLUTIONS
GENTEC®
GENSTAR TECHNOLOGIES
GAS APPARATUS
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MANIPULATOR & TURNING ROLLS
CUTTING MACHINE
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since 1969
QMS REGISTERED
For Info go to www.aws.org/ad-index
SEE US AT THE FABTECH/AWS SHOW BOOTH #1047
Genstar Technologies Company, Inc.
4525 Edison Avenue • Chino, CA
909.606.2726

Welding Show 2007
Exhibit Highlights

This alphabetical listing of AWS welding exhibitors in the FABTECH International & AWS Welding Show offers a preview of what will be displayed in each booth. AWS Sustaining Member Companies are highlighted in color.

AAF International (American Air Filter) 2140

PO Box 35690
Louisville, KY 40232-5690
(800) 477-1214; FAX (800) 254-3019
www.aafintl.com

AAF International will feature its high-quality solutions for dust control needs including cartridge collectors, baghouses, RotoClone® wet collectors, shaker-bag collectors, and mist collectors. It also provides replacement parts and filters for all makes.

A & A Mfg. Co., Inc. 3602

2300 S. Calhoun Rd.,
New Berlin, WI 53151-2708
(262) 786-1500; FAX (262) 786-3280
www.gortite.com

Abbott Furnace Co. 36037

1068 Trout Run Rd., Saint Marys, PA 15857-3146
(814) 781-6355; FAX (814) 781-7334
www.abbottfurnace.com

Abbott Furnace will display its continuous furnaces for the heat treatment of materials commonly used in today's high tech applications. Each furnace is manufactured to meet specific process requirements, including a balanced relationship of time, temperature, and atmosphere. Furnace heating is provided by electric elements or natural gas burner systems or a combination of both methods. Furnaces for the following processes are available: aging, annealing, austempering, austenitizing, brazing, carburizing, carbonitriding, drawing, hardening, infiltrating, martempering, nitriding, normalizing, quenching, sintering, steam treating, stress relieving, and tempering.

ABB Robotics 5141

1250 Brown Rd.,
Auburn Hills, MI 48326-1507
(248) 391-7327; FAX (248) 391-7390
www.abb.com/robotics

ABB will exhibit and demonstrate its robotic MultiMove arc welding, spot welding, and painting systems. The company will also demonstrate its FlexArc cells and the benefits of robotic simulation with Virtual FlexArc. In addition, it will display the IRB 1600ID (Integrated Dressing) that has all cables and hoses routed inside the upper arm, making it suited for arc welding. The dress pack carries all necessary media, including power, welding wire, shielding gas, and pressurized air. This offers users improved lifetime prediction, increased accessibility, simplified programming, and prolonged cable life.

ABICOR Binzel Corp. 3047

650 Research Dr., Ste. 110,
Frederick, MD 21703-2602
(301) 846-4196; FAX (301) 846-4497
www.abicorusa.com

ABICOR Binzel will showcase its newest torch mount, the iCAT, that is useful for the latest generation of welding robots with central service cables guided through the 6th axis. Safety and flexibility describe this product whose integrated crash protection circuitry, during a crash, signals the collision software to immediately stop the robot. The company will also offer the OMEGA 2, 250 A air-cooled torch. These GMA guns provide optimal current transfer through a tight tolerance interface, direct crimped torch body, and neck locking screw. Standard rigid one-piece armored swan necks are 360 deg positionable. Heat resistant rubber reduces torch damage and provides operator comfort. The company will highlight its improved MB501D water-cooled torches. These feature a chrome nozzle seat that improves wear on swan neck and lengthens torch life. Torch handles include an easy grip with standard, extended, or locking trigger.

Abmast Abrasives Corp. 37019

91 Carey Rd., Queensbury
NY 12804-7880
(800) 361-2297; FAX (800) 300-2420
www.abmast.com

Ace Industrial Products 7051

5043 Farlin Ave.
St. Louis, MO 63115-1204
(314) 385-5178; FAX (314) 385-3254
www.aceindustrialproducts.com

Ace will feature its lines of air filtration and fume extraction equipment. Its trademark one-man portable unit, rollaround source capture products, downdraft tables, and ceiling hung ambient air cleaners have all been designed to meet or exceed OSHA and EPA requirements for clean air.

ADF Systems Ltd. 16163

1302 19th St. N., PO Box 278, Humboldt, IA 50548-1062
(515) 332-5400; FAX (515) 332-4475
www.adfsys.com

ADF Systems will exhibit its parts washers, downdraft tables, detergents, and accessories.

Airflow Systems Inc. 5001

11221 Pagemill Rd., Dallas, TX 75243-8314
(214) 503-8008; FAX (214) 503-9596
www.airflowsystems.com

Airflow Systems will display its products to control industrial mist, smoke, dust, and odor problems from manufacturing processes such as machining, welding, and fabrication. It provides solutions from compact portable units, machine-mountable mist/dust collectors to large central systems including low-pressure source pickup hoods to high-pressure vacuum systems.

Airgas, Inc. 6123

259 N. Radnor Chester Rd., Ste. 100
Radnor, PA 19087-5240
(610) 687-5253; FAX (610) 687-6932
www.airgas.com

Airgas will showcase its distributed packaged gases and welding hardgoods, along with safety products.

Air Liquide Industrial US LP 37035

2700 Post Oak, Ste. 1800, Houston, TX 77056
(800) 820-2522; FAX (713) 896-2390
www.us.airliquide.com

Air Liquide Industrial US LP will highlight a new dual-focus technology available for high-power CO_2 laser cutting. It uses a bifocal mirror, which in combination with a standard lens yields also a dual focus effect. This results in a double digit increase in production cutting speeds, particularly when laser cutting stainless steels, galvanized steels, and aluminum under high-pressure nitrogen assist gas.

Air Quality Engineering, Inc. 4108

7140 Northland Dr. N., Brooklyn Park, MN 55428
(763) 531-9823; FAX (763) 531-9900
www.air-quality-eng.com

Air Quality Engineering will offer its DD1000 portable downdraft table. This utilizes a mechanical self-cleaning system, which increases the life of the cartridge filter. The 3 × 3 nominal table has a 1000 ft^3/min rated BI blower, which generates over 200 ft/min average downdraft velocity. Articulating side shields are standard.

Alabama Laser 7095

55 Laser Blvd., Munford, AL 36268
(256) 358-9055; FAX (256) 358-4515
www.alabamalaser.com

Alabama Laser will exhibit its TetraPORT system, a safe-enclosure, modular work cell that can be configured for laser metal deposition, welding, cutting, hardening, and engraving. The metal deposition system uses a laser to melt metal powder or wire onto a substrate.

AlcoTec 6047

2750 Aero Park Rd., Traverse City, MI 49686
(800) 228-0750; FAX (231) 941-9154
www.alcotec.com

AlcoTec will offer aluminum wire in convenient packages designed to provide continuous twist-free wire in high volume for production applications. Twist-free wire delivery ensures ease of use and consistent quality welds. The wire is easily installed, and when empty, the environmentally friendly packaging is fully recyclable.

Alfra Usa LLC 7151

2112 Stonington Ave., Hoffman Estates, IL 60195
(847) 252-7886; FAX (847) 252-7892
www.alfra-usa.com

Alfra Usa will display its high-quality metal cutting saws, magnetic base drills, annular cutting tools, saw blades, hole saws, bevellers, and hydraulic punches.

ALM Corp. 38070

200 Benchmark Industrial Dr., Streator, IL 61364
(815) 673-5546; FAX (815) 673-2292
www.almcorp.com

Americ Corp. **7122**
785 Bonnie Ln., Elk Grove Village, IL 60007-2222
(847) 364-4646; FAX (847) 364-4695
www.americ.com

Americ will highlight its ventilators designed for fume/smoke removal, fan cooling, and bringing in fresh air. They are portable, lightweight, and designed for the most extreme environments. The ventilators are available in 8-, 12-, and 20-in. models, 848 to 8000 ft^3/min. Drum and pedestal fans are available as well.

America Fortune Co. **2106**
6600 Sands Point Dr., Ste. 121, Houston, TX 77074-3726
(713) 779-8882; FAX (713) 774-1763
www.americafortune.com

America Fortune, an agent for Chinese high-pressure gas cylinder and acetylene cylinder manufacturers, will display its DOT gas cylinders, acetylene cylinders, and related products. Engineers and sales staff will be on hand to answer questions. The company is also a supplier of Chinese-made aluminum cylinders, CGA valves, regulators, and other welding supplies.

American Cap Co. LLC **2147**
15 Church St., Wheatland, PA 16161
(724) 981-4461; FAX (724) 981-4495
www.americap-mfg.com

American Cap will showcase its cylinder components for the industrial and specialty gases industries. Its in-house core specialties are deep draw, robotic and automated welding, laser cutting, CNC bending, CNC machining, automatic screw machining, powder coating, and stampings up to 1000 tons.

American Technical Publishers **7145**
1155 175th St., Homewood, IL 60430-4600
(708) 957-1100; FAX (708) 957-1101
www.go2atp.com

American Technical Publishers will feature its award-winning training materials in welding, print reading, and electrical skills.

American Torch Tip Co. **2085**
6212 29th St. E., Bradenton, FL 34203-5304
(941) 753-7557; FAX (941) 753-6917
www.americantorchtip.com

The American Torch Tip will feature its consumables designed to improve cut quality and longevity through improved product engineering. The company will offer replacement consumables for plasma, laser, GMAW, GTAW, oxyfuel, multiuse, and thermal spray parts, along with its line of GMAW guns ranging from 180 to 500 A.

American Welding Society **36005**
550 NW LeJeune Rd., Miami, FL 33126
(305) 443-9353; FAX (305) 443-7559
www.aws.org

The American Welding Society (AWS) was founded in 1919 as a multifaceted, nonprofit organization with a goal to advance the science, technology, and application of welding and related joining disciplines. From factory floor to high-rise construction, from military weaponry to home products, AWS continues to lead the way in supporting welding education and technology development to ensure a strong, competitive, and exciting way of life for all Americans.

AWS Certification. AWS develops and administers a variety of certification programs for welding professionals to help industry identify qualified personnel and provide individuals with meaningful career objectives. The most successful of these programs is the AWS Certified Welding Inspector program. With more than 23,000 inspectors currently certified and more than 53,000 certified since 1976, the AWS CWI program has become the gold standard for weld inspection credentials and has enhanced the careers of many thousands of welding professionals. In 1989, the AWS Certified Welder program was launched to certify the qualifications of welders nationwide. The testing facilities used to conduct the qualification procedures are AWS accredited. AWS maintains these certifications and a list of Accredited Test Facilities (ATF) in a National Registry. AWS also develops customized welder certification programs for other organizations including private companies. Welding instructors can earn an important credential through the AWS Certified Welding Educator program implemented in 1991. Other AWS certification programs are the Senior Certified Welding Inspector, Certified Welding Supervisor, Certified Radiographic Interpreter, Certified Welding Fabricator, and Certified Robotic Arc Welding programs. All of these programs are offered domestically and many are offered internationally. Stop by the Certification booth to find out why AWS certification is the right answer for you and your company. Booth 36005.

AWS Foundation. The AWS Foundation is now in the second year of the capital campaign "Welding for the Strength of America." The funding focus has a two-pronged approach, adding additional scholarships to support welding education at all levels from entry-level training to advanced education support. The entire effort is to provide scholarships to train and better educate a new generation to join the various business segments of the welding profession. The other major focus of the capital campaign is funding for the AWS Welder Workforce Development Program. This will involve recruitment, training, and placement of welders, for industry in the United States, to address the welder workforce need in 2010, estimated to be 200,000. This effort, and the programs as to how to assist this effort, is currently being developed. Funding is still needed to assist with this project. Since the start of the AWS Foundation scholarship program in 1991, it has awarded more than $3.4 million for welding training to more than 2250 individuals. The diversity of the awards is varied, but the major emphasis is welder workforce development. For the 2007–2008 school term, awards were made to more than 290 students for more than $360,000. The need is great for both of our capital campaign funding focuses. Join us today with a gift, a pledge, or a planned future gift. Call Sam Gentry at (800) 443-9343, ext. 331, or visit us in the AWS Foundation Booth #36005. Join the "Welding for the Strength of America" Capital Campaign. We need you!

Membership. AWS services more than 50,000 individual members and 1600 corporate members worldwide. Members consist of engineers, scientists, educators, researchers, welders, inspectors, welding foremen, company executives, and sales associates. Member interests include automatic, semiautomatic, and manual welding, as well as brazing, soldering, ceramics, laminations, robotics, and safety and health. Drop by the AWS Membership Booth on the Show floor, sign up for an Individual Membership, and get a popular welding publication (up to a $189 value) at a 90% discount. Browse through the AWS Bookstore and save 25% on more than 300 AWS publications. Save $135 and get a two-year AWS Membership when you sign up for the Professional Program at the Show. Stay informed on the latest products, trends, and technology through 12 issues of the *Welding Journal*. Looking for a job? As an AWS Member, post your résumé on AWS JobFind at *www.awsjobfind.com* absolutely free. Establish valuable partnerships with others in your field by attending local AWS Section meetings and dozens of educational events. Gain a voice in determining the future of your industry by getting involved in one of AWS's 170 technical committees. For depth, detail, and technical insight — AWS has the answers.

Welding Journal/Inspection Trends. *Welding Journal* is the official publication of the American Welding Society. This monthly journal contains feature articles on practical and applied welding technology, peer-reviewed welding research, information on AWS activities and programs, and a variety of monthly columns, including New Products, News of the Industry, Coming Events, New Literature, and Welding Workbook. Industry experts also answer readers' questions regarding stainless steel, aluminum, and brazing. Winner of many editorial and design awards. *Inspection Trends* will also be featured. This publication serves the nondestructive examination industry including more than 22,000 AWS Certified Welding Inspectors. It contains timely features on all phases of nondestructive examination, profiles of inspection personnel, and columns that bring the latest industry news and practical answers to inspection questions.

Education. Includes seminars, in-plant customized programs, and courses on topics ranging from welding basics to the leading edge of technology. AWS offers the award-winning Schools Excelling through National Skills Education (SENSE) curriculum guide to all qualified U.S. welding schools. Receive up-to-date information on AWS educational offerings and learn how continuing education in welding technology can aid career advancement.

AMET Inc. 3109

35 N. 1st E., Rexburg, ID 83440-1501
(208) 356-7274; FAX (208) 356-8932
www.ametinc.com

AMET will display its complete line of automated welding systems and stand-alone products using digital signal processing to provide precision process/motion control and process verification. These systems can support multiple GTA, GMA, and SAW torches for thick-section applications. The XM controller seamlessly integrates with Lincoln's ArcLink for complete digital power supply control. The company also produces "turn-key" standard and custom welding systems including seamers, lathes, and manipulator/positioner systems as well as stand-alone AVC, wire feeders, oscillators, and seam trackers.

Ampco Metal Inc. **2056**
4475 N. 124th St., Unit F, Brookfield, WI 53005
(262) 790-6940; FAX (262) 790-7150
www.ampcometal.com

Ampco Metal will exhibit its copper-alloy arc welding and rod and bar mill products. The products to be featured are aluminum bronze, nickel-aluminum bronze, manganese-nickel-aluminum bronze welding alloys, copper-alloy machined parts, and high conductivity alloys.

Antenen Research **9103**
4300 Dues Dr., Cincinnati, OH 45246-1004
(800) 323-9555; FAX (513) 860-8807
www.antenen.com

Antenen Research will feature robots for various uses, including welding, grinding/deburring, assembly, palletizing, material handling, and machine loading. Its Roboshine Services subsidiary now offers robotic polishing, buffing, and grinding of a wide variety of parts. It provides consulting, training, and rebuilding services to companies of all sizes. The company will showcase its new RTG ("Ready To Go") Robotic Weld Cells comprised of robots integrated with turntables, power sources, and operator panels, mounted to base plates and surrounded by safety fencing.

Applied Cybernetics, LLC **37029**
5302 Clark Cir., Westminster, CA 92683
(714) 895-0954; FAX (714) 895-1254
www.appliedcybernetics.com

The Orbital Welding Products Division of Applied Cybernetics will exhibit weld heads, coolers, dual weld head switchers, molded connector housings, extension cables, adapters, and embedded microprocessor control systems. These are compatible with most welding power supplies and some will be in the booth for welding demonstrations. The weld heads range from ⅛-in. tube through 6-in. pipe featuring high thoughput, ruggedness, and ergonomics. Other accessories featured will include weld head collets, multibrand collet adapters, and custom fixturing.

Aquasol Corp. **1074**
80 Thompson St., N. Tonawanda, NY 14120-5307
(716) 564-8888; FAX (716) 564-8889
www.aquasolcorporation.com

Aquasol provides products for weld purging from water-soluble paper and tape, to preformed and self-adhesive water-soluble purge dams, purge gas retaining tape, backing tape, clamps, oxygen monitors, and wipes to reduce weld contamination. The company will introduce three new products into its lineup. The WC clamps adjust to a range of 1 to 14 in. in three clamp sizes and can be used for welding of all kinds of materials such as carbon steel, stainless steel, duplex, superduplex, and titanium. The Fiback weld backing tape is a high-temperature-resistant tape with a woven fiberglass center strip designed to eliminate/reduce the need for back purging. The Purge Monitor WGM1 is a small hand-held instrument that accurately measures oxygen concentration down to 0.01% (100 ppm). Its compact design enables it to easily fit in a pocket.

Arc Abrasives, Inc. **35013**
85 Marybill Dr., PO Box 10, Troy, OH 45373-0010
(937) 335-5607; FAX (937) 339-1208
www.arcabrasives.com

Arc Abrasives will showcase its coated and nonwoven abrasives and on-site abrasive solutions.

ArcOne **6109**
85 Independence Dr., Taunton, MA 02780-1076
(800) 223-4685; FAX (508) 884-9666
www.arc1weldsafe.com

ArcOne will highlight various products including a new line of respirators with indicators for clogged filters, low battery, and variable speeds. The company's Flip front Browguard is designed for cutting and brazing, acetylene welding, and plasma cutting. Its new line of V-Crown hard hats comes with ratchet style headgear designed with universal slots for hearing protection, visor attachments, welding helmets, and other accessories. The hats provide Class 1 type G, E, and C protection. The company's new line of designer safety spectacles will also be included. Azure™ combines European design with metal frames, many with flex temples for added comfort. Rich textures and finishes compliment the designer look.

ARCON Welding, LLC **2038**
2203 Northwood Dr., Unit 10, Salisbury, MD 21801-8829
(410) 572-6000; FAX (410) 572-6027
www.arconweld.com

ARCON will offer its rugged and reliable Workhorse line of portable, inverter arc and stud welding machines. The company incorporates standard protection against corrosion on every machine with a 5-year guarantee against corrosion-related failures in natural environments. It will also feature its latest product, the Flexi-volt, which provides automatic voltage selection between 208 and 480 V on all 300–400 A Workhorse models.

Arc Products **2098**
1245 30th St., San Diego, CA 92154-3477
(619) 628-1022; FAX (619) 628-1028
www.arc-products.com

Arc Products will exhibit its components as well as entire systems that enable easy conversion from manual GMA, sub arc, GTA, or plasma processes to a rugged and affordable automated process. The company will also offer seam tacking systems, orbital GTA, magnetic arc control, AVC, GTA wire feed, and weld process controllers.

ARC Specialties, Inc. **3001**
1730 Stebbins Dr., Houston, TX 77043
(713) 631-7575; FAX (713) 356-0844
www.arcspecialties.com

ARC Specialties designs and builds automated manufacturing systems and custom equipment for welding, joining, overlay, coating, and cladding applications. Robots, CNCs, and PLCs are a few of the systems that will be on display. Sample parts welded with GTAW, PTAW, SAW, GMAW, and RSW systems will be available for viewing.

ASEA Welding Co., Ltd. **37071**
601 Dawoo Techno Town, 196 Nae Dong Ojung Gu
Bucheon, South Korea 421806
82-32-679-1055; FAX 82-32-679-1066
www.aseawelding.co.kr

ASEA Welding will feature its portable DC inverters for arc and GTA welding machines.

Ashtead Technology Rentals **38031**
1450 Elmhurst Rd., Elk Grove Village, IL 60007
(847) 718-1246; FAX (847) 718-1423
www.ashtead-technology.com

Asiamet Inc. **1100**
9 Evelyn Ct., Syosset, NY 11791-6816
(516) 942-3884; FAX (516) 942-4058

Asiamet will display its hardfacing materials.

Astro Arc Polysoude **3105**
24856 Ave. Rockefeller, Valencia, CA 91355-3467
(661) 702-0141; FAX (661) 702-0632
www.astroarc.com

Astro Arc Polysoude will feature its advanced modular products for tube, tube to tube sheet, and pipe welding.

Atek Corp. **35047**
PO Box 727, 1650 Burlington Ave.
Kewanee, IL 61443-0727
(888) 226-8261; FAX (847) 963-1545
www.atekcorporation.com

Atek Corp. will showcase its Bantam and PM Series pneumatic/mechanical press brakes available in 12-, 24-, and 42-ton capacities in bed widths from 2 to 8 ft. Featured will also be the new Y-Axis MDRO Ram Stroke Control for all new machines or as a retrofit on older press brakes from the company.

Atema, Inc. **7148**
303 E. Wacker Dr., Ste. 300, Chicago, IL 60601-5212
(312) 861-300; FAX (216) 373-7297
www.atemainc.com

Atema offers distinctive training and management assistance to companies interested in improving their quality management system and meeting various certification requirements (AWS, IAS, AISC, Six Sigma, ISO, State DOT). Visitors to the booth can find out more information, creative ways the company can assist them, and ask about its Continuing Education for Welding Inspectors and CWIs Refresher. The company will also showcase Green Belt Training for fabricators.

ATI Garryson **38053**
1 Teledyne Pl., La Vergne, TN 37086-3529
(615) 641-4206; FAX (615) 641-4441
www.garryson.com

ATI Garryson will highlight its Flexidisc.

ATI Industrial Automation **7029**
1031 Goodworth Dr., Apex, NC 27539-3869
(919) 772-0115; FAX (919) 772-8259
www.ati-ia.com

Atlantic China Welding Consumables, Inc. **1055**
No. 2 Machongkou St., Zigong, China 643010
868-135-103627; FAX 868-135-103072
www.chinaweld-atlantic.com

Atlantic China Welding Consumables will display its welding consumables.

Atlantic Welding & Safety Co. Ltd. (AW&S) 37060
93-5 Dangjeong-Dong, Keumbong Techno Valley #501
Gundo City Kyounggi-Do, Korea
82-31-477-8505; FAX 82-31-477-8503

Atlantic Welding & Safety will display its line of autodarkening welding helmets.

Atlas Welding Accessories, Inc. 4117
501 Stephenson, PO Box 969, Troy, MI 48099
(248) 588-4666; FAX (248) 588-2706
www.atlasweld.com

Atlas Welding Accessories will exhibit its table top welding positioners, a complete line of weld cleaning tools, and a number of select products for the welding industry.

Auburn Mfg., Inc. 4002
34 Walker Rd., PO Box 220
Mechanic Falls, ME 04256-5340
(800) 264-6689; FAX (207) 345-3380
www.auburnmfg.com

Auburn Manufacturing will feature its heat-resistant textiles for use in a variety of hot work/welding applications.

Bacou-Dalloz 3080
900 Douglas Pike, Smithfield, RI 02917-1874
(800) 343-3411; FAX (401) 233-7641
www.bacou-dalloz.com

Bacou-Dalloz will display its personal protective equipment including autodarkening welding helmet technology, safety eyewear, hearing, and respiratory protection.

Balluff Inc. 3149
8125 Holton Dr., Florence, KY 41042-3009
(859) 727-2200; FAX (859) 727-4823
www.balluff.com

Balluff Inc., the U.S. subsidiary of Balluff GmbH & Co., Neuhausen, Germany, will showcase its wide range of inductive, optical, capacitive, and magnetic sensors as well as linear position transducers and ID systems. The company's products for OEM and factory floor solutions are used to control, regulate, automate, assemble, position, and monitor manufacturing, assembly, and packing sequences for industries including metalworking, automotive, packaging, material handling, wood processing, aerospace, electrical, and electronics.

BASF Catalysts, LLC, Surface Technologies 1106
199 Ridgeview Center, Duncan, SC 29334
(864) 486-9311; FAX (864) 486-9307
www.basf.com

Beijing Advanced Metal Materials Co. Ltd. 4148
B2-507 No. 18 Suzhoujie, Beijing, China 100080
86-10-8260-9309; FAX 86-10-8260-9308
www.bam.com.cn

Beijing Advanced Metal will highlight its stainless steel flux cored wires and filler wires/rods AlMg, AlSi, CuSi, CuAl, CuSn, Hf; cored wires and tungsten carbides for hardfacing and spraying; Mo and FeCrC powders; tungsten electrodes WTh, WLa, WZr, WCe, WP, WX, WCu; oxyfuel cutting tips; ceramic backings; and hardfacing and thermal spraying service.

Beijing Jinying Welding Alloys Co. Ltd. 4151
No. 7th Fusheng Rd. - Shahe Changping Dist.
Beijing, China 102206
86-10-80718648; FAX 86-10-80722991
www.alloywelding.com.cn

Bellman-Melcor, Inc. 36061
PO Box 188, Tinley Park, IL 60477-0188
(708) 532-5000; FAX (708) 532-2284
www.bellmanmelcor.com

Bellman-Melcor will offer its brazing and soldering products.

Bernard Welding 4074
449 W. Corning Rd., Beecher, IL 60401-3127
(708) 946-4231; FAX (708) 946-6726
www.bernardwelds.com

Bernard Welding Equipment will exhibit its GMAW welding guns, consumables, accessories, and manual arc products.

Bessey Tools North America 9047
1165 Franklin Blvd., Unit G
Cambridge, ON, Canada N1R 8E1
(800) 828-1004; FAX (519) 621-3442
www.besseytools.com

BGRIMM/China Molding & Diecasting 8034
1501 Norman Dr., Darien, IL 60561-4433
(630) 435-5469; FAX (630) 435-0910

BGRIMM will feature its tungsten electrodes meeting ISO 6848 and ANSI/AWS A5.12-92 requirements. It will also display its new product, MULTI-MIX, a replacement for radioactive tungstens.

BIBIELLE SpA 2078
Via Cuneo 35, 12040 Margarita, Italy
(866) 347-0762; FAX (866) 347-0761
www.bibielle.us

Bibielle, an R&D driven company, will display its high-quality nonwoven abrasive materials and converting coated abrasives products.

Blastec, Inc. 39028
4965 Atlanta Hwy., Alpharetta, GA 30004-2922
(770) 475-2700; FAX (770) 475-2336
www.blastec.com

Blastec will showcase its high-quality, heavy duty shot blasting systems for descaling and surface preparation. As innovators of an efficient shot blast wheel, the company provides cleaning capabilities for industries requiring and processing plate, bridge, and structural steel.

Bluco Corp. 3130
509 Weston Ridge Dr., Naperville, IL 60563-3932
(630) 637-1820; FAX (630) 637-1847
www.bluco.com

Bluco will highlight its Demmeler modular fixturing system that features accurate five-sided tables made of high tensile strength steel. Angles, spacer blocks, clamps, positioning and clamping bolts, and universal stops can be assembled into a ready-to-use welding fixture in a matter of hours. The system is useful for prototypes, spares, and other short run jobs.

BMM Welding Material Co. 4156

No. 5 Fangzhuang Lu, Beijing, China 100078
8610-676-4994; FAX 8610-676-4457
www.bjmmt.com

BMM Welding Material will display its ferrous and nonferrous alloy welding wires, rods, and strips.

Bodycote Testing Group 37038

2395 Speakman Dr., Mississauga, ON, Canada L5K 1B3
(905) 822-4111; FAX (905) 823-1446
www.bodycotetesting.com

Visitors to Bodycote Testing Group's booth will find out how the company supports all industrial sectors with material, component, and product testing, failure analysis, and product development services. Services include welding inspection, weld procedure qualification, weldability studies, welding consultancy, and welder performance qualifications, as well as custom and routine testing of metals to ASTM, federal, and industrial standards.

Bohler Welding Group USA, Inc. 3085

10401 Greenbough Dr., Stafford, TX 77477
(281) 499-1212; FAX (281) 499-4347
www.bwgus.com

At the Bohler Welding Group booth, visitors can discuss the applications, specifications, and approvals needed by the international welding community for petrochemical, power generation, and fabrications, as well as for maintenance and repair. In addition, visitors can learn more about the company's electrodes, wires, strip, and flux cored wires.

Bonal Technologies, Inc. 37017

1300 N. Campbell Rd., Royal Oak, MI 48067-1573
(248) 582-0900; FAX (248) 582-0901
www.bonal.com

Bonal will showcase its Pulse Puddle Arc Welding® equipment and the Meta-Lax® 2700-CC computerized stress relief equipment. This equipment provides less weld distortion, less weld cracking, greater ductility, no size or weight limits, and is portable for field use.

Bortech Corp. 1140

66 Victoria St., Keene, NH 03431-4212
(603) 358-4030; FAX (603) 358-4007
www.bortech.com

Bortech will exhibit its BoreWelders that repair worn bores, pins, shafts, faces, and conical seats, with IDs ranging from 0.5 in. to 12 ft, by applying a GMAW weld overlay. Its BoreCladders will also be exhibited, and these provide ID cladding of round (symmetrical) parts such as nozzles and tubes, using stainless steel or nickel alloys. Local demonstrations and training are available from the company as well.

Bosch Power Tools 2030

1800 W. Central Rd., Mt. Prospect, IL 60056-2230
(224) 232-2584; FAX (224) 232-2611
www.boschtools.com

Bowlin Engineering Co. 7035

600 Burlington Rd., Saginaw, TX 76179-1310
(817) 232-2020; FAX (817) 232-4081
www.bowlinengineering.com

Bowlin Engineering will feature its smoke/dust collectors that recycle plant air, saving energy and creating a healthier plant environment; Bowlin water tables built to users specifications and enhance plasma cutting; and the zoned downdraft cutting tables. Heavy, durable construction using a minimum of 1/4-in. plate combined with a full length fixture keeps its tables straight and level over its entire length.

Bradford Derustit Corp. 8036

PO Box 280, Tualatin, OR 97062
(877) 899-5315; FAX (877) 285-2080
www.derustit.com

Bradford Derustit will display its metal cleaners and pickling products.

Broco, Inc. 7059

10868 Bell Ct., Rancho Cucamonga, CA 91730-4835
(909) 483-3222; FAX (909) 483-3233
www.brocoinc.com

Strong Welding Products Enviro-Arc™ hollow bore gouging electrodes from Broco will be showcased. These result in reduced emissions, lower power requirements, and smoother operation.

Bronco Blast Equipment 17151

2124 Corporate Dr., Waukesha, WI 53189
(262) 544-4211; FAX (262) 544-4020

Bruker 38016

19 Fortune Dr., Billerica, MA 01821
(978) 439-9899; FAX (978) 667-3954
www.bruker.com

Bruker AXS develops and manufactures advanced spark optical emission spectrometers

(OES) and x-ray fluorescence analyzers that provide rapid and accurate elemental analysis. The company will showcase its Q8 CORONADO that brings automation solution for metal foundries. Based on a spark OES system, the product provides rapid analysis of ferrous and nonferrous samples with automated sample preparation. It will also highlight its new S1 TRACER, a hand-held XRF analyzer useful for light elements.

Bug-O Systems 4020

3001 W. Carson St., Pittsburgh, PA 15204-1826
(412) 331-1776; FAX (412) 331-0383
www.bugo.com

Bug-O Systems will offer its system of drives, carriages, rails, and attachments designed to automate welding guns, cutting torches, and other hand-held tools. The systems provide precise path and rate control in any position. Some systems are fully programmable.

Cadi Co., Inc. 7102

60 Rado Dr., Naugatuck, CT 06770-2211
(203) 729-1111; FAX (203) 729-1919
www.cadicompany.com

Cadi Co. will feature at the show its line of high-conductivity copper alloys, including all RWMA alloys, plus electrodes, holders, shanks, adapters, fixtures, weld wheels and dies.

CAR-BER Testing Services 21079

911 Michigan Ave., Point Edward, ON N7V 1H2, Canada
(519) 336-4498; FAX (519) 336-4948
www.carbertesting.com

CAR-BER will show the safety features of its pipe hydrostatic isolation systems to effectively isolate "hot" downstream areas from potentially hazardous materials upstream of the work area by safely diverting such materials off-site.

Carborundum Abrasives North America 38034

1 New Bond St., Worcester, MA 01606-2614
(508) 795-2183; FAX (508) 795-4130
www.carborundumabrasives.com

The company will display its lines of abrasives designed for all welding and metal fabrication applications. Its stock products include bonded, coated, and superabrasives to meet a wide range of price and performance requirements for grinding, cutting, blending, forming, and finishing.

CenterLine (Windsor) Ltd. 1133

655 Morton Dr., Windsor, ON N9J 3T9, Canada
(519) 734-8330; FAX (519) 734-2016
www.cntrline.com

Representatives will demonstrate CenterLine's Supersonic Spray Technologies coating process featuring low-pressure cold-spray equipment that accelerates metal particles fast enough to lock into metal-based substrates. Shown will be a wide variety of coatings and techniques to repair and coat numerous parts and components.

Cepro International 38038

Parallelweg 38 PO Box 183, Rijen, NL-5120 AD
The Netherlands
31-161-226-472; FAX 31-161-224-973
www.cepro.biz

Cepro's booth will display the company's complete lines of safety welding curtains, welding strips, welding booths, welding screens, and welding blankets for use in all welding and grinding workplaces.

Cerbaco, Ltd. 2123

809 Harrison St., Frenchtown, NJ 08825-1122
(908) 996-1333; FAX (908) 996-0023
www.cerbaco.com

Cerbaco will display samples from its extensive line of nonmetallic weld backings that permit finished-quality, complete joint penetration welds from one side. Also, the backings eliminate the need for arc gouging or heavy grinding prior to second-side welding. Technical assistance and free custom design services will be offered at the booth.

CGW-Camel Grinding Wheels USA 7126

7525 N. Oak Park Ave., Niles, IL 60714-3819
(800) 447-4248; FAX (800) 447-3731
www.cgwheels.com

CGW will display its latest extra-thin cut-off wheels featuring contamination-free cuts. Shown will be the Super Quickie cut-off wheels in Types 1 and 27, in several standard diameters, nonwoven EZ strip wheels for cleaning welds, and aluminum flap discs that run cooler to minimize loading on softer materials.

Changzheng Projector Carbon Electrodes Co. 4150

Huzhou City, Zhejiang Prov., Huzhou 313009
Zhejiang, China
86-572-307-0288; FAX 86-572-301-1768
www.czcarbon.com

The company will display its extensive lines of gouging carbon electrodes, including pointed, jointed, flat and half-round rods. Also to be shown is a line of gouging torches.

Changzhou Asia Science & Technology Co., Ltd. 4155

No. 8 Gueng Dian E. Rd., 8-608 Wujin Hi-tech Ind. Zone
Changzhou 213161, China
86-519-630-1676; FAX 86-519-630-5876
www.cn-goldenglobe.com

The company will showcase its CO_2 carbon steel gas shielding welding wire produced, including ERTOS-G, ER49-1, and others used in the steel structure, pressure vessel, container, shipping, and other industries.

Changzhou Foreign Trade Corp. 39018

108 Gingliang Rd., Changzhou Jiangsu 213-14, China
86-519-886-5301; FAX 86-519-886-5211
www.weldingmen.com

Changzhou Global Welding & Cutting Co., Ltd. 2128

Daijia Nanxiashu, Changzhou Jiangsu, 213166, China
86-519-864-83059; FAX 86-519-864-84613
www.quan-giu.com

The company will display its electrode holders, tube/pipe bundling equipment, tungsten electrodes, and GTA, GMA, and plasma arc welding machines and components.

Changzhou Golden Globe Welding & Cutting Eqpt. Co., Ltd. 4167

No. 6 South Lihua Rd., Changzhou City, Jiangsu
Province 213004, China
86-519-886-9582; FAX 86-519-886-9582
www.czgg.com

The company will feature its Blackwolf trademarked line of welding equipment, torches, and accessories.

Changzhou Huarui Welding & Cutting Equipment Co., Ltd. 4149

Nanzai Panjia Town, Changzhou Jiangsu 213178, China
86-519-620-1365; FAX 86-519-620-3167
www.huarui-ca.com

Chart Industries, Inc. 6103

407 7th St. NW, New Prague, MN 56071-1010
(952) 882-5016; FAX (952) 882-5161
www.chart-ind.com

Chart Industries will feature its cryogenic products for the liquefaction, storage, transportation, and use of gases such as helium, nitrogen, argon, oxygen, carbon dioxide, natural gas, and hydrogen, for numerous industrial, commercial, and scientific purposes.

The Chinese Mechanical Engineering Society 38019

2-5-1607 Lianhuaxiaoqu, Haidian Dist.
Beijing 100823, China
86-10-639-72404; FAX 86-10-639-80554
www.cmes.org

The Chinese Mechanical Engineering Society's major tasks are holding technical conferences and exhibitions, as well as conduct academic exchanges. Organizing Chinese companies to attend the FABTECH & AWS Welding Show each year is one of its regular activities.

C. H. Symington & Co., Inc. 4109

6063 Frantz Rd., Ste. 103, Dublin, OH 43017-3369
(614) 766-2602; FAX (614) 766-2715
www.chsymington.com

C.H.Symington will display its full range of air-carbon arc welding accessories. In addition, it will show its automatic, semiautomatic, and manual gouging torches and consumables, exothermic cutting equipment, and the Symex heavy-duty ground clamp, cable connector, and GMAW torch.

Cincinnati Thermal Spray, Inc. 1117

5901 Creek Rd., Cincinnati, OH 45242-4011
(513) 793-0670; FAX (513) 793-4254
www.cincinnatithermalspray.com

Circle Welding Innovations, Inc. 21125

PO Box 370, Tomball, TX 77377
(281) 255-4711; FAX (281) 255-4712
www.circlewelders.com

Circle Welding Innovations will feature its "ultiMATE" rugged trackless welding and cutting carriage with many interesting features, and "intelli-MATE" single-axis, portable, all-position robot with built-in intelligence.

CK Worldwide, Inc. 8038

3501 C St. NE, Auburn, WA 98002-1702
(253) 854-5820; FAX (253) 939-1746
www.ckworldwide.com

CK Worldwide will feature its complete line of gas tungsten arc torches and accessories, gas-saver consumables for standard torches, fingertip current controls, wedge collet, cold-wire feed systems, and large-diameter clear nozzles for titanium welding. Also to be displayed will be a fexible purge chamber, tungsten electrodes, tungsten grinder, super flex cables, Flex-Loc torches, turbine torch, long-neck extended-reach torches, and patented Dinse connectors.

Cloos Robotic Welding, Inc. 2141
911 Albion Ave., Schaumburg, IL 60193-4550
(847) 923-9988; FAX (847) 923-9989
www.cloosrobot.com

The company will feature its turn-key robotic welding systems; robots, power supplies for manual and automated welding; tandem welding packages, positioners, custom fixturing, intergration, training and service.

CM Industries, Inc. 6117
505 Oakwood Rd., Lake Zurich, IL 60047-1534
(847) 550-0033; FAX (847) 550-0444
www.cmindustries.com

CM Industries will exhibit its complete lines of GMA and GTA air- and water-cooled torches for semiautomatic and robotic applications, plus smoke-extractor guns, water-coolers, pneumatic nozzle-cleaning stations for robotic and semiautomatic welding, and push-pull GMA welding guns.

CML USA, Inc. 18058
3100 Research Parkway, Davenport IA 52804
(563) 391-7700; FAX (563) 391-7710
www.ercolina-usa.com

Tube, pipe and profile bending equipment; mandrel and non-mandrel rotary draw benders; manual and hydraulic operated angle rolls. Pipe and tube notchers, portable magnetic drills and centerfree annular cutters.

CMW, Inc. 2058
70 S. Gray St., Indianapolis, IN 46201-4200
(317) 634-8884; FAX (317) 638-2706
www.cmwinc.com

CMW will display its extensive line of resistance welding consumables, holders, shanks, adapters, electrodes, caps, etc. Featured will be its GCAP® economical electrode cap for high-production welding of galvanized steel, electrodes with Elkonite® CuW offering extended life, and Elkaloy® 20 dispersion-strengthened copper to provide longer life, reduced power consumption, and start-up, and resistance to deformation when welding.

COB Industries, Inc. 22052
PO Box 361175, Melbourne, FL 32936-1175
(321) 723-3200; FAX (321) 984-8455
www.cob-industries.com

COB Industries will feature its specialty piping and welding products, including water-soluble purge dams, purge monitors, purge bladders, purge plugs, flexible welding enclosures, backing tapes, and trailing shields. Other products to be shown are Multi Strike nonthoriated tungsten electrodes, TEGIII tungsten electrode grinders, weld force gauges for robotic and manual applications, and pressure test plugs for pipe from 3/8 to 96 in., 0 to 10,000 lb/in.^{2}.

Cold Jet 3033
455 Wards Corner Rd., Loveland, OH 45140-9033
(513) 831-3211; FAX (513) 831-1209
www.coldjet.com

Cold Jet will feature its dry ice blasting and dry ice pellet production equipment for the automotive, aerospace, foundry, food, packaging, rubber, plastics, tires, and other industries. Details will be available about its ice delivery, ice machine rentals, and contract cleaning services.

Computer Engineering, Inc. 7033
509 NW 5th St., Blue Springs, MO 64014-2705
(816) 228-2976; FAX (816) 228-0680
www.computereng.com

Computer Engineering will showcase its welding documentation software supporting code checking and generating accurate WPSs, PQRs, and WPQs in accordance with AWS D1.1 and ASME Section IX.

Computers Unlimited 4102
2407 Montana Ave., Billings, MT 59101-2336
(406) 255-9500; FAX (406) 255-9595
www.cu.net

Computers Unlimited will feature its integrated software solutions for the industrial gas and welding supply industry. Shown will be the *TIMS* for Windows® business management software application that integrates order entry, inventory, warehouse-management, cylinder control, and advanced cylinder management, electronic price updates, mobile delivery, e-docs, document imaging, integrated financials, and powerful data analysis tools.

Computer Weld Technology, Inc. 1163
10702 Old Bammel N. Houston Rd., Houston, TX 77086
(713) 462-2118; FAX (713) 462-2503
www.cweldtech.com

Computer Weld Technology will feature its Thru-Arc seam tracking technology and weld controls along with advanced weld monitoring and quality control solutions. On display will be the new MicroADM Advanced Arc Data monitor, WPM-08 touch-screen PC-based operator interface, and universal weld controls.

CONCOA, Inc. 11000
1501 Harpers Rd., Virginia Beach, VA 23454-5303
(757) 422-8330; FAX (757) 422-3125
www.concoa.com

CONCOA will introduce its next-generation of gas-management systems at the show. It features fully automatic switchover to reduce liquid cylinder waste. On display will be the 632 industrial gas automatic switchover system, the new 629 vent kit, 630 cryogenic manifold, and nexGen *Laser Wizard* software.

Coral S.P.A. 38071
Corso Europa 597, 10088 Volpiono, Torino, Italy
39-011-982-2000; FAX 39-011-982-2033
www.coral.biz

Coral will display its pollution-control systems for all types of mist, dust, and fume applications for a healthier environment. All of the systems are designed to meet OSHA's requirements for the removal of hexavalent chromium.

Cor-Met, Inc. 3126
12500 Grand River Rd., Brighton, MI 48116-8326
(800) 848-2719; FAX (810) 227-9266
www.cor-met.com

Cor-Met will preview its COR-FACE 10V FC-G, a flux cored hardfacing vanadium carbide alloy that provides exceptional wear resistance and strength in cold working applications. The product, with a hardness of 60 HRC with minimal cross checking, is recommended for slitting and trimming knives, agriculture cutting edges, and cold extrusion dies.

Crafford LaserStar Technologies 35037
1 Industrial Ct., Riverside, RI 02915-5218
(401) 438-1500; FAX (401) 434-7260
www.laserstar.net

The BrightStar laser welding systems will be displayed in both a compact and pedestal design featuring the ability to be easily custom configured to the needs of a variety of applications and component part dimensions. Shown will be four styles: an open workspace, open workspace with adjustable shelf, deluxe chamber, and automation chamber.

Cryostar USA 3154
5897 Colony Dr., Bethlehem, PA 18017-9349
(484) 281-3401; FAX (484) 281-3402
www.cryostar.com

Cryostar will display its cryogenic equipment and services, including cryogenic pumping, expansion turbines, and filling stations (LNG, LH2, industrial gas). Applications include shipboard compressors, hydrocarbon turbines, and clean energy.

CS Communication & Systems 37061
5 rue brindejonc des Moulinais, BP 15872 Toulouse Cedex 5,F315061, France
33-561-176-496; FAX 33-561-176-578
http://wave.c-s.fr

The company will demonstrate its unique CS WAVE virtual welding training system that effectively simulates welding situations using a wide range of exercises. The trainer/trainees architecture permits control of the training process for several trainees at the same time. Shown will be how the programming can be altered for the trainer to optimize the training.

CS Unitec, Inc. 6157
22 Harbor Ave., Norwalk, CT 06850-4210
(800) 700-5919; FAX (203) 853-9921
www.csunitec.com

CS Unitec will display its hollow-core abrasive wheels. Previewed will be its PTX EcoSmart 6-in. surface finisher and other portable surface finishers with a finned shaft adapter

Other products will include its new PLANTEX and TRIMTEX lines of flap disks.

Cyl-Tec, Inc. 1086
950 Industrial Dr., Aurora, IL 60506-1150
(630) 844-8800; FAX (630) 844-5100
www.cyl-tec.com

The company will feature its cylinder products including DOT/TC high-pressure cylinders, acetylene cylinders, aluminum cylinders, portable cryogenic and beverage carbonation cylinders, valves, caps, siphon tubes, cryogenic repair parts, and Acrylex fast-dry cylinder paints. Its cylinder services include DOT-approved hydrostatic and ultrasonic testing, portable cryogenic cylinder repair, acetylene cylinder requalification, and aluminum cylinder refinishing.

Daido Steel America, Inc. 2151
1111 N. Plaza Dr., Ste. 740, Schaumburg, IL 60173-6000
(847) 517-7950; FAX (847) 517-7951
www.daido.co.jp/buglish

Daido Steel will show its new gas metal arc welding titanium wire that provides a higher efficiency than gas tungsten arc welding, and the new ferritic stainless steel welding wire that yields finer weld grain microstructures.

Dantherm Filtration, Inc. 3150
102 Transit Ave., Thomasville, NC 27360-8927
(336) 821-0808; FAX (336) 410-0808
www.danthermfiltration.com

Dantherm Filtration will feature its turn-key system, air-filtration collectors, ducting, fans, spark-detection equipment, and related products for systems with air flows ranging from 500 to more than 100,000 ft^3/min.

Dataweld, Inc. 2104
1909 Citizens Bank Dr., Bossier City, LA 71111-3429
(318) 746-6111; FAX (318) 746-0323
www.dataweld.com

Davi North America/Promau 15150
5291 Zenith Pkwy., Loves Park, IL 61111-2727
(815) 282-8550; FAX (815) 282-8675
www.davinorthamerica.com

Davi will display its CNC sheet and plate rolls suitable for job shop applications to high-production specialized applications. It will also feature its double beam folding machines.

Delphi Technologies, Inc. 4129
5725 Delphi Dr., Troy, MI 48098-2815
(248) 813-8075; FAX (248) 813-5008
www.delphi.com

The company will show its deformation resistance welding that provides a viable alternative to conventional brazed welding. Its process applies resistance welding to generate heat, then exerts pressure to create atomically bonded, solid-state joints.

Dengensha America Corp. 1141
7647 First Pl. Dr., Bedford, OH 44146-6701
(440) 439-8081; FAX (440) 439-8217
www.dengensha.com

DE-STA-CO 1078
31791 Sherman Dr., Madison Heights, MI 48071
(248) 397-6735; FAX (248) 397-6733
www.destaco.com

The company will display its new 2000 Series hold-down clamps, pivot units, new electric clamps, SpiderGrip end-effectors, and an assortment of other products.

D & H Secheron Electrodes Pvt., Ltd. 38012
Merchant Chambers 5th Fl., 411 New Marine Lines
Mumbai Mamarash, TRA 400020, India
91-22-220-27661; FAX 91-22-220-27664
www.dnhsecheron.com

Direct Wire & Cable, Inc. 4103
68 Denver Rd., PO Box 57, Denver, PA 17517-0057
(717) 336-2842; FAX (717) 336-0505
www.directwire.biz

Direct Wire & Cable will present its two types of Class K welding cables with a choice of five stock colors, power cords, jumper cables, Ultra-Flexible whip line, and extension cords. These products are supplied with cables cut to specified lengths, with the necessary ends, and coiled or boxed packaging.

Diversi-Tech, Inc. 7140
590 Orly, Dorval, QC H9P 1E9, Canada
(800) 361-3733; FAX (514) 631-9480
www.diversitech.com

Diversi-Tech will feature its Green Filter cleaning machine, a stand-alone unit designed to clean most dust collector filter cartridges to prolong useful life and safe money.

Donaldson Torit 3032
PO Box 1299, Minneapolis, MN 55440
(952) 887-3454; FAX (952) 887-3608
www.donaldsontorit.com

Donaldson Torit will display its new virtually maintenance-free EX-ARM fume-extraction unit featuring 360-deg rotation and external adjustment controls.

Durum USA **1105**
11133 I-45 S. Building I, Conroe, TX 77302
(936) 539-2630; FAX (936) 539-2470
www.durumusa.com

Durum will showcase its hardfacing welding powders, rods, wires, and electrodes generally sold under the name Durmat® for use in the deep drilling, steel, foundries, glass, mining, dredging, brick-and-clay, agriculture, textiles, chemical, aluminum, excavation, and pump manufacture and repair industries. Its specialty is tungsten carbide-based hard-facing products.

Dynabrade, Inc. **11047**
8989 Sheridan Dr., Clarence, NY 14031
(716) 631-0100; FAX (716) 631-2073
www.dynabrade.com

Producer of high quality pneumatic abrasive power tools for grinding, sanding, deburring, filing, and polishing for the needs of numerous markets.

Eagle Bending Machines, Inc. **17111**
34225 Hwy 31, PO Box 99, Stapleton AL, 36578
(251) 937-0947; FAX (251) 937-4742
www.eaglebendingmachines.com

Eagle Bending Machines offers professional, industrial grade section benders and angle rolls in capacities from ½-in to 4-in angle. 30 precision engineered roll bender models offer a choice fit to any application and budget. Automated roll bending is achieved with a choice of optional NC and full CNC controls. All machines bend tube, pipe, profiles, extrusions and have digital readouts. lateral guides, universal tooling, horizontal/vertical operation and non proprietary superior OEM componentry as standard.

Easen Corp. **1148**
A-2-1202 Binnan Garden, 201 Huaizhong Rd.
Shijiazhuang 050021, China
86-311-8582-7722; FAX 86-311-8582-7733
www.easenwire.com

Easen will display its 0.045- and 0.0625-in. metal cored welding wires on 33-lb spools.

ECKA Granules of America, LP **37032**
130 Evergreen Rd., Ste. 100, Louisville, KY 40243
(502) 253-4550; FAX (502) 253-4563
www.ecka-granules.com

ECKA Granules will showcase its Class 20 welding materials, Discup, metal powders, and thermal spray powders.

Edison Welding Institute (EWI) **3003**
1250 Arthur E. Adams Dr., Columbus, OH 43221-3585
(614) 688-5000; FAX (614) 688-5001
www.ewi.org

EWI will display its Virtual Joining Portal that enables remote users access to supercomputer algorithms for computational modeling of welded structures. Detailed will be how users can explore changes in design, materials, and process conditions at a fraction of the time and cost of traditional methods.

ELCO Enterprises, Inc. **4032**
5750 Marathon Dr., Jackson, MI 49201-7711
(517) 782-8040; FAX (517) 782-8039
www.wire-wizard.com

ELCO will display its Wire Wizard® weld wire dispensing and weld cell support equipment; Torch Wizard™ and Torch Wizard II™ nozzle-cleaning stations; and Wire Pilot™ wire feed assist and its Wizard Shield™ antispatter products Blue Magic™ and Blue Chill™ and Nozzle Mister antispatter applicator.

Electric Heating Systems **39054**
109 N. Gold Dr., Robbinsville, NJ 08691
(609) 259-4118; FAX (609) 259-4119
www.hotfoilehs.com

Electric Heating Systems will display its lines of welding and heat-treating equipment. Featured will be its combined 8-Pack with a heat-treating unit that permits welding and post-weld heat treating at the same time.

Electron Beam Technologies, Inc. **2116**
1275 Harvard Dr., Kankakee, IL 60901-9471
(815) 935-2211; FAX (815) 935-8605
www.electronbeam.com

Electron Beam Technologies will display samples of POLY-XL jacketed GMA welding and plasma cutting composite/coaxial cables. Also on display will be its complete line of Fast 'N Easy bulk electrode handling equipment. Application engineers will be available to discuss your needs.

ELTO SpA **36053**
Via Dei Sabbioni nr. 15, Giaveno (Turin) 10094, Italy
39-011-906-8868; FAX 39-011-906-8391
www.elto.com

ELTO will feature its lines of soldering and inverter welding equipment designed for both do-it-yourselfers and professional users. Also to be displayed are its plasma cutting machines and a range of soldering irons, soldering stations, and battery chargers.

Enco **5152**
PO Box 357, Farmingdale, NY 11735-0357
(800) 873-3626; FAX (800) 965-5857
www.use-enco.com

Enco will display some of the more popular machines, tools, and shop supplies from its inventory of more than 40,000 products.

Environmental Air Solutions **7163**
2220 Jessica Ln., Coralville, IA 52241-1110
(319) 358-7794; FAX (319) 248-0345
www.keeptheheat.com

The company will feature its KeepTheHeat™ air-to-air heat exchanger that enables shop ventilation without losing heat.

ESAB Welding & Cutting Products **5047/39059**
411 S. Ebenezer Rd., Florence, SC 29501-7916
(843) 679-5823; FAX (843) 664-5607
www.esabna.com

ESAB will showcase its 16-lb HandyPlasma 250 manual plasma cutting machine for cutting carbon or stainless steel up to 0.25 in. thick. Also to be shown is the HLx Series mechanized laser welding system with laser, laser with cold wire fill, or hybrid laser arc welding capabilities with GMAW. Dual Shield X flux cored wires and AristoRod solid wires will be on display.

Esta Corp. **37056**
2321-A Distribution St., Charlotte, NC 28203
(704) 351-3819; FAX (704) 971-6966
www.esta.com

Esta will feature its mobile fume extractor Models SRF K10 and SRF K15 designed for all types of welding workstations. The units are designed to filter air with 99.9% efficiency before returning the clean air into the workplace, and have economical, cleanable, long-life filter cartridges.

ESCO Tool Co. **19100**
50 Park St., Medfield MA 02052
(800) 343-6926; FAX (508) 359-4311
www.escotool.com

ESCO Tool manufactures sells and rents Mill-hog end prep tools, boiler tube rolling motors and expanders plus Panel Hog saws for cutting tube panels and pipe. These tools work great on all types of alloy including Super Duplex and are available for sale or rent. Stop by out booth and see a live demonstration of these tools in action.

Eutectic Corp. **1132**
N94 W14355 Garwin Mace Dr.
Menomonee Falls, WI 53051-1628
(800) 558-8524; FAX (262) 255-5542
www.eutectic-na.com

Eutectic will display a wide range of products including its patented CDP wear plates, surface coatings, welding consumables (wire and electrodes), brazing rods, and welding accessories.

EXEL Orbital Systems, Inc. **1059**
1448 19th St., Santa Monica, CA 90404-2806
(310) 449-0054; FAX (310) 449-1154
www.exelorbital.com

EXEL Orbital will have on display its 200-A microprocessor-controlled touch-screen power supply, a line of enclosed weld heads with cartridge inserts using the same motor driver in sizes from 1/16 to 3 in., automatic internal pressure control device, and quick-release purge fittings from 1½ to 6 in.

Ezee Roll Mfg., Inc. **4001**
PO Box 47, Hoopeston, IL 60942
(217) 339-2279; FAX (217) 339-2278
www.ezeeroll.com

Ezee Roll, a manufacturer and distributor of quality cylinder trucks, will showcase its latest products.

FCI Molded Products, Inc. **1162**
550 Applewood Crescent, Concord
ON L4K 4B4, Canada
(800) 849-4011; FAX (905) 669-0261
www.fcimoldedproducts.com

FCI will show a wide variety of its molded products including plastic and metal components to close and finish all types of tubing. end caps, tube closures, tube connectors and adjustable glides, levelers, handles, control knobs, ball knobs, lever knobs, instrument/pointer knobs, etc., in stock or custom made from nylon, poly, Teflon®, butyrate, phenolic and a variety of other materials.

Fein Power Tools, Inc. **3071**
1030 Alcon St., Pittsburgh, PA 15220-3436
(412) 922-8886; FAX (412) 922-8767
www.feinus.com

Fein Power Tools will celebrate its 140th anniversary by introducing its GRITbyFEIN multipurpose, multiprocess, modular belt grinding system at the show. It features interchangeable modules for radius, linear, mobile, and centerless grinding. The system, designed for metalworking professionals, offers cost-effective processing of a variety of materials.

Ferris State University **37074**
915 Campus Dr., Swan Bldg. Rm. 108
Big Rapids, MI 49307-2277
(231) 591-2511; FAX (231) 591-2407
www.ferris.edu

Representatives will be at the booth to discuss the Ferris State Welding Engineering Technology (WET) program designed to graduate capable plant-level engineers who can get involved in the concept, design, and engineering of weldments and the implementation of welding processes.

Flame Technologies, Inc. **4163**
PO Box 1776, Cedar Park, TX 78630-1776
(512) 219-8481; FAX (512) 219-8477
www.flametechnologies.com

Flame Tech will feature the Lightning Rod hollow core gouging rod, new lightweight hand cutting torches capable of cutting 60 in. of steel. Also on display will be direct replacement acetylene and fuel gas tips, heating, brazing apparatus, regulators, check valves, flash arrestors, and new complete welding/cutting kits and components.

Flex-North America, Inc. **37021**
13057 W. Center Rd., Ste. 6, Omaha, NE 68144
(402) 933-7759; FAX (402) 933-7729
www.flexnorthamerica.com

Flex will showcase its pipe sanders and metal surface treatment products. To be featured are the Models LRP 1503 VR “BOA” and LBR 1506 VR pipe sanders, the LBS 1105 VE finger belt sander, and the LP 1503 VR finishing machine.

Flexovit USA, Inc. **2070**
1305 Eden-Evans Center Rd., Angola, NY 14006-9734
(716) 549-5100; FAX (716) 549-5455
www.flexovitabrasives.com

Flexovit will display its lines of high-quality abrasive products including grinding wheels, coated abrasives, wire brushes, and diamond products.

Frommelt Safety Products **2120**
4343 Chavenelle Rd., Dubuque, IA 52002-2653
(800) 553-5560; FAX (563) 589-2776
www.frommeltsafety.com

Frommelt will showcase its automated and manual machine-guarding products engineered to protect workers from entry into hazardous areas, and shield from flying debris and weld flash. Products include high-speed safety doors, guards, roll-down curtains, fume-extraction equipment, and area protection fabrics.

Fusion, Inc. **3017**
4658 E. 355th St., Willoughby, OH 44094-4630
(440) 946-3300; FAX (440) 942-9083
www.fusion-inc.com

Fusion will present its lines of brazing and soldering alloys, dispensers, and automatic machines, including fixed station and rotary indexing machines.

F. W. Gartner Thermal Spraying, Ltd. **1125**
25 Southbelt Ind. Dr., PO Box 451509
Houston, TX 77047
(713) 225-0010; FAX (713) 229-9841
www.fwgts.com

F. W. Gartner will display its extensive line of thermal spraying products.

GBC - PDS **3104**
2519 E. Southmore
Pasadena, TX 77502
(713) 472-8122; FAX (713) 472-6804
www.gbcamerica.com

GBC-PDS will feature pipe cutting and beveling equipment for sale or rent, as well as preheat and postweld heat treating equipment and supplies.

GE Inspection Technologies **2127**
4619 Jordan Rd.
Skaneateles Falls, NY 13153
(315) 554-5920; (315) 554-4056
www.GEInspectionTechnologies.com

GE Inspection Technologies will highlight its nondestructive testing (NDT) inspection solutions, which include radiographic, ultrasonic, remote visual inspection, and eddy current technologies.

Gedik Welding, Inc. **4127**
Ankara Cad No. 306
Seyhli-Pendik
Istanbul 34913, Turkey
902 163-785000; FAX 902 163-787936
www.gedik.com.tr

Gedik will feature its line of welding wires and covered electrodes.

Genesis Systems Group **3057**
8900 N. Harrison St.
Davenport, IA 52806-7323
(563) 445-5772; FAX (563) 445-5699
www.genesis-systems.com

Genesis Systems will introduce the Transformation series of configurable platforms that adjust to manufacturing needs with modifications completed onsite. Also featured will be a newly designed safety barrier that allows for a customized configuration of lightweight panels with safety viewing windows to be set up.

Genie Products **1111**
PO Box 1028
Rosman, NC 28712-1028
(828) 862-4772; FAX (828) 877-3480
www.genieproducts.com

Genie Products will display its full line of consumable replacement parts for all the OEM-made plasma and HVOF thermal spray torches. Also on display will be GTV's current line of innovative metallizing systems

Genstar Technologies Co., Inc. (GENTEC) **1047**
4525 Edison Ave., Chino, CA 91710-5706
(909) 606-2726; FAX (909) 606-6485
www.genstartech.com

Genstar Technologies will showcase its cutting and welding equipment, high-quality pressure regulators, fittings, valves, welding apparatus, and various gas control and handling devices.

Goss, Inc. 7046
1511 Route 8
Glenshaw, PA 15116-2301
(412) 486-6100; FAX (412) 486-6844
www.gossonline.com

Goss will showcase its complete line of cutting, welding, and brazing equipment,

Gradient Lens Corp. 37039
207 Tremont St.
Rochester, NY 14608-2303
(585) 235-2620; (585) 235-6645
www.gradientlens.com

Gradient Lens designs, manufactures, and sells Hawkeye Precision Borescopes, which feature the patented endoGRINS® gradient-index optical design.

Gullco International 4111
21568 Alexander Rd.
Cleveland, OH 44146-5586
(440) 439-8333; FAX (440) 439-3634
www.gullco.com

Gullco International will highlight its automated welding and cutting equipment, featuing KAT all-position variable-speed travel carriage for vertical and horizontal multipass welding. Also featured will be Moggy single or dual torch magnetic trackless fillet weld carriage, KBM-18 and KBM-28 high-speed portable plate edge beveling machines, joint tracking systems, positioners, turning rolls, semiautomatic gouging system, and Katbak ceramic weld backing.

H & M Pipe Beveling Co., Inc. 3162
311 E. 3rd St.
Tulsa, OK 74120-2401
(918) 582-9984; FAX (918) 582-9989
www.hmpipe.com

H&M will showcase its portable pipe cutting and beveling machines, pipe alignment clamps, two-hole flange pins, and shape cutting attachments for saddling and mitering pipe.

HAI Advanced Material Specialists, Inc. 1104
9230 Norwalk Blvd.
Santa Fe Springs, CA 90670
(877) 411-8971; FAX (562) 463-8143
www.haiams.com

The company will feature its thermal spray and welding wires, powders, and equipment for twin-wire arc, HVOF, combustion, and plasma spraying.

Hana Engineering Co. Ltd. 39013
3F 901-5 Hogye2-Dong
Dongan-Gu, Anyang-Si
Gyeonggi-Do, Korea
82-31-458 9367; FAX 82-31-458 9387
www.hanalaser.com

The company will highlight laser machines for welding, drilling, and cutting, primarily for the automotive industry.

Harbert's Products Inc./Allied Flux Reclaiming Ltd. 6078
501 S. Cedar Ln., PO Box 418
Greencastle, PA 17225-0418
(800) 377-3103; FAX (717) 597-1748
www.recycleflux.com

Harris Products Group 4028
2345 Murphy Blvd.
Gainesville, GA 30504-6001
(800) 377-3103; FAX (717) 535-0544
www.harriscal.com

Harris will show its gas cutting, welding, and pressure regulating equipment.

Hayden Corp. 1126
333 River St.
West Springfield, MA 01089-3603
(413) 734-4981-22; FAX (413) 785-5052
www.haydencorp.com

Hayden will feature its service of applying metal or ceramic thermal sprayed coatings using flame, plasma, arc-wire, and HVOF processes. The company also provides laser cladding hardfacing services with post machining/grinding capabilities.

HC Starck, Inc. 1116
45 Industrial Pl.
Newton, MA 02461-1951
(617) 630-5800; FAX (617) 630-5879
www.hcstarck.com

H.C. Starck will highlight its advanced ceramic powders, including nitrides (Si_3N_4, AlN, BN), borides (LaB_6, TiB_2, ZrB_2), carbides (B_4C, SiC, TiC), silicides ($MoSi_2$), and oxides (Y_2O_3, Spinal) for structural, electronic, and engineered ceramics. The company will also feature its solid oxide fuel cell ceramic powders and components, advanced materials for electronics and optics, niobium and tantalum ethoxides for specialized coating applications, and a wide variety of materials for semiconductor applications.

Heck Industries 11063
PO Box 425, Hartland MI 48353
(810) 632-5400; FAX (810) 632-6640
www.heckind.net

Bevel-Mill Plate Bevelers, Trace-A-Punch Nibblers, Turbo-Burr Deburring, Hydraulic Angle Notchers, Pipe notchers.

Hispamig SL 38047
Calle L'horteta 52
Rafelbunyol Valencia 46138, Spain
34-961-412264; FAX 34-961-412264
www.hispamig.com

Hispamig will feature its welding torches and an innovative solution for detecting torch breakdowns during use in robotic applications

Hobart Bros. Co. 4070
101 Trade Square East, Troy, OH 45373-2488
(937) 332-4000; FAX (937) 332-5224
www.hobartbros.com

Hobart Brothers will exhibit a complete line of welding filler metals from Hobart, Trimark, McKay and Corex brands, including mild steel electrodes, mild steel solid wires, flux cored and metal cored tubular wires, and stainless steel and hardsurfacing products. Company engineers and sales professionals will be on hand to assist visitors in welding solutions and product recommendations.

Hobart Institute of Welding Technology 5081
400 Trade Square East, Troy, OH 45373-2463
(937) 332-5000; FAX (937) 332-5200
www.welding.org

Hobart Institute offers complete training for welding and certification.

HTM Electronics - Sensors 2101
8651 Buffalo Ave.
Niagara Falls, NY 14304-4382
(800) 644-1756; FAX (888) 283-2127
www.htm-sensors.com

HTM Electronics will display its new Metalhead line of steel faced proximity sensors with ptfe coatings for weld slag resistence. Safety light curtains in all series will also be on display.

Huashi Engineering Co. Ltd. 7144
68 Longchang Rd., Hexi District
Tianjin 300201, China
8622-8428-6262; 8622-2398-3508

Huys Industries Ltd. 6074
175 Toryork Dr. Unit 35
Weston, ON M9L 1X9, Canada
(416) 747-1611; FAX (416) 747-7171
www.huysindustries.com

Huys Industries will showcase its Version 8 of Sorpas resistance welding simulation software, a new screw-in replaceable head to reduce consumable costs for projection welding, and a range of certified Double-Coat™ electrodes for lengthening electrode life in spot welding of aluminum sheet.

Hyd-Mech Group Ltd. 8005
1079 Parkinson Rd.
Woodstock, ON N4S 8A4, Canada
(877) 276-7297; FAX (519) 539-5126
www.hydmech.com

Hyd-Mech Group will exhibit its metal cut-off bandsaws including both straight cutting, double-miter, and single-miter cutting to 45 and 60 deg. The extensive line also includes dual post horizontal saws designed for straight heavy cut-off and vertical bandsaws that miter up to 45 deg in both directions.

Hypertherm, Inc. 4017
PO Box 5010, Hanover, NH 03755-5010
(603) 643-3441; FAX (603) 643-5352
www.hypertherm.com

Hypertherm will highlight its HySpeed Plasma HSD130, a cost-effective oxygen plasma cutting system. Also featured will be PHC, a voltage sensing height control unit to improve cut quality, and consumable starter kits for the Powermax1000, Powermax1250, and Powermax1650 systems.

Hyundai Welding Products 5157
215 Satellite Blvd. NE, Ste. 300
Suwanee, GA 30024-7126
(770) 614-7577; FAX (770) 614-6636
www.hdweld.co.kr

IBEDA Superflash Compressed Gas Equipment, Inc. 4162
28825 Ranney Parkway, Westlake, OH 44145
(888) 327-7306; FAX (440) 716-9964
www.oxyfuelsafety.com

IBEDA Superflash will introduce its new line of flame spraying guns for thermal spraying with powder using oxyfuel with the safety of a gas mixture system using the injector principle.

Idealgas Co. S.R.L. 38041
V Fanno 4 , Casier 31030, Italy
39 0422-9388; FAX 39 0422-331998
www.idealgas.it

Idealgas will feature its Armageddon torch with a piezo system that ignites in any situation, even in a very narrow space.

igm Robotic Systems, Inc. 1052
W133 N5138 Campbell Dr.
Menomonee Fls, WI 53051-7030
(262) 783-2720; FAX (262) 783-2730
www.igmusa.com

Impact (Ironworker Mgt. Prog. Action Co-op Trust) 39070
1750 New York Ave. NW Lobby
Washington, DC 20006-5301
(202) 393-1147; FAX (202) 393-1507
www.impact-net.org

Impact is a Taft Hartley trust whose primary mission is to expand job opportunities for union Ironworkers and their signatory contractors through progressive and innovative labor-management cooperative programs.

Impact Engineering, Inc. 2152
500 E. Biddle St., Jackson, MI 49203-3990
(517) 789-0098; FAX (517) 789-1038
www.impactwelding.com

Impact Engineering will highlight its full range of real-time weld quality analysis tools using data acquisition and monitoring, automated process fault detection, Weld Signature analysis and automated diagnostics. Two new products will be featured: Impact pcOI Gen 4, a welding cell operator-PC interface; and AR-Client v4.00 weld monitoring software.

IMR Test Labs 1131
131 Woodsedge Dr., Lansing, NY 14882-8940
(607) 533-7000; FAX (607) 533-9210
www.imrtest.com

IMR Test Labs is a full-service laboratory offering welder and weld procedure qualifications, thermal spray coating evaluation, mechanical testing failure analysis, and material analysis services.

Indura 38075
18020 Brenridge Dr., Brandy Station, VA 22714
(866) 328-3171
www.indura.net

Industrial Air Quality 12054
95 Cypress Dr., Youngsville, NC 27596
(919) 562-7181; FAX (919) 562-7182
www.industrialairquality.com

Industrial Air Quality will offer its full-service air purification expertise that includes testing, design, engineering, service, and turn-key installations.

Industrial Maid LLC 2155
351 S. 12 Rd., Cortland, NE 68331
(402) 798-7116; FAX (402) 798-7117
www.industrial-maid.com

Industrial Maid will introduce its new EB series fume collectors with reduced energy consumption, no compressed air usage, and no trays, bins, or dust drums to handle. It will also feature the RHV series, a new line of vertical air filtration systems with an overhead-style hood system that can be hung from the ceiling.

Innerspec Technologies, Inc. 31018
4004 Murray Pl., Lynchburg, VA 24501
(434) 948-1306; FAX (434) 948-1313
www.innerspec.com

Innerspec Technologies will feature its proprietary ultrasonic electromagnetic acoustic transducer (EMAT) technology, a noncontact method of inducing sound energy into metals for inspection/monitoring of material properties. The company will also feature its use of EMAT in temate® Si-MWC, a system for post-weld inspection of mash seam welds; temate TG-IL in-line thickness measurement equipment; temate IB inspection system for internal defect detection in steel I-beams; and temate Ti-DP, an automated inspection system designed for inspection of ductile iron pipes in the mill.

Innov-X Systems 10001
100 Sylvan Rd., Ste. 100, Woburn, MA 01801
(781) 938-5005; FAX (781) 569-0528
www.innov-xsys.com

Innox-X will feature its point and shoot handheld XRF analyzers for nondestructive alloy analysis, grade verification, and flow accelerated corrosion (FAC) inspection. The product is software-based and powered by a PDA/Pocket PC.

Instrument Technology, Inc. 7150
PO Box 381, Westfield, MA 01086-0381
(413) 562-3606; FAX (413) 568-9809
www.scopes.com

Instrument Technology will showcase its borescopes, fiberscopes, videoscopes, and other custom remote-viewing instruments useful for industrial applications.

Integrated Robotics LLC 2157
40 Old Dover Rd., Newington, NH 03801-7874
(603) 766-3490; FAX (603) 766-3485
www.integrated-robotics.com

Integrated Robotics will feature its robot-based manufacturing solutions for most manufacturing processes with specialties in welding, machine tending, grinding and polishing, buffing, deburring, cutting, and material handling.

Integro 7124
290 Pratt St., Meriden, CT 06450-8600
(203) 235-4424; FAX (203) 630-1093
www.Integro-USA.com

Integro will highlight its electrode holders made with fill-soldered connectors that are permanently molded to the cable to ensure waterproof and safe welding. The company will also feature its welding preheat system designed to heat steel to appropriate temperatures with strip heaters at the welding application.

Intercon Enterprises, Inc. 4132
1125 Fir Ave., Blaine, WA 98230-9702
(800) 665-6655; FAX (604) 946-5340
www.intercononline.com

Intercon Enterprises wil feature GTA pipe welding accessories, Jokisch anti-spatter and welding-related hardware.

International Thermal Spray Assoc. 1107
208 3rd St., Fairport Harbor, OH 44077-5822
(440) 357-5400; FAX (440) 357-5430
www.thermalspray.org

International Welding Technologies, Inc. 4099
276 Pinedge Dr., West Berlin, NJ 08091-9218
(856) 753-8126; FAX (856) 753-8439
www.internationalwelding.com

International Welding will feature its C.D. stud welding systems and C.D. fasteners in steel, stainless steel, aluminum, brass, and copper.

The line includes the LYNX3 modular, the LYNX3 quickshot, and the LYNX3 Titan with your choice of C-1 contact gun, G-1 gap gun, Ci-1 insulation gun, or S-1 tight access gun.

InterTest, Inc. **36028**
303 Route 94, Columbia, NJ 07832-2761
(800) 535-3626; FAX (908) 496-8004
www.intertest.com

InterTest will highlight its speciality in providing optical inspection equipment for both in-process weld monitoring and postprocess quality inspections with standard and custom solutions.

Irco Automation, Inc. **38046**
1080 Clay Ave., Ste. 3
Burlington, ON L7L 0A1, Canada
(905) 336-2862; FAX (905) 336-7969
www.ircoautomation.com

Irco Automation will display its new and improved G-16 beam positioner.

IRT ScanMaster Systems, Inc. **4145**
319 Garlington Rd., Ste B4
Greenville, SC 29615-4621
(864) 288-9813; FAX (864) 288-9799
www.scanmaster-irt.com

IRT will highlight its UT/Mate portable, full-featured, USB-driven, PC-based ultrasonic instrument, which provides the operator with a flexible and versatile platform for inspection combined with reporting, networking, and archiving capabilities.

ITW Dykem **5081**
805 E. Old Highway 56, Olathe, KS 66061
(913) 397-8704; FAX (913) 397-8761
www.dykem.com

The company will feature its metal marking systems.

Jackson Safety **4016**
1859 Bowles Ave. #200
Fenton, MO 63026-1936
(800) 253-7281; FAX (800) 338-4003
www.jacksonsafety.com

Jackson Safety will showcase its complete line of safety products for head, eye, face, and hearing with an emphasis on the BOSS big window EQC with 13 sq. in. of viewing area; the Arctic, an autodarkening filter for use in extreme weather conditions; OTG over-the-glass safety spectacle with antifog lenses and integral side shields; and the Halo X lightweight helmet.

Jancy Engineering, Inc. **23111**
2735 Hickory Grove Rd., Davenport IA 52804-1240
(563) 391-1300; FAX (563) 391-2323
www.jancy.com

Jancy Engineering Inc. offers a diverse product line anchored by their annular cutters, magnetic based drills and metal cutting saws. The Jancy product line also includes weld preparation equipment such as notchers, bevelers, and positioners. In addition Jancy offers grinding machines, centerless grinding machines, pipe and tube benders and Porta-Vise clamps. Everything the metal worker and fabricator needs and more.

JAZ USA, Inc. & Bullard Abrasives Inc. **2081**
6 Carol Dr., PO Box 861
Lincoln, RI 02865-0861
(877) 529-8721; FAX (877) 529-3291
www.jazusa.com

JAZ personnel will provide demonstrations of the company's line of wire brushes.

Jetline Engineering **4082**
15 Goodyear, Irvine, CA 92618-1812
(949) 951-1515; FAX (949) 951-9237
www.jetline.com

Jetline Engineering will feature its engineered weld systems including longitudinal seamers, circumferential welding machines, positioners, and weld head locators. New introductions will include CSC controlled short circuit welding, Cyclomatic bolt on automation arc controls, and CMC coordinated motion control for multi-axis bore cladding and elliptical shape joining.

Jiangsu Changzhou Zhongjiang Welding Wire Co. Ltd. **38021**
No 1 Changyezhong Rd.
Chunjiang Town, Xinbel District
Changzhou, Jiangsu 213034, China
86 -519-5860999; FAX 86-519-58601034
www.zjwelding.com

JLC Electromet Pvt. Ltd. **37047**
G 153 A Road No 11-H VKI
Jaipur Rajasthan 302013, India
91-141-233-0375; FAX: 91-141-233-0345
www.jlcelectromet.com

The company will feature its nickel alloys and speciality welding wires available in coil and cut lengths for GMAW and GTAW.

John Tillman Co. **7110**
1300 W. Artesia Blvd.
Compton, CA 90220-5307
(310) 764-0110; FAX (310) 764-2700
www.jtillman.com

Tillman will exhibit its welding gloves, clothing, curtains, and screens.

Joysun Abrasives Co. Ltd. 35019

No. 129 5th Ave., E. Hanghai Rd.
Economy and Tech Develop Zone
Zhengzhou Henan Province
China 450016
86-3716-7622388; FAX 86-3716-7622389
www.joysunabrasives.com

Joysun will highlight its abrasive products, mainly standard and high-density zirconia, alumina, ceramic, and SiC products, including the jumbo flap disc for professional welding applications.

J.P. Nissen Co. 8046

2544 Fairhill Ave., PO Box 339
Glenside, PA 19038-0339
(215) 886-2025; FAX (215) 886-0707
www.nissenmarkers.com

J.P. Nissen will exhibit and demonstrate its line of markers for the welding and fabricating industries. These include ball-point metal markers, solid paint markers and feltip paint markers, as well as, specialized products intended for fabricating, nuclear and high temperature applications. All of the markers are permanent paint markers that will write on wet, oily or dry, rough, or smooth surfaces.

Kaliburn (formerly Innerlogic, Inc.) 2109

455 Fleming Rd., Charleston, SC 29412-2410
(843) 795-4286; FAX (843) 795-8931
www.innerlogic-inc.com

Kaliburn will display its newest and most innovative high current density plasma cutting and marking systems.

Kawasaki Robotics (USA) 36013

28140 Lakeview Dr., Wixom, MI 48393-3157
(248) 446-4100; FAX (248) 446-4200
www.kawasakirobotics.com

Kawasaki will demonstrate its FSJ system for joining light alloy materials, which uses a robot equipped with a dual-servo FSJ gun to join materials with 1/20 of the electrical power. required by resistance welding. Also featured will be the F-Series robots suited for many arc welding applications.

Keystone Fastening Technologies Inc. 2086

409 Parkway View Dr.
Pittsburgh, PA 15205-1408
(412) 787-5970; FAX (412) 788-6627
www.keystonefastening.com

Keystone Fastening will feature its capacitor discharge (CD) and drawn-arc (ARC) stud welding equipment, stud welding accessories for all makes and models, and a complete range of studs in mild steel, stainless steel, aluminum, and other alloys. Portable hand-gun models to fully-automated production machines will be displayed.

Kinetic Cutting Systems 3005

304 W. Prospect Rd., Ste. F
Fort Collins, CO 80526-2084
(970) 498-8441; FAX (970) 498-8451
www.kineticusa.com

Kinetic will display its new K5000 heavy-duty combination drilling and cutting machine with a 48-HP high-speed spindle, 24 toolchanger and dual Hypertherm HPR260 plasmas on automated bevel heads.

Kiswel USA, Inc. 3119

3575 Koger Blvd., Ste. 225
Duluth, GA 30096-4983
(770) 935-5532; FAX (770) 935-5589
www.kiswel.com

Kobelco Welding of America 3131

4755 Alpine Rd., Ste. 250
Stafford, TX 77477-4129
(281) 240-5600; FAX (281) 240-5625
www.kobelcowelding.com

Kobelco, a supplier of flux cored wire for stainless and mild steel, and solid wire for mild steel, will be demonstrating its new E7048 mild steel electrode for tack welding.

Koike Aronson, Inc.,/Ransome 6009

635 W. Main St., PO Box 307
Arcade, NY 14009-0307
(800) 868-0640; FAX (585) 457-3517
www.koike.com

Koike Aronson will highlight its Lasertex-3560TRV, 6-kw, CO_2 laser cutting machine, as well as its full line of welding positioners, turning rolls, welding manipulators, and the automatic girth welding machine for tank fabrication.

Kokuho Co. Ltd. 39042

1-8-54 Uchikowa, Yokosuka-city
Koragawa 239-083, Japan
81-46-835 6404; FAX 81-46-835 2204

Kokuho will feature its high-performance automatic welding machine.

Koyo Giken, Inc. 37059

4020-4 Tana, Sagamihara Kanagawa-Pref
229-1124, Japan
81-42-760-4306; FAX 81-42-760-4309
www.koyogiken.co.jp


TRIPLE YOUR
VERSATILITY.
X-SERIES
X-SERIES

Koyo Giken will introduce its table spot welding machine with EasySetting programmed memory for popular materials and thicknesses.

KUKA Robotics Corp. **1082**
22500 Key Dr., Clinton Township, MI 48036-1193
(248) 819-0230; FAX (586) 795-4871
www.kukarobotics.com

Kundel Industries, Inc. **1150**
PO Box 4686, Austintown, OH 44515-0686
(330) 716-2757; FAX (330) 259-9001
www.kundel.com

Kundel will highlight its cranes and overhead lift kits.

Laboratory Testing, Inc. **35056**
2331 Topaz Dr., Hatfield, PA 19440-1936
(800) 219-9095; FAX (800) 219-9096
www.labtesting.com

Laboratory Testing specializes in materials testing, calibration, specimen machining, and failure analysis services. Mechanical, chemical, metallurgical, and nondestructive testing services are performed, as well as dimensional, pressure, force, torque, mass. and vacuum calibration services.

LA-CO/Markal **16004**
1201 Pratt Blvd., Elk Grove Village, IL 60007
(847) 956-7600; FAX (847) 956-9885
www.laco.com

Featuring our complete line of industrial marking products for all types of metal surfaces, plus glass, plastic, wood, cardboard and other surfaces. Includes paint markers in liquid and solid form for marking hot or cold, wet or dry, rough or smooth surfaces.

Lapco Mfg., Inc. **2156**
98 Glenwood St., Morgan City, LA 70380-2317
(985) 385-5380; FAX (985) 384-5081
www.lapcomfg.com

LASAG Industrial-Lasers **8098**
1615 Barclay Blvd.
Buffalo Grove, IL 60089-4544
(847) 483-6300; FAX (847) 483-6333
www.lasag.com

LASAG Industrial-Lasers will showcase its diode-pumped and flash lamp-pumped lasers for precision cutting, drilling, and ablating of metals and other materials. as well as laser sources with real-time power supply for spot and seam welding applications.

Liburdi Automation, Inc. **3100**
400 Highway 6 N
Dundas, ON L9H 7K4, Canada
(905) 689-0734; FAX (905) 689-0739
www.liburdi.com

Liburdi Automationwill feature its precision, vision-based LAWS, Dabber and Pulsweld power sources, multi-axis articulated motion systems and controllers for applications in turbine, aerospace, nuclear, industrial, and automotive industries. The company will also highlight its extensive orbital welding products and precision lathes, seamers, and positioners for welding of tube and pipe, medical devices, industrial, nuclear power generation, and automotive components.

Lincoln Electric Co. **4029/5029**
22801 Saint Clair Ave.
Cleveland, OH 44117-1199
(216) 481-8100; FAX (216) 486-1751
www.lincolnelectric.com

Lincoln Electric will showcase its arc welding power sources, wire feeders, welding consumables, plasma and oxyfuel cutting equipment, and robotic welding systems.

Lineage Alloys, Inc. **1129**
1901 Ellis School Rd.
Baytown, TX 77521-1215
(281) 426-5535; FAX (281) 426-7484
www.lineagealloys.com

Lineage Alloys will highlight its thermal spray powders.

Little Giant Ladder Systems **37040**
1325 W. Industrial Cir.
Springville, UT 84663-3075
(801) 489-3684; FAX (801) 806-9333
www.littlegiantladders.com

Little Giant Ladder will highlight its versatile, aluminum alloy ladder that meets or exceeds OSHA and ANSI standards for 300+ lb weight capacity. Also featured will be accessories including a platform, leg-leveler, wall stand-off, and a ladder rack.

Lucas-Milhaupt, Inc.
A Handy & Harman Co. **2041**
5656 S. Pennsylvania Ave.
Cudahy, WI 53110-2453
(414) 769-6000; FAX (414) 769-1093
www.lucas-milhaupt.com

Lucas-Milhaupt will feature its complete line of brazing and soldering products and services, such as alloys, fluxes, automated equipment, product design, training, and technical assistance.

Luvata Ohio, Inc. 1077
1376 Pittsburgh Dr., Delaware, OH 43015-3814
(740) 272-7526; FAX (740) 368-4348
www.luvata.com

Luvata will emphsize its metal fabrication, component manufacturing, and related engineering and design services. Its Formed Products unit will feature resistance welding and projection welding electrodes, and GMAW contact tips and wire.

Magid Glove and Safety 37037
2060 N. Kolmar Ave., Chicago, IL 60639-3418
(773) 289-1379; FAX (773) 289-9379
www.magidglove.com

The company will showcase its work gloves, protective clothing, industrial hygiene products, and safety equipment.

Magnaflux – A Division of ITW 4088
3624 W. Lake Ave., Glenview, IL 60026-1215
(847) 657-5300; FAX (847) 657-5388
www.magnaflux.com

Magnatech Limited Partnership 5120
PO Box 260, East Granby, CT 06026-0260
(860) 653-2573; FAX (860) 653-0486
www.magnatech-lp.com

Magnatech will display equipment for orbital tube/pipe, and tubesheet welding applications. The Tubemaster power source, with Autoprogram will be demonstrated welding sanitary stainless tubing, and the Pipemaster for multipass welding will be introduced.

Magswitch/Romar USA 1041
218 W. Richey Rd., Houston TX 77090
(281) 440-1725; FAX (281) 440-1724
www.romarusa.com

Mailam USA 39032
11442 Chairman Dr., Dallas, TX 75243
(214) 503-9941; FAX (214) 503-9948
www.pct.edu

Mailam will feature its FCAW, GMAW, SMAW, and hardfacing electrodes and wires.

Mannings USA 2110
351-3 Lowery Ct., Groveport, OH 43125-9344
(614) 836-0021; FAX (614) 836-0028
www.manningsusa.com

Mannings will showcase its on-site heat treating, high-frequency induction, and bolting services. including preheat, postweld heat treatment, dryout/curing, induction bolt heating, and hydraulic bolting.

Maryland Brush Co. 38018
3221 Frederick Ave.
Baltimore, MD 21229-3807
(800) 654-0774-613; FAX (888) 278-7440
www.marylandbrush.com

Maryland Brush will feature its brush products for weld cleaning and pipeline industries in both carbon and stainless wire constructions.

Massaging Insoles by Sweet Feet 37023
2400 Interlachen Rd., #321
Spring Park, MN 55384
(800) 301-3338; FAX:(952) 471-1102
www.massaginginsoles.com

The company will feature its glycerin-filled insole and offer free test walks at the booth.

Master Magnetics, Inc. 6001
747 S. Gilbert St., Castle Rock, CO 80104
(888) 293-9399; FAX (800) 874-6248
www.magnetsource.com

The company will highlight its magnets and magnetic assemblies for applications requiring lifting, positioning, holding, retrieving or separating, and materials handling.

Master Weld Products LLC 6005
3962 Portland St., Coplay, PA 18037
(610) 261-1000; FAX (610) 261-1555
www.masterweld.net

Master Weld will showcase its consumables, GMA welding guns, and GTA torches.

Matheson Tri Gas, Inc. 36035
1861 Lefthand Cir., Longmont, CO 80501-6740
(303) 678-0700; FAX (303) 442-0711
www.mathesongas.com

Matheson Tri-Gas will feature its complete line of gas handling and purification equipment; bulk, specialty, and industrial gases; and cutting/welding equipment.

Mathey Dearman, Inc. 2077
PO Box 472110, 4344 S. Maybelle Ave.
Tulsa, OK 74147-2110
(918) 447-1288; (918) 447-0188
www.mathey.com

Mathey Dearman will spolight its patented cutting and beveling machines, the CGM blade milling machine, numerous accessories for all sizes and types of pipe, pipe alignment and reforming clamps, welding electrode and flux ovens, and pipe tools for pipe fitting and layout.

Matuschek Welding Products, Inc. 7162
42378 Yearego Dr.
Sterling Heights, MI 48314-3267
(586) 991-2434; (586) 991-2438

Matuschek will feature its resistance welding controls and instrumentation for sheet metal and micro welding.

Medi-Rub USA 2126
10 Cedar Dr., Arden, NC 28704-9764
(843) 372-1011; (508) 819-3002
www.medirubusa.com

Merritt Precision Technology 2037
1080 Classic Rd.., Apex, NC 27539-4403
(919) 362-7170; FAX (919) 363-8559
www.mpt-inc.com

Merritt Precision Technology will emphazsize its welding systems, robotic torch cleaning stations, plasma and laser brazing, and advanced welding wire delivery systems.

Meta Vision Systems, Inc. 2105
8084 TransCanada
Montreal QC H4S 1M5, Canada
(800) 661-0140; FAX (514-) 33-8636
www.meta-mvs.ca

Meta Vision will feature its welding process control systems utilizing 3-D laser vision hardware and software.

Metal Supermarkets 8060
1675 Tonne Rd., Elk Grove Village, IL 60007
(866) 867-9344; FAX (847) 439-3105
www.metalsupermarkets.com

Metal Supermarkets wiil offer its services as a source for a wide variety of metals including steel, stainless, and aluminum, in all standard shapes and sizes.

Metallisation Ltd./TMS Metalizing 1123

Pear Tree Lane, Dudley DY2 0XH, UK
44-138-4 252464; FAX 44-138-4237196
www.metallisation.com

The company will showcase its thermal spray equipment and consumables including arc, flame, plasma, and HVOF processes.

MG Systems & Welding 5005

W141 N9427 Fountain Blvd.
Menomonee Falls, WI 53051-1624
(262) 255-5520; FAX (262) 255-5170
www.mg-systems-welding.com

MG Systems & Welding will showcase its newest machine, the EdgeMax. which features precision plasma cutting with three basic models, the H, G, and P powered by the Global S CNC control with touch screen interface and the familiar Windows® screen layout. Also featured will be the Global Rotator Infinity machine capable of accurately cutting bevel profiles (non-vertical) on many contours.

Midalloy 3076

2519 Cassens Dr., St. Louis, MO 63026-2522
(636) 349-6000; FAX (636) 349-2240
www.midalloy.com

Midalloy will feature its stainless steel, nickel, and low-alloy welding consumables.

Miller Electric Mfg. Co. 4071/39029

PO Box 1079, Appleton, WI 54912-1079
(920) 734-9821; FAX (920) 735-4013
www.millerwelds.com

Miller will highlight its Millermatic 140 with auto-set and Spoolmate 100 series for GMA welding of aluminum, steel, and stainless steel. Also featured will be the XR-Aluma-Pro push-pull gun combined with the Millermatic® 350P or an XMT® 350 with an XR˙ control for aluminum welding, and the Dynasty® 350 GTAW inverter designed to increase productivity in heavy industrial applications. Additionally, Arc Armor Safety Apparel, a line of safety apparel that focuses on style, design, and comfort, will be spolighted.

Miyachi Unitek Corp. 6127

1820 S. Myrtle Ave.
Monrovia, CA 91017
(626) 303-6575; FAX (626) 599-7906
www.muc.miyachi.com

Miyachi Unitek will feature its laser welding machines, laser markers, and AC and inverter weld controls. The company will introduce its new PCB-1000 printed circuit board laser marker that permanently marks ceramic, plastic, and metal with logos, lot date, serial numbers, and other QA information.

MK Products, Inc. 2071

16882 Armstrong Ave..
Irvine, CA 92606-4975
(949) 863-1234; FAX (949) 798-1428
www.mkproducts.com

MK Products will showcase its Cobramatic® push-pull wire feed technology for aluminum welding, the Aircrafter tabletop rotary positioner, and orbital tube welding systems for sanitary, high-pressure, and ultra-high-purity applications.

Moldex Metric, Inc. 4098

10111 Jefferson Blvd.
Culver City, CA 90232-3509
(310) 837-6500; FAX (310) 837-9563
www.moldex.com

Moldex Metric will feature its hearing and respiratory protection products for industrial worker safety.

Motoman, Inc. 5017

805 Liberty Ln.
West Carrollton, OH 45449-2176
(937) 847-6200; FAX (937) 847-6277
www.motoman.com

Motoman will introduce two new six-axis SSA2000 and SSF2000 Super Speed welding robots designed to reduce welding cycle time 15%, the new ArcWorld C-500 compact workcell with a robot partially enclosed by a cylindrical safety enclosure that is integrated with the robot. The company will also feature the new MH1600-500TR positioner comprised of two standard headstock modules combined to provide flexible, AC servo-controlled tilt/rotate part positioning, the six-axis ES165N and ES200N Expert Spot welding robots designed to optimize spot welding performance, and the new IA20 Robot with 7-axis actuator-driven design.

MPT Industries 4100

6-B Hamilton Business Pk.
85 Franklin Rd., Dover, NJ 07801
(973) 989-9220; FAX (973) 989-9234
www.mptindustries.com

The company will showcase its lubricants that increase equipment life including chemical-resistant and oxygen-compatible thread sealants, multipurpose lubricants and greases, engine oil additive, gear oil additive, air tool oil, and assembly lube.

NanoSteel Co, The 36039

67 Cedar St., Ste. 101
Providence, RI 02903-1042
(401) 270-3549; FAX (401) 270-9306
www.nanosteelco.com

NanoSteel will showcase its high-strength, iron-based alloys. Its Super Hard Steel® (SHS) alloys form very small property-enhancing, nanometer-sized grain structures. SHS is designed for use with conventional processing and application equipment.

Nantong Free Mechantronic, Co. Ltd. 4157

B31 Yao Gang Rd.
Nantong City, Jiangsu, China 226006
86513-835-14986; FAX 86513-83552238
www.ntfree.com

Nantong Free Mechantronic will feature its lines of inverter welding machines and plasma arc cutting equipment. Included will be AC/DC GTAW, DC pulse GTAW, and GMAW machines, as well as plasma arc cutting machines and welding and cutting accessories.

Nation Coating Systems, Inc. 1102

501 Shotwell Dr., Franklin, OH 45005-4663
(937) 746-7632; FAX (937) 746-7658
www.nationcoatingsystems.com

Nation Coating systems will showcase its new coatings for all types of industrial applications, and discuss ways to improve products with thermal spraying.

Nation Wide Products/ Pipe-Pro Cutting Guides 37053

1301 S. Treadaway
Abilene, TX 79602
(325) 675-5062; FAX (325) 675-5053
www.nationwideproduct.com

Nation Wide Products will feature its line of Pipe-Pro cutting guides used to mark angles and saddles for pipe and tube cutting. All products come with a storage container, and private labels are available.

National Bronze & Metals, Inc. 7054

2929 W. 12th St., PO Box 800818
Houston, TX 77280-0818
(713) 869-9600; FAX (713) 869-2897
www.nbmmetals.com

National Bronze & Metals will showcase its line of brass, bronze, and copper alloys.

National Center for Advanced Manufacturing (NCAM) 36029

13800 Old Gentilly Rd., Bldg. 420, Rm. 200
New Orleans, LA 70129
(504) 257-0969; (504) 257-5458

NCAM (The National Center for Advanced Manufacturing) is a governmental/business/academic partnership located at NASA's Michoud Assembly Facility in New Orleans that promotes the use of advanced manufacturing technologies and research for industrial applications. NCAM's installed equipment includes a large-scale friction stir welding system with 6-axes of motion weld head and self-reacting pin tool technology. NCAM's other equipment includes several fiber placement (composites) machines as well as high-speed machining and NDE systems.

National-Standard Co. 4057

1631 Lake St., Niles, MI 49120-1270
(269) 683-8100; FAX (269) 683-6249
www.nationalstandard.com

National-Standard will display its Satin-Glide® stainless steel welding wire, Copper-Free® welding wires, inert gas control, and bulk packages for precise arc placement.

Nelson Stud Welding 5098

7900 W. Ridge Rd
Elyria, OH 44036
(440) 329-0400; FAX (440) 329-0492
www.nelsonstudwelding.com

Nelson Stud Welding will be conducting live demonstrations of its newest technology in stud welding equipment. The lightweight and portable N1500i inverter system is well suited for shipyards and construction job sites. The Nelweld line of equipment is designed for applications in the industrial and construction markets, while its capacitor dischage systems solve fastening problems in the light-gauge metal markets.

New Fire Co., Ltd. 36041

Rm 101, Lane 666 Hongqiao Rd.
Shanghai, 200030 China
86 -21-64479803; FAX 86-21-64480281
www.newfire.biz

New Fire will highlight its industrial thermal insulating, welding and cutting protection, and safety equipment.

Newland (Tianjin) Welding Wire & Metal Products Co. 39013

No. 7 Zifudao, Ziya Huanbao Industrial Pk.
Jinghai Cnty, Tianjin 301605, China
86-22-68711221; FAX 86-22-68711220

Ningbo East Machinery & Equipment Import & Export Corp. 1156

Rm 305, No. 17 Xiaowen St.
Ningbo 315010, China
86-574-8734-8251; FAX 86-574-8734-5492
www.eastwelding.com

Ningbo East will display its line of welding and cutting torches and pressure meters.

NLF Protective Products, Inc. 7055

3131 Cedar Cross Ct., Unit 4
Dubuque, IA 52003-7758
(563) 582-6488; FAX (563) 582-5570

NLF Protective Products will feature its line of welding/safety curtains, welding blankets/covers, portable safety screens, custom-fabricated roller curtain partitions, roll-up curtains, strip doors/curtains, noise control curtains, glove/hand protection, protective aprons and sleeves, thermal insulation pads, and heat- and flame-resistant fabrics.

Noise Barriers LLC 1108

1207 Remington Rd., Ste. E
Schaumburg, IL 60173
(847) 843-0500; FAX (847) 843-0501
www.noisebarriers.com


GeKa
GEDİK
WELDING TECHNOLOGY
"IT IS ALL ABOUT WELDING"
CE
TÜV CERT
RWTÜV
www.gedikwelding.com
GeKa
GeKaTeK
GEDİK Welding
in all fields of industry...
For Info go to www.aws.org/ad-index
SEE US AT THE FABTECH/AWS SHOW BOOTH #4127
GEDİK WELDING INC.
Ankara Caddesi No: 306 Seyhli 34913 Pendik - ISTANBUL / TURKEY
Tel: +90 216 378 50 00 (Pbx) Fax: +90 216 378 79 36 - 378 20 44
Web: www.gedikwelding.com E-mail: gedik@gedik.com.tr

Nordfab 1164
150 Transit Ave., PO Box 429
Thomasville, NC 27361-0429
(800) 532-0830; FAX (336) 889-7873
www.nordfab.com

Nordfab will feature Quick-Fit, clamp-together ducting that can convey wood dust, metal grindings, powder, plastic, dry concrete, smoke, carbon black, fumes, grains, wood chips, mists and hundreds of others. Also featured will be the company's Leak-Free Duct System that is appropriate for applications using a wet scrubber or mist collector. The company's Tuff Shield ducting product has a flame-sprayed RC60 abrasion coating on the inside. This coating increases the life of the ductwork when conveying highly abrasive material.

North American Safety Products 34053
9233 Gulfstream Rd., Frankfort, IL 60423-2516
(815) 469-1144; FAX (815) 469-2131
www.versa-guard.com

North Safety Products 6149
2000 Plainfield Pike
Cranston, RI 02921-2019
(401) 275-2440; FAX (401) 275-7560
www.northsafety.com

Norton Abrasives/Saint Gobain Abrasives 3021
1 New Bond St., PO Box 15008
Worcester, MA 01615-0008
(800) 962-9379; FAX (508) 795-5950
www.ind.nortonabrasives.com

Norton will showcase its extensive line of more than 6000 bonded, coated, and superabrasives to meet a wide range of price and performance requirements for grinding, cutting, blending, forming and finishing. The company can also help you engineer the most cost-effective nonstock abrasive solution for production runs on all types of materials.

Nova-Tech Engineering, Inc. 36031
20818 44th Ave W., Ste. 201
Lynnwood, WA 98036-7709
(425) 245-7000; FAX (425) 245-7099
www.ntew.com

Nova-Tech Engineering will offer its services as a designer and builder of complete friction stir welding (FSW) and aerospace tooling. The comany has more than 10 years of experience in building FSW machines, including tank, flat plate, and pipe welding machines, and custom retrofits of existing milling machines.

NSRW 7152
701 Thames Ct., Pelham, AL 35124-1926
(205) 663-1500; FAX (205) 663-3221
www.nsrw.com

NSRW will offer its capabilities to ensure weld process integrity and cost containment, engineering services, weld process verification, installation, and production support.

NTC America Corp 10107
46605 Magellan Dr.
Novi, MI 48377-2442
(248) 560-2154; FAX (248) 560-0215
www.ntclaser.com

NTC's Laser Group will feature its line of 3- and 5-axis laser beam cutting and welding systems. Laser powers are available from 2500 to 6000 W provided by PRC Laser, and Dimplex (Koolant Kooler) chillers offer additional reliability and performance. NTC is a full-service company supplying sales, service, and parts support for all of its laser products.

Nu-Tec Systems LLC 39020
4376 Lee Ave., Gurnee, IL 60031
(847) 662-8500; FAX (847) 662-9019
www.nu-tecsys.com

Ohio Nut & Bolt Co, The 2034
33 Lou Groza Blvd., Berea, OH 44017-1293
(440) 243-0200; FAX (440) 243-4006
www.on-b.com

Ohio Nut & Bolt will show its resistance weld fasteners, weld nuts, screws, pins, and adjusting screws. Inch and metric sizes in both low-carbon steel and stainless steel will be offered. Also, a standard line of levelers will be shown.

Ohio State University 37077
1248 Arthur E. Adams Dr.
Columbus, OH 43221-3560
(614) 292-4139; FAX (614) 292-6842
www.iwse.eng.ohio-state.edu/we/

OKI Bering 2017
9901 Princeton-Glendale Rd.
Cincinnati, OH 45246-1131
(513) 341-4002; FAX (513) 341-4903
www.oki-bering.com

OKI Bering will show its line of welding, safety, and industrial products. The company will provide information on its service throughout multiple industrial channels in North, Central, and South America, Europe, Middle East, and other world markets.

Olympus NDT 7056
48 Woerd Ave., Waltham, MA 02453-3824
(781) 419-3900; FAX (781) 419-3980
www.olympusndt.com

Olympus NDT will showcase its portfolio of ultrasonic testing, phased array, eddy current, eddy current array, and related technologies. Its brands include R/D Tech, Panametrics-NDT™, NDT Engineering, Sonic, and Nortec.

O. R. Lasertechnology, Inc. 8095
1420 Howard St.
Elk Grove Village, IL 60007-2221
(847) 593-5711; FAX (847) 593-5752
www.orlaserwelding.com

O. R. Lasertechnology will features its laser welding process, which makes it possible to treat precision components of all conventional types of mold and tool steel, aluminum alloys, beryllium-copper, and even exotic materials such as CuZn alloys.

Orbitalum Tools GmbH 4084
15 Goodyear St., Irvine, CA 92618
(949) 951-1515; FAX (949) 544-7988
www.orbitalum.com

Orbitalum Tools will exhbit its line of pipe and tube cutting, facing, and beveling machines. Featured will be its new generation of lightweight tube cutting and facing tools, as well as bench mounted and portable-type pipe or tube facing and pipe beveling machines.

ORS NASCO 3095
2348 E. Shawnee Rd.
Muskogee OK 74403-1423
(918) 687-5441; FAX (918) 682-5936
www.orsnasco.com

ORS Nasco will features its line of welding, safety, and industrial supplies.

Oskar Air Products 5124/2074
95 Cypress Dr., Youngsville, NC 27596
(919) 562-7181; FAX (919) 562-7182
www.oskarairproducts.com

Oskar Air Products will feature its welding smoke and fume extraction arms, small-size filtering units, and other fume exhaust equipment. Introduced at the show will be the SPC-230, a lightweight hand-held portable fume collector; the SPC-1200, a state-of-the-art portable fume collector that filters fume or smoke from oily metals; and the SDT-600, a portable downdraft table with filtration.

Osram Sylvania, Inc. 1101
100 Endicott St., Danvers, MA 01923-3782
(978) 777-1900; FAX (978) 750-2152
www.sylvania.com

Osram Sylvania's Tungsten and Powders Div. produces tungsten, tungsten carbide, molybdenum, and cobalt powder products. Featured will be Syl-Carb™ tungsten carbide powders, Powder Perfect™ thermal spray powders, and high green strength tungsten powders for a number of applications and manufacturing processes. The company produces tungsten and molybdenum ingots, billets, plate, sheet, and wire.

OTC Daihen, Inc. 4047
1400 Blauser Dr., Tipp City, OH 45371-2471
(937) 667-0800; FAX (937) 667-0885
www.daihen-usa.com

OTC Daihen will feature the AX-2PF series of tilt-turn positioners, which feature heavier working payloads (300 kg/661 lb and 500 kg/1102 lb payloads) than older models. It also operates with tilting speeds up 2.5 times faster, and rotating speed 2 times faster.

Owosso Automation, Inc. 2102
503 S. Chestnut St., PO Box 488
Owosso, MI 48867-0488
(989) 725-8804; FAX (989) 725-8719
www.owossoautomation.com

Oxford Alloys, Inc. 2146
2632 Tee Dr., Baton Rouge, LA 70814-4913
(225) 273-4800; FAX (225) 273-4814
www.oxfordalloys.com

Oxford Alloys will showcase its broad range of welding wire and electrodes. The company's products include a complete line of corrosion-resistant alloys including nickel, stainless steel, and titanium. It also stocks mild and low-alloy steel, aluminum bronze, silicon bronze, deox copper, and aluminum.

Oxylance Corp. 3163
2501 27th St. N., Birmingham, AL 35234-1225
(205) 322-9906; FAX (205) 322-4808
www.oxylance.com

Oxylance will highlight its cutting systems designed for heavy demolition, fire and rescue, underwater construction, and equipment repair.

PacMont, Inc. **4141**
18855 Chessington Pl.
Rowland Heights, CA 91748-4969
(626) 839-1443; FAX (626) 964-0158

PacMont will display its autodarkening lenses and helmets, and cutting/grinding disks.

Panasonic Factory Solutions Co. **2047**
909 Asbury Dr., Buffalo Grove, IL 60089-4525
(847) 495-6100; FAX (847) 495-6094
www.panasonicfa.com

Panasonic Factory Solutions will exhibit its line of arc welding robots, power sources, and pre-engineered work cells. Industries served include automotive and its subcontractors, farm and heavy equipment, over-the-road vehicles, general metal fabrication, and job shops.

Pandjiris, Inc. **7047**
5151 Northrup Ave., St. Louis, MO 63110-2031
(314) 776-6893; FAX (314) 776-8763
www.pandjiris.com

Pandjiris will showcase its line of positioners, grippers, turning rolls, manipulators, slides and swivels, seamers, sidebeams and carriages, headstocks and tailstocks, turntables, and 3 o'clock welding machines. The company will also offer its engineering expertise for turnkey welding systems designed and manufactured to meet the needs of industry.

Pangborn Corp. **8039**
580 Pangborn Blvd.
Hagerstown, MD 21742-4152
(301) 739-3500; FAX (301) 739-0566
www.pangborn.com

Pangborn will highlight its line of surface preparation equipment and related accessories and services.

Parker domnick hunter **1099**
5900-B Northwoods Pkwy.
Charlotte, NC 28269
(800) 345-8462; FAX (704) 921-1960
www.domnickhunter.com

Parker domnick hunter will exhibit its Hyperchill-TS thermal spray process chiller, which can handle plasma spray, HVOF, or both. The TS version encompasses nonferrous circuits, high-pressure stainless steel pumps, compressed air blow back and water flow regulation with visual flow indication.

Parker Hannifin Corp. **1041**
6035 Parkland Blvd., Cleveland, OH 44124-4141
(216) 896-2185; FAX (216) 896-4009
www.parker.com

Parker will exhibit its weld control solutions, which consists of cylinders, valveblocks, fluid connector products, and air/water preparation. The cylinders have two, three, or four ports depending on the welding requirements to actuate an X- or C-type pneumatic weld gun.

Pat Mooney, Inc. **21095**
502 S. Westgate St., Addison, IL 60101-4525
(630) 543-6222; FAX (630) 543-5584

Friction sawblades for tube mills with new coating. Allows longer use with less cracking FMB direct drive precision mitre band saws.

Permadur Industries, Inc. **7057**
186 Rt. 206, Hillsborough, NJ 08844-4123
(908) 359-9767; FAX (908) 359-9773
www.permadur.com

Permadur will feature its permanent lifting magnets, custom-built magnets, and vacuum systems to support plate loading and multiple part/skeleton offloading and individual cut part handling associated with oxyfuel, plasma, and laser cutting systems.

PFERD, Inc. **5106**
30 Jytek Dr., Leominster, MA 01453-5932
(978) 840-6420; FAX (978) 840-6421
www.pferdusa.com

PFERD and PFERD/Advance Brush Co. will highlights its extensive product range, which includes more than 9000 surface finishing, cutting, and power tools. Hundreds of products will be demonstrated.

Phoenix International, Inc. **4130**
8711 W. Port Ave., Milwaukee, WI 53224-3429
(414) 973-3400; FAX (414) 973-3241
www.phx-international.com

Phoenix will feature its high-temperature Type 300 oven, created to accommodate many electrode manufacturers' high-temperature holding requirements and store 350 lb of electrodes. The company will also feature its line of DryRod® and dryWIRE® ovens for holding, reconditioning, and rebaking welding electrodes, and the Safetube®, a watertight, durable container for maximum protection of electrodes.

Plasma Automation, Inc. 3036
1801 Artic Ave., Bohemia, NY 11716-2413
(631) 563-7634; FAX (631) 563-7239
www.plasma-automation.com

Plasma Automation will demonstrate its Vicon Elite precision plasma cutting system and its new ViSoft cutting software program for Windows®. Featured will be the Vicon Monarch plasma cutting system, which offers a unitized, one-piece table frame with heavy-duty slat design and I-beam construction that allows versatile cutting of sheet metal, structural steel, I-beams, square or rectangular tubing, angle iron, flat plate, channel, and fixturing. The Fabricator, Edge King High Density, and Water Table Systems will also be featured.

PlymoVent Corp. 1155
115 Melrich Rd., Cranbury, NJ 08512-3512
(800) 644-0911; FAX (609) 655-0569
www.plymovent.com

PlymoVent will show its complete metalworking smoke, fume, dust, and mist capture and removal systems. Systems are available from a simple one station setup to multiple station systems with automatic controls to enhance efficiency and maximize energy conservation.

Polymet Corp. 1095
10073 Commerce Park Dr.
Cincinnati, OH 45246-1333
(513) 842-1119; FAX (513) 874-2880
www.polymet.us

Polymet, a manufacturer of high-performance welding, hardfacing, and thermal spray wire, will offer a wide range of iron-, nickel-, cobalt-, aluminum-, or copper-based alloys for the aerospace, automotive, mining, lumber, nuclear, land-based turbines, power-generating, and cement industries. The company's manufacturing capabilities include hot extruded wire processing, rolling, drawing, and alloy cored wire fabrication.

Powerweld, Inc. 7050
3635 W. Ridge Rd., Unit C
Gary, IN 46408-1841
(800) 826-9073; FAX (888) 684-3759
www.powerweld.net

Powerweld will exhibit a wide variety of its manual arc welding accessories, gas welding and cutting apparatus, PPE safety equipment, and welding filler metals. The Parweld range of GMAW guns and GTAW torches, including the Ergo-Tig range of fully functional torches, will be displayed.

Praxair, Inc. 5095
39 Old Ridgebury Rd., Danbury, CT 06810-5109
(800) 772-9247; FAX (800) 772-9985
www.praxair.com

Praxair will feature its welding and cutting solutions both automated and manual. Its laser gas systems, the ProStar brand of quality products, Star family of gases, dry ice blasting, the company's Express e-business solution, and its StarSolver simulator software will also be featured.

Praxair Surface Technologies 1110
1555 Main St., Indianapolis, IN 46224-6539
(317) 240-2650; FAX (317) 240-2596
www.praxair/.com/thermalspray

Praxair Surface Technologies will showcase its complete line of thermal spray materials and equipment. Products include carbide, metallic and ceramic powders, wires, and spare parts complemented by the company's plasma, HVOF, and arc spray equipment.

Preco, Inc./Laser Group 7111
500 Laser Dr., Somerset, WI 54025-9774
(715) 247-3285; FAX (715) 247-5650
www.precoinc.com

Preco will provide information on its standard and custom laser beam welding, cladding, and heat-treating systems and services. The company's applications knowledge includes hybrid laser welding, deep-penetration welding, wire feed welding, laser brazing, and seal-face cladding. Capabilities include laser technology (with lasers up to 12 K), robotics, automation, and fully staffed metallurgical and quality labs.

Preston-Eastin, Inc. 2095
PO Box 582288, Tulsa, OK 74158-2288
(918) 834-5591; FAX (918) 834-5595
www.prestoneastin.com

Preston-Eastin will show its motion control and positioning equipment for the welding industry. Its standard products include positioners, turning rolls, head and tailstocks, turnta-


"Welders Choice for Quality"
SINCE 1981
Cutting Guides
Small Degree Level
NEW
Centering Heads
Pocket Pro Level
Miter Marker
Pipe Wraps
Master Miter Marker
flange wizard® tools
Contact Your Local Welding Supplier
MADE IN THE U.S.A
Visit us at the 2007 AWS Welding Show in Chicago - Booth #2017.
For Info go to www.aws.org/ad-index
www.flangewizard.com

bles, manipulators, and accessories. The company also manufactures equipment used in robotic applications, and can design and build custom equipment for special applications. Its experienced sales staff will be available to assist visitors with their requirements.

Primax Mfg. & Trading, Inc. 37042
9078 Rosecrans Ave., Bellflower, CA 90706-2038
(562) 272-2762; FAX (562) 272-2761
www.caimangloves.com

Primax will exhibit its new glove designs, Revolution™ and Kontour™, which combine fine materials, style, dexterity, comfort, and safety. A new line of premium Boarhide™ welding apparel will also be shown.

Process Equipment Co. 36043
4191 U.S. Rt. 40., Tipp City, OH 45371-9283
(937) 667-7105; FAX (937) 667-2591
www.peco-us.com

Process Equipment will provide information on its turnkey manufacturing equipment and its knowledgeable engineering and assembly teams. Its products include welding systems, gear measurement systems, inspection machines, marking systems, robotic end-effectors, robotic automation, special machines, assembly automation, build-to-print machines/tooling and eddy current testers. Services include production CD and laser welding, large part machining and fabrication, and precision grinding.

Profax/Lenco 5087
PO Box 898, Pearland, TX 77588-0898
(281) 485-6258; FAX (281) 485-6925
www.profax-lenco.com

Profax will feature its GMA, flux core, submerged arc welding equipment, guns, and consumables; arc gouging torches, and carbons; GTA torches, spool guns; replacement plasma torches and consumables; wire feeders; and repair parts for most major brand power sources and feeders. Lenco will feature its welding accessories including electrode holders, ground clamps, cable connectors, cable ligs, and chipping hammers. It also furnishes rod ovens and automotive spot welding machines.

Progressive Systems, Inc. 3029
701 Mayde Rd
Berea KY 40403-9723
(859) 985-1776; FAX (859) 986-7423
www.prorobots.com

Welding Solutions will introduce its Super-MIG™ hybrid welding system, which combines two reliable standard welding processes, plasma arc and gas metal arc, into one hybrid process. The company offers weld consulting, process development, and prototype welding applications. It develops specific welding applications to suit customers' needs in the automotive, tube/pipe fabrication, general industry, and defense industries.

ProMotion Controls, Inc. 1085
1484 Medina Rd., Ste. 118
Medina, OH 44256-8116
(330) 721-1464; FAX (330) 239-1531
www.promotioncontrols.com

ProMotion Controls specializes in shape-cutting controls and associated products with advanced intelligence for shape-cutting processes such as oxyfuel, plasma, and waterjet. The company is introducing iControl enhancements and innovations, and intelligent new software options. The company's new AC iDrives are available in two- or three-axis configurations and fit easily inside any ProMotion iCNC®. They can accommodate smaller shape-cutting machines to the biggest frames in the industry.

PTR-Precision Technologies, Inc. 37046
120 Post Rd., Enfield, CT 06082-5690
(860) 741-2281; FAX (860) 745-7932
www.ptreb.com

PTR-Precision Technologies will feature electron beam welding. It builds new systems of all sizes and provides service and retrofits for the systems it built under the name of its predecessors, Hamilton Standard and Leybold. In addition, it offers EB welding experience on a contract welding basis.

Pyro Shield, Inc. 37036
870 N. Madison St., Crown Point, IN 46307-8212
(219) 661-8600; FAX (219) 661-8612
www.pyroshield.com

Pyro Shield will display its high-temperature silica insulation products, fabricated insulation pads, insulation roll goods, welding protection,and furnace liners

Quality Welding Products, Inc. 2033
PO Box 60476, King of Prussia, PA 19406
(610) 783-0295; FAX (610) 783-0446
www.qwpinc.net

QWP will exhibit new products/methods to pickle and passivate stainless steel/nickels. It will also display its new isojet zinc system (The Galvinator) for resurfacing metal with zinc electrochemically. The product resurfaces metal with zinc electrochemically after the surface has been damaged. Staff will be on hand to answer questions about pickling and passivation of stainless steel, and to discuss pickling applications. It will also features its new Backing Flux for stainless steel GTAW.

Radyne Corp. 8035
211 W. Boden St., Milwaukee, WI 53207-6277
(414) 481-8360; FAX (414) 481-8303
www.radyne.com

Radyne will feature its induction heating systems for heat treating, brazing, soldering, shrink fitting, wire and pipe heating and coating, power integrated and segregated systems, complete system design, build, and service. Demonstrations of induction heating will be given.

Rasco Mfg. 4105
11674 Darryl Dr., Baton Rouge, LA 70815-2137
(225) 273-3163; FAX (225) 273-3176
www.rascodist.com

Rasco will display its line of work, welding, and fire-retardent clothing.

Ray Murray, Inc. 37041
50 Limestone Rd., Lee, MA 01238
(413) 243-9482; FAX (413) 243-4211
www.raymurray.com

Retro Systems LLC 6131
430 W. Clay St., Valley Center, KS 67147-2247
(316) 755-3683; FAX (316) 755-1675
www.retroplasma.com

Retro Systems will highlight its CNC plasma arc profile cutting machines. Two machines will be available to demonstrate the speed, accuracy, and ease of operation.

Revco Industries, Inc. (Black Stallion) 4118
10747 Norwalk Blvd., Santa Fe Springs, CA 90670-3823
(800) 527-3826; FAX (800) 527-7587
www.blackstallion.com

Revco Industries, a manufacturer and importer of Black Stallion protective gloves and apparel, will be offering a variety of gloves and garments for the welding and industrial markets. A full line of welding gloves, leather palm, drivers, fire retardant and protective clothing, fire blankets, and welding screens will be featured.

Rex-Cut Products Co. 8058
960 Airport Rd., PO Box 2109
Fall River, MA 02722-2109
(800) 225-8182; FAX (800) 638-8501
www.rexcut.com

Rex-Cut will exhibit its cotton fiber and specialty abrasive products for use on stainless steel, aluminum, mild steel, and exotic alloys and materials, as well as other products designed for grinding, cutting, and blending. Featured will be the Sigma Screen, an abrasive mesh screen designed for flexible grinding, blending, and sanding on a wide variety of metals, composites, and wood; and Megabrite Fusion interleaf flap discs that have both coated and nonwoven flaps designed for blending and finishing in one step. Megabrite T27 finishing flap discs are nonwoven flap discs designed for surface conditioning applications.

RoMan Manufacturing, Inc. 6070
861 47th St. SW., Grand Rapids, MI 49509-5103
(616) 530-8641; FAX (616) 530-8953
www.romanmfg.com

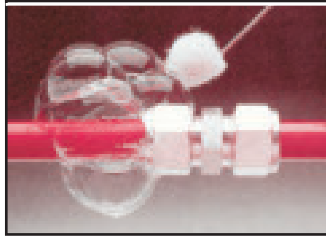
RoMan Mfg. will display its line of improved resistance welding transformers as well as MFDC power supplies. RoMan Engineering Service (RES) will be in the booth to discuss the products and services it provides. RES offers a state-of-the art metallurgical laboratory, in-plant consultants, and numerous testing capabilities. Featured will be the ultra-lightweight MFDC inverter power supply.

rose plasic USA, LP 5156
525 Technology Dr., Coal Center, PA 15423-1053
(724) 938-8530; FAX (724) 938-8532
www.rose-plastic.com

rose plastic will detail its line of more than 3000 types and sizes of packaging, designed and manufactured to be sturdy, versatile, and ecomomical. Products are made of durable, recyclable polyethylene, polyproplylene, and PVC providing protection from dampness and physical impact during shipment and storage.

FREE WELDING CHEMICAL PRODUCT SAMPLES

- OXYGEN COMPATIBLE
- MILITARY CERTIFIED
- FULL RANGE OF SIZES



- DAUBER APPLICATORS
- OXYGEN COMPATIBLE
- TWO TEMPERATURE RANGES

- STANDARD & REGULAR GRADES
- AEROSOL & BULK SIZES
- SOLVENT & WATER WASHABLE

- SOLVENT BASED
- WATER BASED
- AEROSOL & BULK SIZES

- PREMIUM QUALITY
- PLASTIC & METAL CONTAINERS
- PRIVATE LABEL AVAILABLE

- PRE-TREATED PADS
- NON-TREATED ALUMINUM PADS
- BULK LUBRICANT

- FIVE TEMPERATURE RANGES
- OSHA EXEMPT FORMULAS
- 1 GALLON, 5 GALLON AND DRUM SIZES

- OXYGEN CYLINDER CLEANER
- ALUMINUM CLEANER

Now celebrating our 25th anniversary, Cantesco Corporation continues its role as a leading ISO 9001:2000 registered welding chemical manufacturer world wide. As a single source supplier, Cantesco provides high quality welding chemical products including leak detection compounds, gas leak detectors, cold galv sprays, dye penetrants, anti-spatters, nozzle tip dip, wire lube pads, cooling fluids, cylinder cleaner and aluminum cleaners from one vendor!

For a complete product binder, free samples or technical information call us directly or visit us on the web at www.cantesco.com.

CANTESCO CORPORATION

WELDING PRODUCTS DIVISION

023 - 60 INDUSTRIAL PARKWAY, CHEEKTOWAGA, NY 14227 • (PH) 716-693-8206 • (FAX) 716-693-8373 • EMAIL SALES@CANTESCO.COM

RWMA - Resistance Welding Manufacturing Alliance **38003**
550 NW LeJjeune Rd., Miami, FL 33126-5649
(800) 443-9353; FAX (305) 442-7451
www.aws.org/rwma

RWMA is a standing committee within the American Welding Society. Since 1935, it has been the authoritative source of information and experience for the resistance welding industry. It offers a host of benefits to its members. At its booth, visitors can meet with members who will discuss any technical questions dealing with the resistance welding process.

Saf-T-Cart **3037**
1322 Industrial Park Dr., PO Box 1869
Clarksdale, MS 38614-7869
(662) 624-6492; FAX (662) 627-1640
www.saftcart.com

Saf-T-Cart will display and demonstrate its line of cylinder carts, cages, medical carts, pallets, and cradles. The company specializes in solving cylinder handling problems. Products range from e cylinders to cylinder trailers, as well as carts for welding machines, including trailers for gas drives.

Sahajanand Laser Technology Ltd. **32035**
41 New York Tower-A; SG Hwy. Thaltej
Ahmedabad Gujarat 380054, India
91-79-2685 4537; FAX 91-79-2685 4539
www.sahajanandlaser.com

Sahajanand Laser Technology will display fiber laser cutting systems with linear drives. Featured will be its Brahmastra F Series fiber laser cutting system for precision sheet metal fabrication, which offers fast, deep cutting capabilities with rapid warmup time, a small footprint, low operating cost, and maintenance-free operation.

Saint Louis Metallizing **1098**
4123 Sarpy Ave., St. Louis, MO 63110-1796
(314) 531-5253; FAX (314) 531-4706
www.stlmetallizing.com

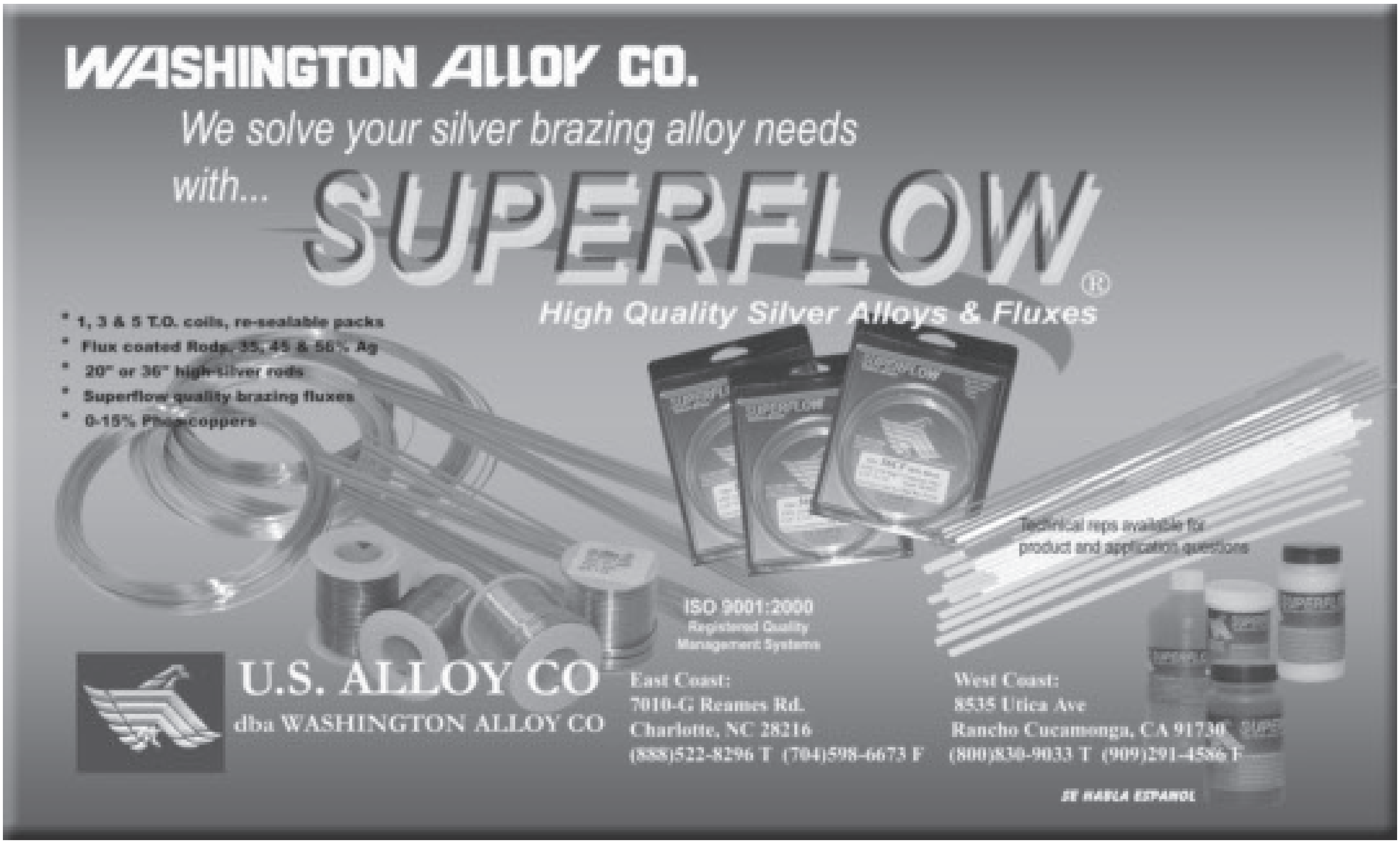
Sandvik Materials Technology **5148**
PO Box 1220, Scranton, PA 18501-1220
(570) 585-7691; FAX (570) 585-7686
www.smt.sandvik.com

Sciaky **38029**
4915 W. 6th St., Livonia, MI 48150-1733
(708) 594-3800; FAX (708) 594-9213
www.sciaky.com

Sciaky will display its latest electron beam welding technology. The new NG1 is an advanced electron beam welding machine, which features state-of-the-art controls, rapid pump-down times, reduced footprint, and an array of new capabilities. Also on display will be the company's exclusive Electron Beam Free Form Fabrication (EBFFF) process, a robust, fully programmable means of achieving near-net-shape parts ready to undergo final machining.

Secoa Technology **7155**
205 Bear Creek Rd., Dalton, GA 30721-4836
(706) 272-0133; FAX (706) 272-0135
www.secoatech.com

Secoa Technology will showcase its wide range of functional coatings and platings, including wet coatings, powder coating, fluidized bed, metallizing, hard anodizing, and nonstick. Featured will be Diamonite™ CR



and Polished Diamonite. Diamonite is an electroless plating process that offers hardness of 72–74 RC with very low frictional properties. Diamonite CR offers corrosion resistance beyond 1000 hours salt spray.

Sellstrom Mfg. Co. 4095

1 Sellstrom Dr., Palatine, IL 60067-6288
(847) 358-2000; FAX (847) 358-8564
www.sellstrom.com

Sellstrom will exhibit a wide variety of personal protective equipment including welding helmets, filters, goggles, eyewear, and fall protection.

Servo Robot Corp. 2054

1370 Hocquart
St. Bruno, QC J3V 6E1, Canada
(450) 653-7868; FAX (450) 653-7869
www.servorobot.com

Servo Robot will exhibit the SENSE-i/D sensor, a laser-based, precision depth-sensing system for factory automation. It is a modern, fast, and reliable replacement for robotic "touch sensing" systems. Also featured will be the ROBO-PAL, a noncontact digital part locator and measurement system designed to increase industrial process reliability and to reduce manufacturing costs, and the SF/D robotic laser profiling sensor, a noncontact joint/part locator and also a precise measurement system designed to improve the precision of robotic processes for various manufacturing applications.

Shanghai Gonglue Machinery & Elect. Tech. Co. Ltd. 4144

Rm. 1302, No. 14, Lane 1673
Zhangyang Rd.
Shanghai 200135, China
86-21-5821-1886; FAX 86-21-5821-6371
www.xunweld.com

Gonglue will showcase its line of agglomerated fluxes and wires for welding heat-, fire-, and weather-resistant steel; low-temperature service steel; stainless steel; and nickel alloy material. The company also produces flux and strip for cladding stainless steel and nickel-based alloys. In addition, it manufactures fluxes and wires for submerged arc, electroslag, high-speed, and one-side welding processes.

Shanghai Hugong Electric Welding Machine Mfg. Co. Ltd. 36023

7177 Waigingsong Rd., Qinypu District
Shanghai 210700, China
8621-69729166; FAX 8621-69715399
www.gugong.com

Shanghai Wtl. Welding Equipment Mfg. Co. Ltd. 1081

No. 33, Lianlin Rd., Pudong
Shanghai 201204, China
8621-689-23300; FAX 8621-504-29799
www.wtl.com.cm

The company will exhibit its line of GMA and GTA welding machines.

Shenzhen Jasic Technology Development Co. Ltd. 1151

C4 Bldg. Hengfeng Industrial
Hezhou Xixiang Basan Dist.
Shenzhen 518126, China
86 -755-27474398; 86 -755-27364308

Shenzhen Jasic will exhibit its line of inverter welding machines and cutting equipment, which includes 9 series and more than 60 models.

Sherwin, Inc. 4128

5530 Borwick Ave., South Gate, CA 90280-7402
(562) 861-6324; FAX (562) 923-8370
www.sherwininc.com

Sherwin will show its line of welding inspection penetrant materials. The line includes high-temperature penetrant, cleaner, and developer; water-washable penetrants; fluorescent penetrants; and magnetic particle materials.

Shield Technologies 37028

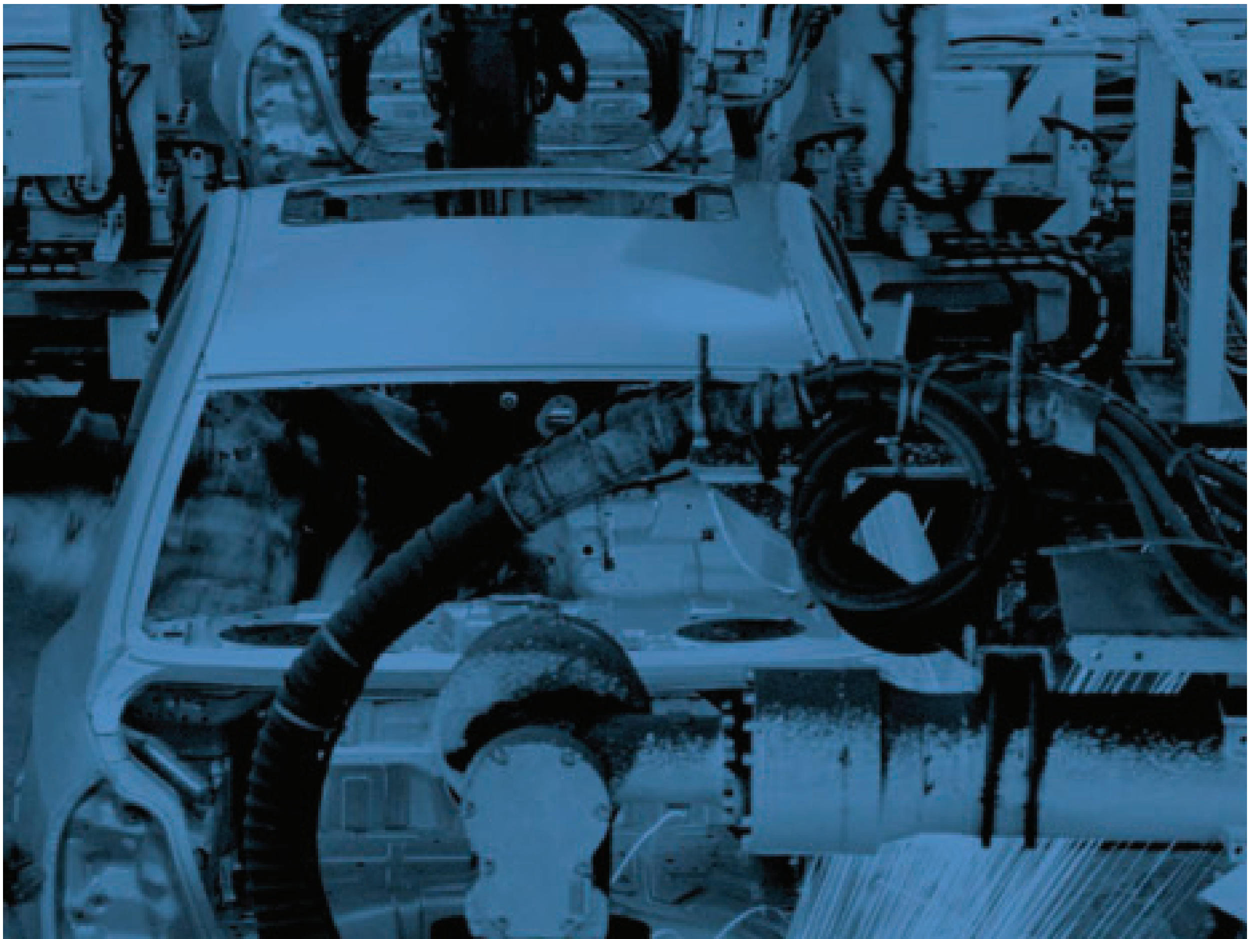
54 Marion Place Dowerglen
Edenvale 1609, South Africa
27-11-453 7152; FAX 27-866-11 2401
www.shieldtechnologies.co.za

Shield Technologies will display the Shielding Gas Economiser, which reduces shielding gas wastage attributed to pressure buildup in supply hoses. The lockout feature prevents tampering with the preset gas flow rate. The system substantially reduces surging and lessens the potential for the formation of weld start porosity created by excessive turbulence at the nozzle opening. Also featured will be Spatter Guard, which prevents spatter adherence.

SmartTCP, Inc. 3141

26602 Haggerty Rd., Farmington Hills, MI 48331
(248) 994-1041; FAX (248) 994-1042
www.smarttcp.com

SmartTCP will introduce its automatic welding solution for complex fabrications in small-batch



production. The company's gantry welding system is a turnkey solution that includes hardware, software, installation, training, and support.

Smith Equipment 4078
2601 Lockheed Ave., Watertown, SD 57201-5636
(800) 843-7912; FAX (605) 882-2100
www.smithequipment.com

Smith Equipment will show its new Series 30 regulators, flowgauges, and flowmeter regulators, which are built for extended service life and accurate outlet flows and pressures. The company's new Sure Seat technology keeps debris from entering the high-pressure seat, protecting it from damage.

Soutec Soudronic 2150
46956 Liberty Dr., Wixom, MI 48393
(248) 896-9401; FAX (248) 896-9433
www.soutec.com

Soutec Soudronic will highlight its laser beam and resistance welding equipment, which it supplies to a variety of industries. Applications for the company's welding machines and equipment include tailored blanks, laser welded tubes, exhaust gas components, fuel tanks, filters, airbag housings, tubular components for heating, ventilation, and air conditioning.

Southern Copper & Supply Co. 8050
875 Yeager Pkwy., Pelham, AL 35124-1846
(205) 664-9440; FAX (205) 664-1365
www.southerncopper.com

Southern Copper & Supply will exhibit its resistance welding supplies and copper alloys.

Spanco, Inc. 2167
604 Hemlock Rd., Morgantown, PA 19543-9710
(610) 286-7200; FAX (610) 286-0085
www.spanco.com

Spanco will features its ergonomic enclosed track workstation cranes in capacities from 100 lb to 2 tons, workstation and I-beam jib cranes, portable and motorized gantry cranes, articulating jib cranes, and fall arrest track systems.

Special Metals Welding Products Co. 5071
1401 Burris Rd., Newton, NC 28658-1754
(800) 624-3411; FAX (828) 464-8993
www.specialmetalswelding.com

Special Metals will show its nickel-based welding consumables for joining nickel alloys, high-performance steels, cast irons, and dissimilar metals as well as overlaying on steel for corrosion or erosion protection. Products are sold under the brand names such as INCONEL, MONEL, INCO-FLUX, and INCO-WELD.

Stanco Manufacturing, Inc. 5128
2004 W. Main St., PO Box 1148
Atlanta, TX 75551-1148
(903) 796-7936; FAX (903) 796-9237
www.stancomfg.com

Stanco will showcase its line of welding, work, and high-temperature gloves and mittens, protective clothing and safety accessories; available with printing, labeling, and bar coding for self-service store needs. The target markets are welders and steel mill, foundry, and chemical plant workers. The products are made from heat- and abrasion-resistant materials such as leather, Kevlar, Nomex, fiberglass, and other flame resistant fabrics, and are designed for worker comfort and safety.

Standard Resistance Welder Co. **3122**
7833 Conners Rd., PO Box 268
Winston, GA 30187-0268
(770) 949-2479; FAX (770) 489-1826
www.srwelder.com

Standard Resistance Welder will exhibit its resistance spot, seam, flash, protections, and bench welding machines; portable gun welding machines; special multispot, projection, and seam welding machines; special fixtures and transfers; automated arc welding fixtures; assembly-type welding machines; wire forming equipment; and welding consumables.

SteelTailor Portable CNC Cutting Machine **38023**
Cannes Industrial Park
No. 18, Shuangqiao East Rd.
Chaoyang Dist., Beijing 100024, China
86-10-51662600; FAX 86-10-85370386
www.steeltailor.com

SteelTailor will display its portable CNC cutting machine that can cut profiles designed with the company's software. It supports both oxyfuel and plasma cutting.

Steiner Industries **7039**
5801 N. Tripp Ave., Chicago IL 60646-6013
(800) 621-4515; FAX (773) 588-3450
www.steinerindustries.com

Steiner Industries will display its high-quality welding and industrial safety products. The product line includes general welding, GTAW, GMAW, work, driver's, and mechanic's gloves; leather and flame-retardant cotton clothing; and welding blankets, screens, and curtains.

Stellite Coatings **7116**
1201 Eisenhower Dr. N.
Goshen, IN 46526-5311
(574) 533-3322; FAX (574) 534-3417
www.stellite.com

Stellite Coatings will present its high-quality wear- and corrosion-resistant products of STELLITE® and DELORO® alloys available as castings, rods, powders, and wires plus equipment for hardsurfacing applications. It can also offer castings, wrought products, P/M and hardsurfaced components.

Strong Hand Tools **2117/2121**
7141 Paramount Blvd., Pico Rivera, CA 90660-3769
(562) 949-8625; FAX (562) 949-4875
www.stronghandtools.com

Strong Hand Tools will display its line of welding clamps, magnets, and pliers. Featured will be the new JointMaster™ angle pliers and fixtures, which can quickly and easily clamp round pipes or flat stock at right angles, corners, and T-Joints. The floating head clamps workpieces up to 1 in. thick. The new NOMAD™ tilting, slotted welding table features fully adjustable height and accepts a wide variety of clamps.

Suhner Industrial Products Corp. **35059**
100 Anderson Rd. SW, Rome, GA 30161
(706) 235-8046; FAX: (706) 235-8045
www.suhner.com

Suhner will provide information on its hands-on technical training and problem solving for all grinding, polishing, and material finishing applications. The company will feature a wide range of flexible shaft, electric, and pneumatic tools and abrasives for all material grinding and finishing.

Sulzer Metco (US), Inc. **1094**
1101 Prospect Ave., Westbury, NY 11590-2724
(516) 338-2422; FAX (516) 338-2414
www.sulzermetco.com

Sulzer Metco will showcase its advanced thermal spray materials, integrated systems, and equipment for all thermal spray processes; specialized coating and surfacing services; high-quality braze and weld hardfacing materials; and global customer support services.

Sumner Mfg. Co., Inc. **1063**
7514 Alabonson Rd., Houston, TX 77088-4036
(281) 999-69008; FAX (281) 999-6966
www.sumner.com

Sumner will highlight its pipe handling equipment, line of material lifts, wire and storage carts, work tables, and electrician equipment.

Sunstream Scientific **38042**
2149 W. LeLand, Chicago, IL 60625
(773) 728-8852; FAX (773) 728-8852
www.sunstreamsci.com

Superheat FGH Services, Inc. **7000**
RR #1, 1463 Hwy 21
Kincardine ON N2Z 2X3, Canada
(519) 396-1324; FAX (519) 396-6722
www.superheatfgh.com

Superheat FGH Services will feature its on-site heat treatment and temperature control systems and services. The company speciales in large plant turnarounds, new plant construction, fabrication, and advanced nuclear projects. The systems feature advanced wireless technology.

Superior Abrasives, Inc. **32034**
4800 Wadsworth Rd., Dayton, OH 45414-4224
(937) 278-9123; FAX (937) 278-7581
www.superiorabrasives.com

Superior Products, Inc. **2094**
3786 Ridge Rd., Cleveland, OH 44144-1127
(216) 651-9400; FAX (216) 651-4071
www.superiorprod.com

Superior Products will show its line of compressed gas fittings, assemblies, and manifold systems for the welding, medical, and specialty gas markets. The company Technical Information Team will be available to work with you to develop a manifold system to improve your compressed gas delivery.

Team Industries, Inc. **2162**
1200 Maloney Rd., Kaukauna WI 54130-4112
(920) 766-7977; FAX (920) 766-0486
www.teamind.com

Team Industries will show its Generation IV 4000-lb elevating weld positioner that features variable height control, custom throughhole purge system, wireless foot control, and serrated jaws. The company's products are designed and built by pipe fabricators for pipe welding. Also on display will be the Model WEH 3000-lb welding positioner and gripper.

TEC Torch Co., Inc. **8062**
PO Box 1870, San Marcos, CA 92079-1870
(760) 747-3700; FAX (760) 747-2121
www.tectorch.com

Techalloy Co., Inc. **3146**
2310 Chesapeake Ave., Baltimore, MD 21222-4098
(800) 638-7111; FAX (410) 633-2033
www.techalloy.com

Techalloy will show its line of stainless steel and nickel alloys in solid wire forms and electrodes.

TECMEN Electronics Co. Ltd. 4146
Bldg D-B, No. 21 N. Liuzhou Rd.
XiaoLiu Indusry Park, Nanjing 210031, China
86-25-85551955; FAX 86-25-85551933
www.tecmen.cn

TECMEN will display its autodarkening welding helmets. The products confirm to the ANSI Z87.1 standard and also meet CSA and CE standards for use in Canada and Europe.

Tempil, Inc. 4086
2901 Hamilton Blvd., South Plainfield, NJ 07080-2517
(908) 757-8300; FAX (908) 757-9273
www.tempil.com

Tempil will feature its TEMPILSTIK quality temperature-indicating products.

Tennessee Rand Co. 3079
702 Moccasin Bend Rd., Chattanooga, TN 37405-4413
(423) 664-7263; FAX (423) 664-7264
www.tennrand.com

Tennessee Rand will highlight its capabilities as a full-service automation integrator with core competencies in advanced welding system design, high-quality weld fixtures, robotic integration, process automation, manufacturing, and on-going service and support. The company also manufactures a complete line of industrial clamping products, specifically designed for a harsh welding environment. The following products will be featured: A three-station indexer with tool changeout capability, a four-station quad cell with tool changeout capability, and three models of compact pneumatic toggle clamps, TRC 27C, TRC 38C, and TRC 50C.

Texas State Technical College 37075
3801 Campus Dr., Waco, TX 76705
(254) 867-4884; FAX (254) 867-3550
www.waco.tstc.edu

Texas State Technical College offers two options in the welding program: a one- year combination welding certificate program and a two-year welding technology associate degree program. The combination welding program is designed to develop the skills needed to enter the job market ready to work as a welder. The welding technology program is designed to develop skills in the major welding processes as well as in technical areas of study such as metallurgy, inspection and testing, and automated and robotic welding applications.

Thermacut, Inc. 5132
19 Sullivan St., PO Box 1197
Claremont, NH 03743-1197
(603) 543-0585; (603) 542-5745
www.thermacut.com

Thermacut will highlight its line of advanced cutting and welding consumables, accessories and replacement torches. Featured products will include the patented Tungsten-EX® nozzle for mechanized plasma cutting systems, which incorporates a tungsten alloy insert within the nozzle orifice. The company has expanded its line of Silver-EX® electrodes with additional part numbers for key mechanized plasma systems used in the metalworking industry.

Thermadyne Industries Inc 6029
16052 Swingley Ridge Rd., Ste. 300
St. Louis, MO 63017-2079
(636) 728-3181; FAX (636) 728-3021
www.thermadyne.com

Thermadyne will showcase its lines of metal cutting and welding products and accessories. Brand names include Victor®, Tweco®, Arcair®, Thermal Dynamics®, Thermal Arc®, Stoody®, Turbo Torch®, Firepower® and Cigweld®.

Thermion, Inc. 1124
PO Box 780, Silverdale, WA 98383-0780
(860) 492-6469; FAX (860) 447-8314
www.thermioninc.com

3M 6095
Bldg. 235-2W-70, St. Paul, MN 55144
(651) 736-1751; FAX (651) 736-6677
3m.com/occsafety

ThyssenKrupp VDM USA, Inc. 4140
306 Columbia Turnpike, Florham Park, NJ 07932
(973) 236-1664; FAX (973) 236-1963
www.thyssenkrupp.com

ThyssenKrupp VDM will showcase its nickel-based alloys for heat- and corrosion-resistant applications. Wire products for joint and overlay welding are available in a wide variety of alloys and forms. Cut lengths, spools, and pail packages of bare wire are offered, as are coated electrodes. Featured will be Alloy 59, a filler metal used to join corrosion-resistant alloy sheet and plate.

Tianjin Jinlong Welding Materials Co. Ltd. 4154
Yuantian Rd. Changsheng St
Gegu Town Jinnan District
Tianjin 300352 CHINA
8622-286-95656; FAX 86 22-286-86879
www.safmm.com

Tianjin Xinsen Welding Materials Co. Ltd. 4166
Huyuan Town, Shuangjie Zhen Beichen District
Tianjin 300400, China
86-22-26972630; FAX 86-22-26972720
www.xinsenwelding.com

Tianjin Xinsen Welding Materials will feature its copper and copper-alloy welding wires and rods.

TJ Snow Co. 1071
6207 Jim Snow Way, Chattanooga, TN 37421-3512
(423) 894-6234; FAX (423) 308-3187
www.tjsnow.com

TJ Snow will showcase its automatic and manually operated resistance welding machinery and consumable supplies; spot welding and arc welding robots; welding seminars; weld controls and transformers; and repairs.

Torch Wear 5075
2374 Edison Blvd., Twinsburg, OH 44087-2376
(330) 425-2738; FAX (330) 425-2739
www.torchwear.com

Torch Wear will feature safety apparel made from fabric that provides protection while being comfortable enough to wear next to the skin. The fabric doesn't char, shrink, or burn when exposed to heat and flame.

TR Automation 3125
106 Spring Rd., Chattanooga, TN 37405-2020
(423) 875-8862; FAX (423) 875-4902
www.trauto.com

TR Automation will show its high-quality automated machinery for tube bending, robotic welding, resistance welding, spot welding, and handling. Products include tube bending machines, human machine interface (HMI) touch screens, software, weld monitors, networking, and real-time data management and information.

Trafilerie di Cittadella SpA Fileur 7053
Via Mazzini 69
Cittadella PD 35013, Italy
39049-940-1593; FAX 39049-940-1594
www.fileur.com

Trafilerie Di Cittadella will display its line of welding wires.

Tregaskiss 4005
2570 N. Talbot Rd., Windsor ON N0R 1L0, Canada
(519) 737-3000; FAX (519) 737-1530
www.tregaskiss.com

Tregaskiss will feature its line of durable GMAW guns and robotic peripherals. New products on display will include the company's upgraded nozzle cleaning station, the TOUGH GUN® reamer; the patent-pending TOUGH GUN low-stress robotic unicable, and its line of sleek TOUGH ACCESS™ consumables. Technical and sales staff will be on hand to answer questions.

Trendex Information Systems, Inc. **4126**
2367 Guenette St.
St Laurent QC H4R 2E9, Canada
(514) 333-6373; FAX (514) 333-5705
www.trendexsys.com

Trendex Information Systems will highlight Gastrend, its trilingual (English, French, Spanish), accounting and cylinder control software designed for the gases and welding supply distributor. The demonstration will show the user how to control accounts receivable, accounts payable, general ledger and inventory. The company will also feature Routrend, an off-truck invoicing system developed on an industrial handheld mini-computer capable of reading bar codes. Invoices for gases and products can be generated and printed in the truck. Information is automatically transferred to the main system each day.

Tri Tool **23026**
3041 Sunrise Blvd., Rancho Cordova, CA 95742
(800) 345-5015; FAX (916) 288-6160
www.tritool.com

Trion, Inc. **38056**
101 McNeill Rd., Sanford, NC 27330-9451
(919) 777-6341; FAX: (919) 777-6399
www.trioninc.com

Trion will display its air purification products designed to meet the stringent indoor air quality demands of industrial manufacturing. A variety of filtration technologies are offered to ensure high-efficiency removal of mist, smoke, and fumes from metalworking processes such as machining and welding.

United Abrasives, Inc. **7062**
PO Box 75, Rt. 66
Willimantic, CT 06226
(860) 456-7131; FAX (860) 456-8341
www.unitedabrasives.com

United Air Specialists **4121**
4440 Creek Rd.
Cincinnati, OH 45242
(513) 354-8710; FAX (513) 891-4171
www.uasinc.com

United Air Specialists will feature MERV 15 nanofiber cartridge filters in its dust collection systems for extended life and lower pressure drop.

Uniweld Products, Inc. **6141**
2850 Ravenswood Rd.
Ft. Lauderdale, FL 33312-4920
(954) 584-2000; FAX (954) 334-2882
www.uniweld.com

Uniweld will highlight its flame tools, gas control equipment, and accessories that cover gas welding, and cutting/brazing/soldering applications. Meet senior corporate managers.

Vanguard Machinery International LLC **5117**
14309 Sommermeyer St.
Houston, TX 77041-6204
(713) 462-5800; FAX (713) 462-8222
www.vanguardmachinery.com

Vanguard Machinery will feature its complete line of new CNC and conventional machine tools from lathes to large horizontal and vertical boring mills to saws. The company will also feature its complete line of welding equipment, including manipulators, positioners, and turning rolls in sizes and capacities to meet any welding and fabrication need.

Verichek Technical Services, Inc. **7146**
664 Cochran Mill Rd.
Jefferson Hills, PA 15025-3210
(412) 655-3491; Fax (412) 655-3493
www.verichek.net

Verichek Technical Services will focus on the Test-Master Pro, an optical-emission spectrometer to field analize metals; and the Min-Sort2, a six-base, hand-held, optical-emission spectrometer to sort multiple bases including Al, Fe, Cu, Ni, Ti, and Zn.

Vitronic Machine Vision Ltd. **1070**
11900 Plantside Dr., Ste. G
Louisville, KY 40299
(502) 266-2699; FAX (502) 266-2695
www.vitronic.com

Vitronic will display its weld joint inspection technology.

Washington Alloy Co **5140**
7010 Reames Rd., Ste. G
Charlotte, NC 28216-2230
(888) 522-8296; FAX (704) 598-6672
www.weldingwire.com

Washington Alloy will spotlight its diverse

SmartTCP
Automatic Welding

for complex fabrications in small batch production

The future of welding technology is here - don't let it pass you by !

SmartTCP robotic welding solution is a unique gantry system that integrates software and hardware components to automate both the robot programming and the weld production, making it possible for job-shops and manufacturers to quickly and easily optimize the fabrication of complex parts in low volume production.

Find out how you can eliminate the need for expert welders, improve your time to market, and increase your production volume and quality by calling to book an "in-action" demo: **1.248.994.1041**

See us at FABTECH International & AWS Welding Show
Booth #3141, November 11-14, 2007, Chicago, IL

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

www.weldmold.com

product offering for all welding applications including filler metals and other welding accessories.

Watts Specialties 21131
800 Fife Way, Milton, WA 98354
(253) 922-1414; FAX (253) 922-6808

Watts Specialties will include a CL124 computerized pipe cutting machine, shor pipe bevelers, and straight pipe cut off machines.

Weartech International, Inc. 7121
13032 Park St., Santa Fe Spgs, CA 90670-4006
(562) 698-7847; FAX (562) 945-5664
www.weartech.net

Weartech will display its complete line of cobalt- and nickel-based hardfacing rods and electrodes of different alloys in diameters from 3/32 to 3/8 in., its cobalt-based GMAW wires, and PTA spray and fuse powders. Centrifugal static and investment cast wear-resistant alloy parts will also be exhibited. Company brochures explaining all product lines will be available.

Weil Engineering North America LLC 8111
1180 E. Big Beaver Rd., Troy, MI 48083-1907
(248) 743-1200; FAX (248) 743-1201
www.weilengineering.com

Weil Engineering will emphasize its complete laser welding systems for tubing in the automotive, heavy-duty trucking, and general industries. The company will also feature its roll-forming and tube cutting machines.

Weiler Corp 4110
1 Weiler Dr., Cresco, PA 18326-9804
(570) 595-7495; FAX (570) 595-2002
www.weilercorp.com

Weiler will spotlight its power brushes and abrasives for the welding industry including a wide selection of wheel, cup, end, and tube brushes in addition to its Roughneck® weld cleaning products.

Weld Engineering Co., Inc. 4038
34 Fruit St., Shrewsbury, MA 01545-3200
508-842-2224; 508-842-3893
www.weldengineering.com

Weld Engineering will display its complete line of medium- and heavy-duty submerged arc flux handling systems, including air- and electric-powered automatic, portable and tractor units. Also featured will be advanced pressure feed and recovery systems. On display, will be flux re-bake and holding ovens. Live demonstrations of flux recovery will be taking place continuously.

Weld Aid Products 5116
14650 Dequindre St., Detroit, MI 48212
(313) 883-6977; FAX (313) 883-4930
www.weldaid.com

Weld Aid will feature its antispatter products.

Weldas Co 2132
128 Seaboard Ln., Franklin, TN 37067-8219
(615) 377-4722; FAX (615) 377-3635
www.weldas.com

Weldas will feature its premium line of leather gloves and clothing, flame-retardant clothing, and accessories with a spotlight on a new 9-oz FR jacket in a bright safety orange color.

Weldcoa 1058
335 E. Sullivan Rd., Aurora, IL 60506-1465
(630) 806-2000; FAX (630) 806-2001
www.weldcao.com

Weldcoa will premier its gas cylinder handling and filling equipment including palletized trucks and trailers.

Weldcraft 4080
2741 N. Roemer Rd.
Appleton, WI 54911-8629
(800) 752-7620; FAX (920) 882-6840
www.weldcraft.com

Weldcraft will feature its complete line of GTAW torches and accessories, including the Crafter Series, MicroTig™, Quick Connect System™, WP Series and the single piece collet/collet body.

Welding Alloys USA, Inc. 4133
8535 Dixie Hwy., Florence, KY 41042-3298
(859) 525-0165; FAX (859) 525-9094,
www.welding-alloys.com

Welding Alloys specializes in stainless steel, duplex and super duplex, nickel- and cobalt-based, as well as a wide range of hardfacing products.

Welding Expert 3603
5033 Park Rim
San Diego, CA 92117
(858) 483-9451; FAX (858) 483-4740
www.weldingexpert.net

The company will feature its bench-top tool for weld bead measurement, providing real-time digital images, measurements, and report generation.

Welding Technology Corp. 7120

24775 Crestview Ct.
Farmington Hills, MI 48335-1507
(248) 477-3900; FAX (248) 477-8897
www.weldtechcorp.com

Welding Technology will feature its controls for resistance welding, inverter technologies, monitoring equipment in the form of the WAVE (wireless), USLT 2000 ultrasonic inspection, and total productive welding networks.

Weldmotion LLC 39021

N1091 Midway Rd., Hortonville, WI 54944
(920) 716-9241; FAX (920) 748-3518

Weldmotion will be exhibiting its variable speed TP-75 and TP-200 benchtop weld positioners with foot control, along with its C-40 precision GTA welding machine.

Weldsale Co. 5000

2151 Dreer St., Philadelphia, PA 19125-1918
(215) 739-7474; FAX (215) 426-1260
www.weldsale.com

Weldsale will exhibit its platens, stands, and tooling.

Weldship Corp. 4124

225 W. 2nd St., Bethlehem, PA 18015-1274
(610) 861-7330; FAX (610) 861-5175
www.weldshipcorp.com

Weldship will highlight its services in supplying tube trailers, gas and liquid ISO containers, ground storage assemblies, and CO_2 transports to industrial gas manufacturers, their independent distributors, and specialty chemical producers.

WEMCO 39002

550 NW LeJeune Rd.
Miami, Fl 33126
(305) 443-9353; FAX (305) 442-7451
www.aws.org

WEMCO is a Standing Committee of the American Welding Society that is dedicated to providing a common voice to the welding industry, government bodies, and technical organizations worldwide. WEMCO also provides value-added information and services to end users, distributors, and manufacturers' in the welding industry, as well as promote coalitions between AWS and manufacturers of welding, cutting, and related welding-industry equipment. Learn how to increase your networking capabilities in the welding industry.

Wentgate Dynaweld, Inc. 1147

630 Silver St., Unit 7A
Agawam, MA 01001-3051
(413) 789-4600; FAX (413) 786-0508
www.wentgatedynaweld.com

Wentgate Dynaweld will emphasize its expertise in electron beam welding technology offering standard systems with either 60-kV or 150-kV electron guns, as well as complete turnkey systems with tooling packages.

WESCAN Systems Ltd.
LINATROL Profile Cutting Div. 1046

777 Walkers Line
Burlington, ON L7N 2G1, Canada
(905) 333-6000; FAX (905) 333-6005
www.linatrol.com

The company will spotlight the LINATROL family of industrial CNC controls for profile and shape cutting. Additionally, optical tracing units, servo drive systems, plasma cutting systems, and programming software will be featured.

West Cryogenics, Inc. 4104

17301 E. Fm 1097 Rd.
Willis, TX 77378-3959
(936) 856-6549; FAX (936) 856-0432
www.westcryogenics.com

West Cryogenics will feature its cryogenic vassels for liquid oxygen, nitrogen, argon, and CO_2.

Western Enterprises 3157

875 Bassett Rd., Westlake, OH 44145-1142
(800) 783-7890; FAX (440) 835-8283
www.westernenterprises.com

Western Enterprises will display its nickel-plated Caliber flashback arrestors with buna nitrile O-ring, Quickmate quick connects, and Safemate combination flashback arrestors and quick connects.

Wilson Industries 4094

123 Explorer St.
Pomona, CA 91768-3278
(800) 423-4277; FAX (909) 468-3640
www.wilsonindustries.com

Wilson Industries will feature its welding curtains, high-temperature fabrics, and protective clothing.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Quality aluminum welding starts with a quality filler metal – material with the consistency, feedability, surface finish and cleanliness required to produce welds with aesthetic appeal and x-ray quality. Welders around the world find their solution for quality in AlcoTec aluminum wire, the choice of experts and the number one provider of aluminum wire worldwide. With AlcoTec, in addition to top-quality wire, you receive continued support after the sale. The experienced AlcoTec staff is always ready to assist with welding problems, help improve your manufacturing techniques or develop new welding procedures.
For your next aluminum welding job, ask for quality. Ask for AlcoTec by name.
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For Info go to www.aws.org/ad-index
SEE US AT THE FABTECH/AWS SHOW BOOTH #5047
2750 Aero Park Drive, Traverse City, MI 49686-9263
Phone: 1-800-228-0750
www.alcotec.com
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AWS Foundation, Inc.

Building Welding's Future through Education

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Wire Crafters, Inc. **4131**
6208 Strawberry Ln.
Louisville, KY 40214-2900
(800) 626-1816; FAX (502) 361-3857
www.wirecrafters.com

Wire Crafters, a provider of woven wire partitions for safety and physical barriers, will premier its light curtains and interlocks to help create a complete safety package.

Zhejiang Yuguang Alumium Material Co. Ltd. **36057**
22nd Hehua Rd.
Economic Development Zone
Jinhua 321200, China
86-57987-921164; FAX 86-57987-921166
www.zjyuguang.com

The company will feature its aluminum welding wire.

Zhengzhou Anxin Abrasives Co. Ltd **2164**
No. 36 Xuzhuang Industrial Zone
Zhengzhou, China 450002
86-371-6782-6976; FAX 86-371-6782-6977

Zhengzhou Sanhui Co Ltd **2100**
Unit C, 14th Fl., Yuanzheng Plaza
No. 106 Chengdong Rd.
Zhengzhou, PR China 450004
86-371-663-11492; FAX 86-371-663-64729
www.zzstc.com.cn

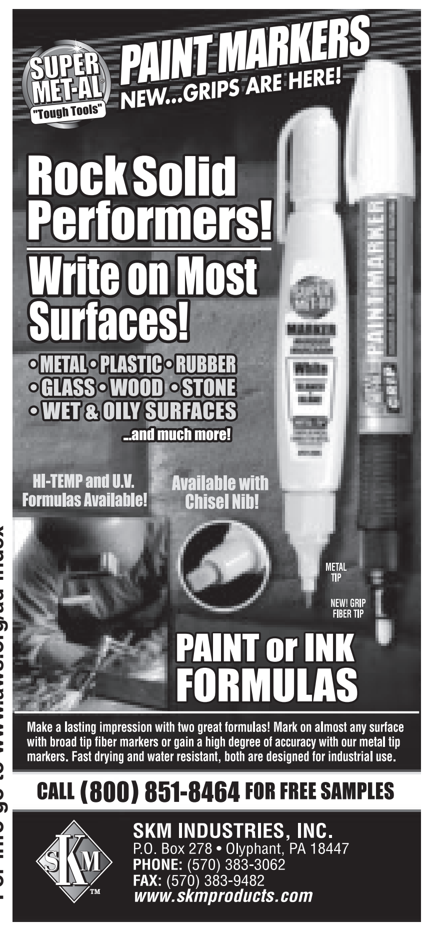
Zhuji Lissam Welding Equipment Co. Ltd. **4152**
Jiangdong Park, Gaohu Rd.
Zhuji Zhejiang, China 311800
86-575-87012323; 86-575- 87010214
www.lissam.com

Zhuji Lissam Welding Equipment will highlight its arc welding accessories, gas equipment, GTAW torches and parts, GMAW guns and parts, welding consumables, welding machines, and safety products.

ZJ Industries, Inc. **7156**
125 Factory Rd., Addison, IL 60101-5103
(630) 543-6655; (630) 543-6644
www.zjindustriesinc.com

ZJ Industries will feature its resistance welding products including a diverse inventory of welding electrodes, tips, adapters, holders, shunts, cables, welding machine arms, seam welding wheels, resistance welding controls, tip dressers, copper alloys and accessories.

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



Friction Welding Conference
Chicago, Illinois
FABTECH International & AWS Welding Show
November 12

The big three of friction welding — conventional friction welding, linear friction welding, and friction stir welding — will all be included in a full-day conference on Monday, Nov. 12, at the FABTECH International & AWS Welding Show in Chicago. Among the presentations will be talks on such topics as direct drive vs. inertia friction welding, the friction welding of automotive pistons, the linear friction welding of blades onto discs in aircraft engines, the marriage of robotics and friction stir welding, and the ability of any process within this family to weld just about any metal or alloy or even plastic. Also, experts will be on hand to discuss the ability to use any of these processes to weld dissimilar metals on the fly.

Hot Wire Welding and Cladding Conference
Chicago, Illinois
FABTECH International & AWS Welding Show
November 13

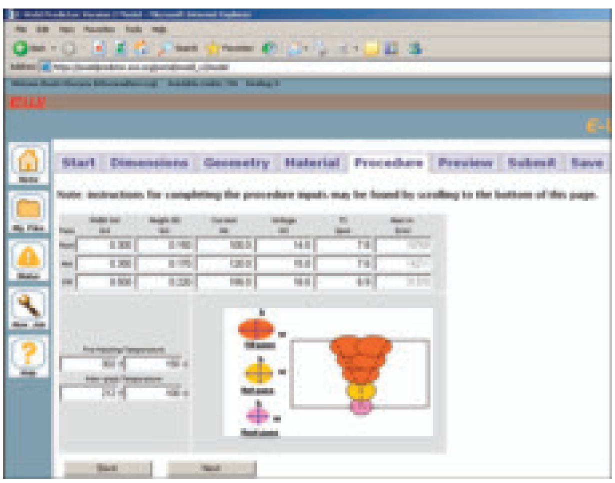
There is a great deal of interest lately regarding hot wire welding and cladding. Although invented many years ago, this technology never really saw the light of day until recently. One version or other is already being used by participants in the oil and gas industry, by the U.S. Navy, and by builders of aircraft engines. Hot wire welding and cladding will be the subjects of a one-day conference at the FABTECH International & AWS Welding Show in Chicago. Presentations on both the hot wire GTA and plasma processes will be on the agenda. One topic that will be addressed will be the popular use of hot wire GTA cladding of tube and piping for the offshore oil and gas industries. In another, hot wire GTA "narrow groove" welding will be shown to perform well on titanium. The overall advantages are increased deposition rates and faster travel speeds.

For more information, please contact the AWS Conferences and Seminars Business Unit at (800) 443-9353, ext. 223. You can also visit the Conference Department at *www.aws.org* for upcoming conferences and registration information.

Automated Weld Modeling – E-Weld Predictor

Currently, weld procedure qualification and design of welding processes are done by expensive and time consuming experimental trial and errors. In the past three decades, attempts have been made by academic scholars, national laboratory researchers, and industrial engineers to develop computational models to reduce these trial and error experiments. Even with the availability of computational software and high-performance computers throughout the world, the adoption of modeling technology by welding industries has been limited. This was due to the lack of a modeling tool that focused on welding predictions.

To meet this need, EWI staff developed an innovative technology, E-Weld Predictor©, that couples the welding engineering, finite-element analysis (FEA), materials modeling, and supercomputing domain knowledge seamlessly. The successful implementation of this was a technical challenge. It required creating the non-existent automation technology and merging with the current knowledge of modeling the welding processes.



A snapshot of E-Weld Predictor

The automatic weld modeling tool, E-Weld Predictor, is an on-line portal which takes the input from engineers and provides a report on the effect of welding on materials. The service has two technical components: (a) a front-end web-interface for taking the information and providing output and (b) a back-end automatic computational framework that runs on a high performance computer calculations and report.

In a typical usage scenario, a user first specifies the weld configuration, indicating whether their application is for pipe welding or plate welding, and providing specimen dimensions after launching the tool. Then, welding groove configurations are defined and, after setting the weld bead size and process parameters, the simulation can be submitted for running the analysis. After the completion of the analysis, a report summarizing the temperature, residual stress, distortion, and microstructure will be generated automatically.

Proven weld simulation modules are the backbone of E-Weld Predictor. The analysis is a sequentially coupled thermal and mechanical process. The thermal analysis is conducted using Goldak's formulation. An algorithm has been developed to fill the weld groove appropriately using the size of the weld beads input by the user. The total number of weld beads and the positions of different passes are generated automatically. The meshing and model file generation is also done without a user's interference. This was realized using a custom-built python algorithm that interacts with ABAQUS/CAE. The analysis is carried out on an Ohio Supercomputer Center (OSC) computer server.

This service is completely different from the node-locked, single all-in-all encompassing FEA applications that are currently available in the market place. This online automated usage approach allows the customers to focus on the engineering solution rather than expensive and time-consuming model development and running exercise. This provides tangible advantages of modeling tools to the final end-user. This automatic weld modeling framework has been validated with experimental studies.

*To celebrate the launch of E-Weld Predictor, EWI is providing **five free credits for a limited time** to try this innovative new tool. Please contact EWI at 614.688.5242 or eweldsupport@ewi.org to activate your free credits today.*

EWI®

1250 Arthur E. Adams Drive Columbus, Ohio 43221 • 614.688.5000 • www.ewi.org

The Results of Overwelding

One of the most frustrating outcomes of a job occurs when the costs have been estimated, the order has been received, and the product has been built, only to have the cost of the job exceed the estimate. Often the problem results from failing to identify all the factors affecting cost, especially those that are not direct material or labor costs. Sometimes costs are hidden in operations that were not foreseen. Overwelding can be one such unforeseen cost.

Overwelding results from inaccurate cutting and fitting, poor supervision, insufficient training, or lack of confidence in the strength of the weld as specified. Two joint configurations that often result in overwelding are complete- or partial-penetration welds in T-joints produced in the horizontal position, and butt joints fabricated between plates of unequal thickness.

Overwelding significantly contributes to excessive welding cost. The increase in weld cross section as a result of overwelding is shown in Fig. 1. In Fig. 2, the weld detail is shown in A, the desired weld is illustrated in B, and the common overwelded condition is represented in C. Figure 3 illustrates the potential overwelding of a transition butt joint, and Fig. 4 shows the effect of poor fitup on the weld cross section.

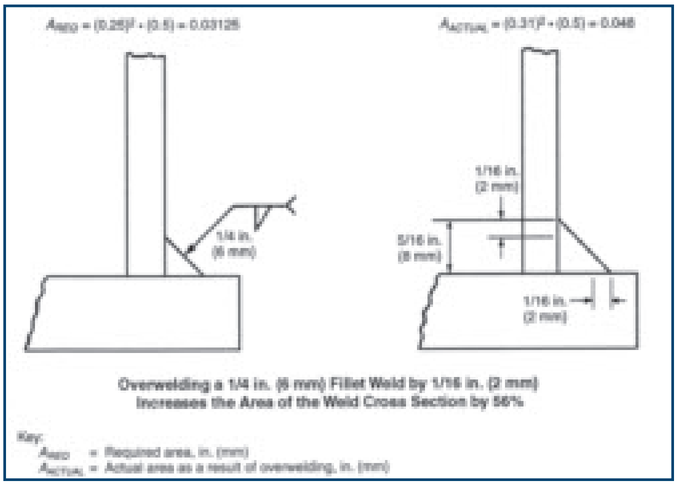


Fig. 1 — Effect of overwelding on a weld cross section.

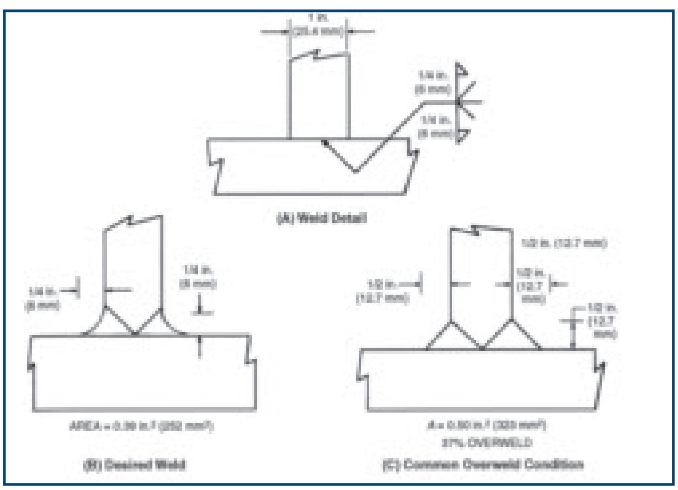


Fig. 2 — Common overwelded complete penetration T-joint fabricated in the horizontal position: A — Weld detail; B — desired weld; and C — common overweld condition.

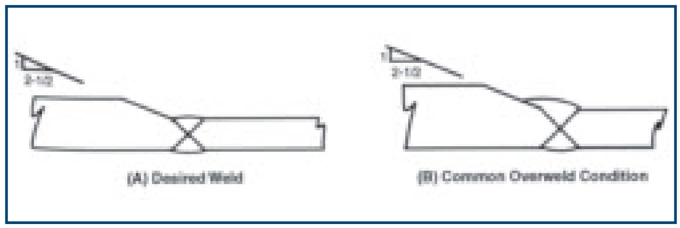


Fig. 3 — Potential overwelding of transition butt joints: A — Desired weld; B — common overweld condition.

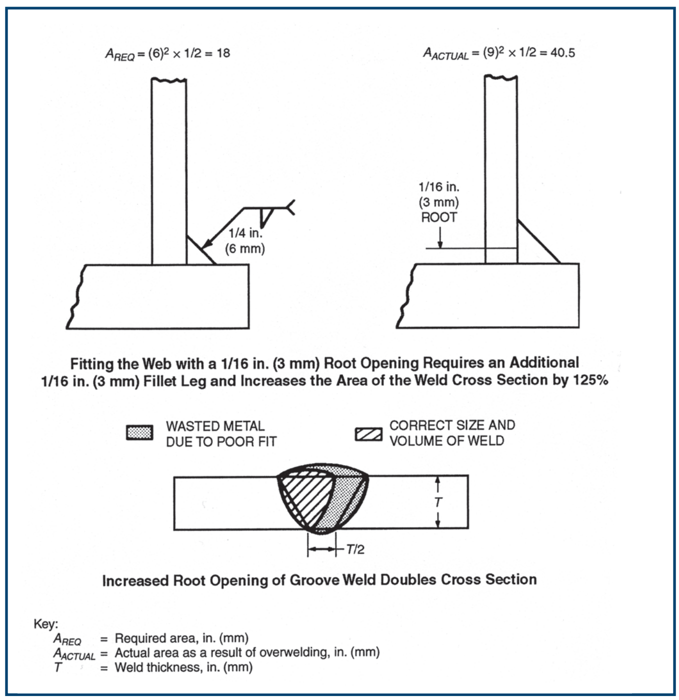


Fig. 4 — Effect of poor fitup on a weld cross section.

Excerpted from the *Welding Handbook,* Vol. 1, ninth edition.

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

♦**FABTECH International & AWS Welding Show.** Nov. 11–14, McCormick Place, Chicago, Ill. This show is the largest event in North America dedicated to showcasing the full spectrum of metal forming, fabricating, tube and pipe, and welding equipment and technology. Contact: American Welding Society, (800/305) 443-9353, ext. 462; *www.aws.org.*

♦**Friction Welding.** Nov. 12, Chicago, Ill., during the FABTECH Int'l & AWS Welding Show. Will include numerous short presentations on linear friction, friction stir, and conventional friction welding. Contact: AWS Educational Services, (800/305) 443-9353, ext. 455; *www.aws.org/conferences/friction.pdf.*

♦**Hot Wire Welding and Cladding Conf.** Nov. 13, McCormick Place, Chicago, Ill., during the FABTECH Int'l & AWS Welding Show. Will address hot wire GTA cladding of tube and piping for offshore oil and gas industries, and narrow groove welding performed on titanium. Contact: AWS Educational Services, (800/305) 443-9353, ext. 455; *www.aws.org/conferences/hotwire.pdf.*

PACE 2008, The Power of Paint + Coatings. Jan. 27–30, Los Angeles Convention Center, Los Angeles, Calif. Visit *www.PACE2008.com.*

METALFORM. April 1–3, Birmingham-Jefferson Convention Complex, Birmingham, Ala. Contact: Precision Metalforming Assn., (216) 901-8800; *www.pma.org; www.metalform.com.*

PICALO 2008. April 16–18, Capital Hotel, Beijing, China. Third Pacific Int'l Conf. on Applications of Lasers and Optics. Visit *www.laserinstitute.org/conferences.*

XXXIX Steelmaking Seminar — Int'l. May 12–16, Estação Embratel Convention Center, Curitiba, Paraná, Brazil. Visit: *www.abmbrasil.com.br/seminarios/aciaria/2008/default-i.asp.*

Automotive Laser Application Workshop, ALAW 2008. May 13–15, Plymouth, Mich. Contact: The Laser Institute of America, *www.alawlaser.org;* (407) 380-1553.

IIW Int'l Regional Congress, 2nd Latin America Welding Congress. May 18–21. Club Transatlantico, São Paulo, Brazil. Visit *abs-soldagemlorg.br*.

15th Int'l Conf. on Textures of Materials. June 1–5. Carnegie Mellon University Center, Pittsburgh, Pa. Contact: American Ceramic Society, *www.ereleases.com.*

♦**Trends in Welding Research™, 8th Int'l Conf.** June 2–6. Callaway Gardens Resort, Pine Mountain, Ga. Sponsored by ASM International, *www.asminternational.org/trend;* cosponsored by the American Welding Society, *www.aws.org.*

Educational Opportunities

Advanced Pipe Welding. Nov. 12–16, Nov. 19–23, Nov. 26–30, Cleveland, Ohio. Contact: Lincoln Electric Co. Welding School. Call (216) 383-8325, or visit *www.lincolnelectric.com* to request Bulletin ED.122.

ASME Section IX Seminars. Dec. 3–5, Atlanta, Ga.; April 8–10, 2008, Las Vegas, Nev. Contact: ASME Continuing Education Institute. Call (800) 843-2763, or visit *www.asme.org/education.*

Automotive Body in White Training for Skilled Trades and Engineers. Orion, Mich. A 5-day course covers operations, troubleshooting, error recovery programs, and safety procedures for automotive lines and integrated cells. Contact: Applied Mfg. Technologies. Call (248) 409-2000, or visit *www.appliedmfg.com.*

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

Continuing Education for Welding Inspectors and CWIs. Dec. 11–14. Chicago, Ill. Atema, Inc. Call (312) 861-3000, or visit *atemasolutions.com.*

CWI/CWE Course and Exam. This is a ten-day program. Contact: Hobart Institute of Welding Technology. Call (800) 332-9448, or visit *www.welding.org*.

CWI Preparation. Courses on ultrasonic, eddy current, radiography, dye penetrant, magnetic particle, and visual at Levels 1–3. Meet SNT-TC-1A and NAS-410 requirements. Contact: T.E.S.T. NDT, Inc. Call (714) 255-1500, or visit *www.testndt.com.*

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

Environmental Health and Safety-Related Web Seminars. These 30-min-long Web seminars on various topics are online, real-time events conducted by industry experts. Most seminars are free. Visit *www.augustmack.com/Web%20Seminars.htm.*

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

Essentials of Safety Seminars. Two- and four-day courses are held at numerous locations nationwide to address federal and California OSHA safety regulations. Contact: American Safety Training, Inc. Call (800) 896-8867, or visit *www.trainosha.com*.

Fabricators and Manufacturers Assn. and Tube and Pipe Assn. Courses. Call (815) 399-8775, or visit *www.fmametalfab.org*.

Firefighter Hazard Awareness Online Course. A self-paced, ten-module certificate course taught online by fire service professionals teaches how to detect commonly encountered gas hazards. Fee is $195. Contact: Industrial Scientific Corp. Call (800) 338-3287, or visit *www.indsci.com/serv_train_ffha_online.asp*.

Flux Cored Arc Welding/Semiautomatic. A one-week course offered Nov. 5–9, Dec. 17–21, Cleveland, Ohio. Contact: Lincoln Electric Co. Welding School. Call (216) 383-8325, or visit *www.lincolnelectric.com* to request Bulletin ED.122.

Fundamentals of Brazing Course. Nov. 13–15, Hartford, Conn. Includes furnace, torch, dip, resistance, and induction brazing of metals based on Ni, Al, Ag, Cu, etc. Contact: Kay & Associates. Call (860) 651-5595, or visit *www.kaybrazing.com*.

AWS Certification Schedule

Certification Seminars, Code Clinics and Examinations

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

Certified Welding Inspector (CWI)

Location	Seminar Date	Exam Date
Sacramento, CA	Dec. 9-14	Dec. 15
Miami, FL	Dec. 9-14	Dec. 15
Syracuse, NY	Dec. 9-14	Dec. 15
Reno, NV	Dec. 16-21	Dec. 22
Houston, TX	Dec. 16-21	Dec. 22
Beaumont, TX	Jan. 6-11, 2008	Jan. 12, 2008
Fresno, CA	Jan. 6-11	Jan. 12
Miami, FL	Jan. 13-18	Jan. 19
Albuquerque, NM	Jan. 13-18	Jan. 19
Knoxville, TN	EXAM ONLY	Jan. 19
Pittsburgh, PA	Jan. 27-Feb. 1	Feb. 2
Denver, CO	Jan. 27-Feb. 1	Feb. 2
Seattle, WA	Feb. 3-8	Feb. 9
Milwaukee, WI	Feb. 3-8	Feb. 9
Indianapolis, IN	Feb. 10-15	Feb. 16
Atlanta, GA	Feb. 10-15	Feb. 16
Miami, FL	EXAM ONLY	Feb. 21
Houston, TX	Feb. 24-29	Mar. 1
San Diego, CA	Feb. 24-29	Mar. 1
Norfolk, VA	Feb. 24-29	Mar. 1
Corpus Christi, TX	EXAM ONLY	Mar. 1
Boston, MA	Mar. 2-7	Mar. 8
Phoenix, AZ	Mar. 2-7	Mar. 8
Portland, OR	Mar. 2-7	Mar. 8
Perrysburg, OH	EXAM ONLY	Mar. 8
Anchorage, AK	Mar. 9-14	Mar. 15
Miami, FL	Mar. 9-14	Mar. 15
Mobile, AL	EXAM ONLY	Mar. 15
Rochester, NY	EXAM ONLY	Mar. 29
York, PA	EXAM ONLY	Mar. 29
Dallas, TX	Mar. 30-Apr. 4	Apr. 5
Chicago, IL	Mar. 30-Apr. 4	Apr. 5
Springfield, MO	Apr. 6-11	Apr. 12
Baton Rouge, LA	Apr. 6-11	Apr. 12
San Francisco, CA	Apr. 6-11	Apr. 12
Miami, FL	EXAM ONLY	Apr. 17
Portland, ME	Apr. 13-18	Apr. 19
St. Louis, MO	EXAM ONLY	Apr. 22
Nashville, TN	Apr. 20-25	Apr. 26
Jacksonville, FL	Apr. 20-25	Apr. 26
Baltimore, MD	Apr. 27-May 2	May 3
Detroit, MI	Apr. 27-May 2	May 3
Waco, TX	EXAM ONLY	May 3
Miami, FL	May 4-9	May 10
Albuquerque, NM	May 4-9	May 10
Spokane, WA	May 4-9	May 10
Corpus Christi, TX	EXAM ONLY	May 10
Oklahoma City, OK	May 18-23	May 24
Birmingham, AL	May 18-23	May 24
Long Beach, CA	EXAM ONLY	May 31
Hartford, CT	Jun. 1-6	Jun. 7
Pittsburgh, PA	Jun. 1-6	Jun. 7
Fargo, ND	Jun. 1-6	Jun. 7
Sacramento, CA	Jun. 8-13	Jun. 14
Kansas City, MO	Jun. 8-13	Jun. 14

For information on any of our seminars and certification programs, visit our website at **www.aws.org/certification** or contact AWS at (800/305) 443-9353, Ext. 273 for Certification and Ext. 455 for Seminars. Please **apply early** to save Fast Track fees. **This schedule is subject to change without notice.** Please verify the dates with the Certification Dept. and confirm your course status before making final travel plans.

9-Year Recertification Seminar for CWI/SCWI

Location	Seminar Dates	Exam Date
Orlando, FL	Dec. 3-8	NO EXAM
New Orleans, LA	Jan. 14-19, 2008	NO EXAM
Denver, CO	Feb. 11-16	NO EXAM
Dallas, TX	Mar. 10-15	NO EXAM
Sacramento, CA	Apr. 14-19	NO EXAM
Pittsburgh, PA	May 19-24	NO EXAM
San Diego, CA	Jun. 9-14	NO EXAM
Orlando, FL	Sept. 8-13	NO EXAM
Dallas, TX	Oct. 20-25	NO EXAM
Miami, FL	Dec. 1-6	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
Atlanta, GA	Jan. 21-25	Jan. 26
Houston, TX	Jan. 28-Feb. 1	Feb. 2
Baton Rouge, LA	Mar. 31-Apr. 4	Apr. 5
Atlanta, GA	Apr. 28-May 2	May 3
Columbus, OH	May 19-23	May 24
Minneapolis, MN	Jun. 23-27	Jun. 28
Atlanta, GA	Jul. 14-18	Jul. 19
Philadelphia, PA	Aug. 18-22	Aug. 23
Atlanta, GA	Sept. 15-19	Sept. 20

CWS exams are also given at all CWI exam sites.

Certified Radiographic Interpreter (CRI)

Location	Seminar Dates	Exam Date
Long Beach, CA	Jan. 14-18	Jan. 19
Indianapolis, IN	Feb. 11-15	Feb. 16
Houston, TX	Mar. 10-14	Mar. 15
Philadelphia, PA	Apr. 14-18	Apr. 19
Nashville, TN	May 19-23	May 24
Manchester, NH	Jun. 9-13	Jun. 14

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

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.

Certified Welding Fabricator

This program is designed to certify companies to specific requirements in the ANSI standard AWS B5.17, *Specification for the Qualification of Welding Fabricators*. There is no seminar or exam for this program. Call ext. 448 for more information.

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. 219 for more information.

American Welding Society®

SOCIETY NEWS

BY HOWARD M. WOODWARD

Make the Most of Your Trip to the Show

Photos courtesy of Chicago Convention and Tourism Bureau

While you're in Chicago for the FABTECH International & AWS Welding Show, Nov. 11–14, set aside some quality time to enjoy the attractions unique to the Windy City.

Chicago's newest landmark, the ***Cloud Gate*** **sculpture** (Fig. 1) in **Millennium Park,** is a gleaming $23-million, 110-ton, stainless steel "bean" measuring 33 ft high, 42 ft wide, and 66 ft long that reflects the heavens, the city's skyline, and anybody who comes near. Its 12-ft-high arch provides a concave passage beneath the sculpture where visitors can touch its mirrored surface and experience their reflections from a variety of perspectives.

Chicago's oldest inhabitant resides at the **Field Museum,** she's Sue the T-rex — Fig. 2. The fossil is the largest, most complete, and best-preserved tyrannosaurus rex yet discovered.

The massive **Picasso sculpture** in Daley Plaza has no official name — Fig. 3. In fact, folks argue about what it is. The top four guesses are a woman's head, a swan, a horse, or an angel.

If you dare, indulge in a **Chicago-style hot dog** while in town — Fig. 4. To earn the Chicagoan's seal of approval, the dog must be topped with mustard, green relish, chopped onion, sliced tomato, hot peppers, and sprinkled with celery salt.

Relax near the **Buckingham Fountain** — Fig. 5. Built of Georgia pink marble in 1927, this baroque beauty is modeled after the fountain at the Palace of Versailles near Paris — except it's twice as big. Visit it by day and at night.

The **Shedd Aquarium** displays 8000 marine animals. The glass-walled Oceanarium is a spectacular pool for dolphins and whales to strut their stuff with Lake

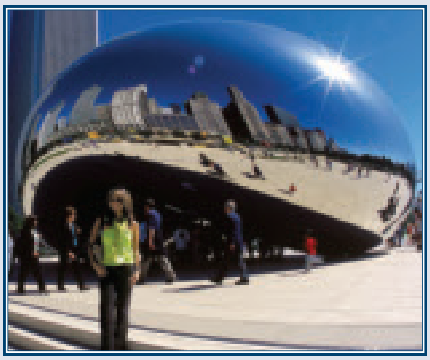


Fig. 1 — Chicago's newest landmark, Cloud Gate *sculpture, draws visitors day and night.*

Fig. 2 — Sue, the city's resident T-rex, bemuses visitors in the Field Museum.

Fig. 3 — The "what is it?" Picasso sculpture confounds passersby in Daley Plaza.

Fig. 4 — The Chicago hot dog must include six condiments to qualify as "the real thing."

Fig. 5 — The Buckingham Fountain is twice as big as its model at Versailles in France.

Michigan as the backdrop.

Lincoln Park Zoo is a top attraction and admission is still free.

Shopping is great in **The Loop** (the downtown district) and **The Magnificent Mile** (Chicago Place). The Mag Mile, as it is often called, stretches north from the Chicago River to Oak St. beach. One of the world's premier shopping boulevards, it is home to four indoor shopping centers, 460 retailers, 275 restaurants, 51 hotels, and a variety of cultural and entertainment venues.

Navy Pier is almost a destination unto itself. It offers fun for the whole family, including boat trips, shops, restaurants, the **Children's Museum,** the **Smith Museum of Stained Glass,** the **Botanical Garden,** an **IMAX theater,** as well as a Ferris wheel, a carousel, and outdoor concert stage featuring daily performances. Most of all, it's a great place just to stroll along the promenade enjoying the magnificent views of Lake Michigan or just do some people watching.

Boat trips include architectural tours, lunch or dinner cruises, fishing charters, and lake excursions.

By night, Chicago offers an abundance of jazz and blues clubs featuring some of the swingingest live jazz music around — from hot New Orleans style to cool bebop to big band brass.

Experience dining in the restaurant atop the **John Hancock Building** where you can enjoy excellent food complemented by spectacular views of the city and Lake Michigan.

With myriad things to do in Chicago, be sure to experience some of the city's unique attractions to make your trip to the FABTECH International & AWS Welding Show even more memorable.♦

AWS Life Members Offered Free Registration for Professional Program

AWS Life Members are urged to take advantage of their free admission to the upcoming FABTECH International & AWS Welding Show (Nov. 11–14 in Chicago, Ill.) plus free registration to the entire Professional Program (a $325 value), scheduled for November 12–14.

The complimentary registration to the Professional Program entitles AWS Life Members to attend any of the technical sessions taking place during the three-day period.

Registration forms are available in issues of the *Welding Journal,* as well as in the *Advance Program* that was mailed to members previously.

To obtain your free registration, mark "AWS Life Member: Free Registration" at the top of your registration form. Then FAX both sides of the form to (305) 443-7559, Attn.: Ruben Lara, accounting director, or mail the form to Ruben Lara, AWS, 550 NW LeJeune Rd., Miami, FL 33126.

Nominees Solicited for Robotic Arc Welding Awards

Nominations are solicited for the 2008 Robotic and Automatic Arc Welding Award. December 31 is the deadline for submitting nominations.

The nomination packet should include a summary statement of the candidate's accomplishments, interests, educational background, professional experience, publications, honors, and awards.

Send your nomination package to Wendy Sue Reeve, awards coordinator, 550 NW LeJeune Rd., Miami, FL 33126.

For more information, contact Reeve at *wreeve@aws.org,* or call (800/305) 443-9353, ext. 293.

In 2004, the AWS D16 Robotic and Automatic Arc Welding Committee, with the approval of the AWS Board of Directors, established the Robotic and Automatic Arc Welding Award. The award was created to recognize individuals for their significant achievements in the area of robotic arc welding. This work can include the introduction of new technologies, establishment of the proper infrastructure (training, service, etc.) to enable success, and any other activity having significantly improved the state of a company and/or industry. The Robotic Arc Welding Award is funded by private contributions. It will be presented this year at the AWS Awards and AWS Foundation Recognition Ceremony and Luncheon to be held in conjunction with the FABTECH International & AWS Welding Show, Nov. 11–14, in Chicago, Ill.

Notice of Annual AWS Meeting

The Annual Meeting of the members of the American Welding Society will be held on Monday, Nov. 12, 2007, beginning at 9:00 A.M., at McCormick Place, Chicago, Ill., during the FABTECH International & AWS Welding Show.

The regular business of the Society will be conducted, including election of officers and ten members of the Board of Directors. Any business properly brought before the membership will be considered.

Nominations for National Officers

AWS members who wish to nominate candidates for President, Vice President, and Director-at-Large on the AWS Board of Directors for the term starting January 1, 2009, may either:

1. Send their nominations electronically by October 10, 2007, to Gricelda Manalich at *gricelda@aws.org;* c/o Damian J. Kotecki, chairman, National Nominating Committee; or

2. Present their nominations in person at the open session of the National Nominating Committee meeting scheduled for 2:00 to 3:00 P.M., Tuesday, November 13, 2007, at McCormick Place, Chicago, Ill., during the 2007 FABTECH International & AWS Welding Show. Nominations must be accompanied by biographical material on each candidate, including a written statement by the candidate as to his or her willingness and ability to serve if nominated and elected, plus a 5 × 7-inch head-and-shoulders photograph. Note: Persons who present their nominations at the Show must provide 20 copies of the biographical materials and written candidate's statement.

Tech Topics

ERRATA

AWS D1.6/D1.6M:2007, *Structural Welding Code — Stainless Steel*

The following error has been identified and corrected in the current printing of this document.

Page 82, Table 4.2 (B) Fillet Welds, last column for Plate T-test Multiple pass under the heading "Sizes Qualified" and subheading "Fillet Weld Size," change "smaller" to "larger" in the second row.

ERRATA

AWS QC1:2007, *Standard for AWS Certification of Welding Inspectors*

The following errata have been identified and corrected in the current printing (second printing) of this document.

Page *iii* — Statement on the Use of American Welding Society Standards. The first paragraph has been revised to state the following:

"All standards (codes, specifications, recommended practices, methods, classifications, and guides) of the American Welding Society (AWS) are voluntary consensus standards that are developed through a consensus standards development process that brings together volunteers representing varied viewpoints and interests to achieve consensus. While the American Welding Society administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards. Further, given the rapid changes in the field, AWS cannot warrant that the certification standard will at all times reflect the most current knowledge."

ISO Drafts for Public Review

Copies of the following Draft International Standards are available for review and comment through your national standards body, which in the United States is ANSI, 25 W. 43rd St., 4th Floor, New York, NY, 10036; (212) 642-4900.

In the United States, if you wish to participate in the development of International Standards for welding, contact Andrew Davis, (305) 443-9353, ext. 466; *adavis@aws.org.* Otherwise contact your national standards body.

ISO/DIS 15609-4, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 4: Laser beam welding.*

ISO/DIS 25239-1, *Friction stir welding — Aluminium — Part 1: Vocabulary.*

ISO/DIS 25239-2, *Friction stir welding — Aluminium — Part 2: Design of weld joints.*

ISO/DIS 25239-3, *Friction stir welding — Aluminium — Part 3: Qualification of welding operators.*

ISO/DIS 25239-4, *Friction stir welding — Aluminium — Part 4: Specification and qualification of welding procedures.*

ISO/DIS 25239-5, *Friction stir welding — Aluminium — Part 5: Quality and inspection requirements.*

Standards for Public Review

AWS is an ANSI-accredited standards-preparing organization. AWS rules, as approved by ANSI, require that all standards be open to public review for comment during the approval process. Draft copies of these standards may be obtained from Rosalinda O'Neill, *roneill@aws.org;* (305) 443-9353, ext. 451.

A5.6/A5.6M:200X, *Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding.* Revised — $25. 11/5/07.

A5.12/A5.12M-98 (R200X), *Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting.* Reaffirmed — $25. 10/22/07.

Standards Approved by ANSI

A5.16/A5.16M: *Specification for Titanium and Titanium-Alloy Welding Electrodes and Rods.* Approved 8/17/07.

C3.4M/C3.4: *Specification for Torch Brazing.* Approved 8/24/07.

C3.5M/C3.5: *Specification for Induction Brazing.* Approved 8/24/07.

F4.1: *Safe Practices for the Preparation of Containers and Piping for Welding and Cutting.* Approved 8/24/07.

Technical Committee Meetings

All AWS technical committee meetings are open to the public. Persons wishing to attend a meeting should dial (800/305) 443-9353 and the extension of the committee contact listed.

Nov. 7, B2F Subcommittee on Plastic Welding Qualifications. Las Vegas, Nev. Contact: S. Hedrick, ext. 305.

Nov. 7, G1A Subcommittee on Hot Gas Welding and Extrusion Welding. Las Vegas, Nev. Contact: S. Hedrick, ext. 305.

Nov. 11, C7 Committee on High Energy Beam Welding and Cutting. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 11, C7B Subcommittee on Electron Beam Welding and Cutting. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 12, A5H Subcommittee on Filler Metals and Fluxes for Brazing. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 12, C1 Committee on Resistance Welding. Chicago, Ill. Contact: A. Alonso, ext. 299.

Nov. 12, C3A Subcommittee on Brazing Handbook. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 12, C3B Subcommittee on Soldering. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 12, C3D Subcommittee on Brazing Specifications. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 12, 13, D11 Committee on Welding Iron Castings. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 12, 13, D17 Committee on Welding in the Aircraft and Aerospace Industries. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 12, 13, D17J Subcommittee on Friction Stir Welding. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 12, 13, D17K Subcommittee on Fusion Welding. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 12, 13, D17X Executive Subcommittee. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 13, D18 Committee on Welding and Sanitary Applications. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 13, G2C Subcommittee on Nickel Alloys. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 13, J1 Committee on Resistance Welding Equipment. Chicago, Ill. Contact: A. Alonso, ext. 299.

Nov. 14, C3 Committee on Brazing and Soldering. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 14, C3C Subcommittee on Education and Safety. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 14, C3E Subcommittee on Brazing Conferences. Chicago, Ill. Contact: S. Borrero, ext. 334.

Nov. 14, D15C Subcommittee on Track Welding. Chicago, Ill. Contact: R. Starks, ext. 304.

Nov. 15, C6 Committee on Friction Welding. Chicago, Ill. Contact: R. Starks, ext. 304.

December 5, 6, SHC Safety and Health Committee. Miami, Fla. Contact: S. Hedrick, ext. 305. ♦

Member-Get-A-Member Campaign

Listed are the members participating in the 2007–2008 AWS Member-Get-A-Member Campaign for the period between June 1, 2007, and May 31, 2008. For campaign rules and a prize list, see page 161 of this *Welding Journal.* Standings are as of 9/17/07. If you have any questions regarding your member proposer points, call the Membership Department, (800) 443-9353, ext. 480.

Winner's Circle

Members who have sponsored 20 or more new Individual Members, per year, since June 1, 1999. The superscript indicates the number of times the member has achieved Winner's Circle status.

J. Compton, San Fernando Valley[7]
E. Ezell, Mobile[5]
J. Merzthal, Peru[2]
G. Taylor, Pascagoula[2]
B. Mikeska, Houston[1]
R. Peaslee, Detroit[1]
W. Shreve, Fox Valley[1]
M. Karagoulis, Detroit[1]
S. McGill, NE Tennessee[1]
L. Taylor, Pascagoula[1]
T. Weaver, Johnstown/Altoona[1]
G. Woomer, Johnstown/Altoona[1]
R. Wray, Nebraska[1]
M. Haggard, Inland Empire[1]

President's Guild

Members sponsoring 20 or more new Individual Members.

L. Taylor, Pascagoula — 55

President's Club

AWS Members sponsoring 3–8 new Individual Members.

R. Ellenbecker, Fox Valley — 7
E. Ezell, Mobile — 7
A. Castro, South Florida — 6
K. Kotter, Utah — 4
L. Garner, Mobile — 3
P. Hanley, Peoria — 3

President's Honor Roll

AWS Members sponsoring 1 or 2 new Individual Members. Only those sponsoring 2 AWS Individual Members are listed.

J. Compton, San Fernando Valley
R. Gaffney, Tulsa
H. Jackson, L.A/Inland Empire
J. Johnson, Northern Plains
D. Landon, Iowa
F. Schmidt, Niagara Frontier
P. Zammit, Spokane

Student Member Sponsors

Members sponsoring 3 or more new AWS Student Members.

G. Euliano, NW Pa. — 34
R. Evans, Siouxland — 34
G. Seese, Johnstown-Altoona — 19
T. Zablocki, Pittsburgh — 15
C. Overfelt, Southwest Virginia — 14
A. Stute, Madison-Beloit — 14
R. Munns, Utah — 12
R. Tully, San Francisco — 10
P. Bedel, Indiana — 9
D. Williams, North Texas — 9
W. Komlos, Utah — 8
A. Badeaux, Washington D.C. — 7
R. Hutchison, Long Bch./Or. Cty. — 7
J. Boyer, Lancaster — 6
E. Norman, Ozark — 6
B. Wenzel, San Francisco — 6
B. Hardin, San Francisco — 5
J. Angelo, El Paso — 4
D. Vranich, North Florida — 4
N. Carlson, Idaho/Montana — 3
R. Olesky, Pittsburgh — 3
C. Rossi, Washington, D.C. — 3
D. Zabel, Southeast Nebraska — 3 ♦

New AWS Supporters

Sustaining Company

Loadcraft Industries, Ltd.
3811 North Bridge
Brady, TX 76825
Representative: **Kenneth Richardson**
www.loadcraft.com

Loadcraft Industries is an internationally known manufacturing facility specializing in building mobile drilling rigs and trailers. The company is committed to the uncompromising engineering and production of oil field equipment and excellent customer service. The facility includes a state-of-the-art machine shop, three weld production lines, on-site testing areas, a vast warehouse, indoor assembly area, and local administrative officers. With the given infrastructure, the company has the ability to meet each customer's specific needs to insure them the ability to compete in the oil field industry.

Supporting Companies

Falcon Industries, Inc.
2455 S. Leonine
Wichita, KS 67217

Int'l Welding Electrodes Pvt. Ltd.
Plot No. 4, Sector 12/C, North Karachi
Ind. Area, Karachi, Sindh, Pakistan

Welding Distributors

Dressel Welding Supply, Inc.
20 Prestige Ln.
Lancaster, PA 17347

General Air Service & Supply
1105 Zuni St.
Denver, CO 80204

Welders Choice Warehouse, Inc.
805 N. Gordon
Alvin, TX 77511

Educational Institutions

Anuptech Tech & Trade Accred. Inst.
R-84, TTC Ind. Area, MIDC, Rabale, Navi,
Mumbai, Maharashtra 400701, India

Florida Keys Community College
5901 College Rd.
Key West, FL 33040

Institute for Construction Education
2353 Federal Dr.
Decatur, IL 62526

Tennessee Tech. Center at Hohenwald
813 W. Main St.
Hohenwald, TN 38462

Tennessee Tech. Center at Whiteville
1685 Hwy. 64
Whiteville, TN 38075

Whitewater Tech. Career Center
1300 Spartan Dr.
Connersville, IN 47331

Membership Counts

Member Grades	As of 10/1/07
Sustaining	469
Supporting	292
Educational	438
Affiliate	407
Welding distributor	52
Total corporate members	**1,658**
Individual members	47,068
Student + transitional members	5,164
Total members	**52,232**

SECTION NEWS

DISTRICT 1
Director: Russ Norris
Phone: (603) 433-0855

MAINE
AUGUST 25
Activity: The Section conducted examinations for 40 applicants for the CWI and 9-year certifications. The exam proctors included District 1 Director **Russ Norris** and his daughters **Nissa** and **Teila Norris,** and **Art Gallant,** Maine Section past chairman. The exam was held at Holiday Inn in West Portland, Maine.

DISTRICT 2
Director: Kenneth R. Stockton
Phone: (732) 787-0805

PHILADELPHIA
AUGUST 13
Activity: The Section board members, led by Chairman **John DiSantis,** toured Sheet Metal Workers Local Union 19 in Philadelphia, Pa. **Charles McClure,** training coordinator/director, conducted the program assisted by the facility's six, AWS CWI-certified, welding instructors. Highlights included the well-equipped welding shop, computer-aided-design training rooms, and testing areas. Participating were instructors-CWIs **Robert Day, John Tenuto, John Weimer, Ed Levering, Bill Coates,** and **Paul Romano;** journeyman **Bill Tustin;** and apprentice **Kurt Heilner.**

Shown at the Philadelphia Section's tour of Sheet Metal Workers Local Union 19 are (from left) Robert Day, John Tenuto, Bill Tustin, John Weimer, Section Chair John DiSantis, speaker Charles McClure, Kurt Heilner, Ed Levering, Bill Coates, and Paul Romano.

DISTRICT 3
Director: Alan J. Badeaux Sr.
Phone: (301) 753-1759

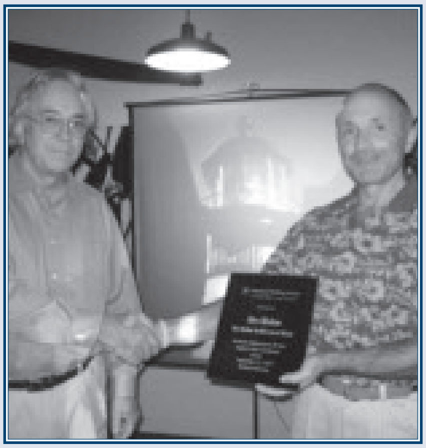
Upcoming Casino Night Event
MAY 17, 2008
Activity: The York-Central Pennsylvania Section will host the District-wide Casino Night fund-raising event to benefit the District 3 scholarship named for **Shirley Bollinger,** an AWS past president, advocate for furthering students' educations, and former member of the Section. The evening will feature games of chance, door prizes, dinner buffet, silent and live auctions, music, dancing, and other entertainment and activities. For more information on the activity and ways to support the event and the scholarship program, e-mail **Claudia Bottenfield** at *cbottenfield@dressel1.com*

Carts at the ready, 128 golfers amass for the annual York-Central Pennsylvania Section event in August.

The winning team members at the York-Central Pennsylvania Section golf outing are (from left) Tony Kaz, Johnstown-Altoona Section Chair Bart Sickles, District 7 Director Don Howard, and Tyler Williams.

YORK-CENTRAL PA.
AUGUST 17
Activity: The York-Central Pennsylvania Section hosted its annual golf outing at Cool Creek Golf Club in Wrightsville, Pa. District 7 Director **Don Howard,** District 3 Director **Alan Badeaux,** and Johnstown-Altoona Section Chair **Bart Sickles** were special guests. The event attracted 128 contenders. The winning team included **Don Howard, Bart Sickles, Tony Kaz,** and **Tyler Williams.**

Shown are the members and guests at the Florida West Coast program in September.



Alex Klahm (left) receives a speaker's appreciation plaque from Al Sedory, Florida West Coast Section chairman.

DISTRICT 4

Director: Roy C. Lanier
Phone: (252) 321-4285

DISTRICT 5

Director: Leonard P. Connor
Phone: (954) 981-3977

FLORIDA WEST COAST

SEPTEMBER 12
Speaker: **Alex Klahm,** owner
Affiliation: Architectural Metal and Design, Inc.
Topic: Restoring historic metal work
Activity: Section Chair **Al Sedory** presented Klahm a plaque of appreciation. The program was held in Tampa, Fla.

DISTRICT 6

Director: Neal A. Chapman
Phone: (315) 349-6960

DISTRICT 7

Director: Don Howard
Phone: (814) 269-2895

PITTSBURGH

Calendar

NOVEMBER 15: **Jim Pellegrino** of R. J. Lee's Facility will discuss "What Fracture Surfaces Reveal about Welding."

DECEMBER 7: Student Weld Off Competition with the Boiler Makers.

DECEMBER 11: Board meeting.
Contact **Peter Kinney** at (412) 503-4109; *peter.kinney@us.bureauveritas.com.*

DISTRICT 8

Director: Wallace E. Honey
Phone: (256) 332-3366

CHATTANOOGA

Activity: The Section elected its incoming slate of officers. Named were **William Brooks,** chair; **Eric Zumbrun** and **Dusti L. Jones,** vice chairs; **Gerald Hargis,** secretary and *Buzz Box* editor; **Don Russell,** treasurer; **Eric Zumbrun,** program chair; **Greg Wilmoth,** membership committee chair; **Delbert Butler,** technical representative; **David Hamilton,** chair of certification, education, student affairs, and scholarships; **Dusti L. Jones,** publicity chair; and **Ronnie Smith** awards chair.

NASHVILLE

Activity: The Section elected its incoming slate of officers. Named were **Roy Petty,** chairman; **Ken Lloyd** and **Delbert Stone,** vice chairs; **Jeff Ross,** secretary-treasurer; **Joe Livesay,** education committee chair; and **Mohammed Ismaili,** awards chair.

Calendar: Dec. 7 Party

Holiday party, Cherokee Steak House, Lebanon, Tenn. Make reservations now. Contact **Bob O'Neal** at *bob@worldtesting.com;* (615) 754-4147, ext. 23.

DISTRICT 9

Director: George D. Fairbanks
Phone: (225) 673-6600

DISTRICT 10

Director: Richard A. Harris
Phone: (440) 338-5921

District 10 Council

JULY 10
Activity: The AWS District 10 Education Advisory Council held a meeting to finalize its mission statement, goals, and basic function. Selected was the statement: *Our mission is to educate the community about the opportunities and benefits that a career in welding and related occupations create for the young people who reside in District 10.* The council's function is to increase the effectiveness of welding instructors in District 10 with a proactive program including personal visitations and support. The participating members of the council are District 10 Director **Richard Harris, Scott Burdge, Rob Davis, Dave Hughes, Huck Hughes, Larry Klemens, John Nesta,** and **Dennis Klingman.**

MAHONING VALLEY

AUGUST 3
Activity: The Section hosted its 32nd annual Jim Best golf outing at Knoll Run Golf Course in Lowellville, Ohio. **Leon Stitt, Kevin Krieger, Chuck Moore,** and **Carl Ford** served on the planning committee. The hole sponsors included Airgas Great Lakes, Avesta Polarit, Brilex Ind., Cedar Steel, City Machine, Columbiana Boiler, Diamond Steel, ESAB, Falcon Foundry, Kobelco, Hobart, Lincoln, Miller, Northeast Fab, Praxair, Reichard Ind., Specialty Fab, Spectrochemical, Steel & Alloy, Stoody, Tillman, Timken Ind. Services, Tweco/Arcair, United Abrasives, Valley National Gas, and Youngstown Oxygen.

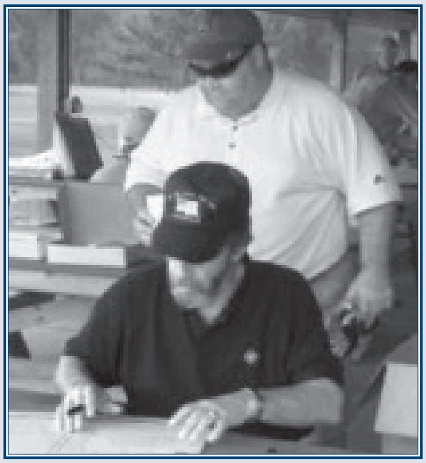
DISTRICT 11

Director: Eftihios Siradakis
Phone: (989) 894-4101

DETROIT

SEPTEMBER 13
Activity: The Section held its annual student night program at Macomb Community College in Warren, Mich. The college presented an education initiative, No Welder Left Behind, a review of its programs and partnerships designed for the Michigan economy. **Joseph L. Petrosky,** assoc. dean of applied technology, automotive and technical education, and **John E. Kacir,** professor, materials joining applied technology, headed the program. The Section presented 26 scholarships totaling $34,000 to students from state postsecondary welding schools. About 125 members and guests attended the event.

Detroit Section Past Chair Don DeCorte (right) celebrates with his son, Bryan, after learning Bryan won one of the 26 Detroit Section scholarships.



Shown preparing for the Mahoning Valley Section golf outing are Leon Stitt (front) and Kevin Krieger.

Shown at the Lakeshore Section tour of Bay Shipbuilding are General Foreman Dennis Mueller (left) and Section Chairman James Hoffman.

DISTRICT 12

Director: Sean P. Moran
Phone: (920) 954-3828

District Director Awards

District 12 Director **Sean Moran** has nominated the following members to receive the 2006–2007 District 12 Director Award:

Al Sherrill, *Fox Valley*
Ken Karwowski, *Racine-Kenosha*
Lloyd Cudnohufsky, *Upper Peninsula*
Anton Stute, *Madison Area T. C.*

The District Director Award provides a means for District Directors to recognize individuals who have contributed their time and effort to the affairs of their local Section and/or District.

Detroit Section Technical Program Chair Mark Rotary (left) presents speaker gifts to John E. Kacir (center) and Joseph L. Petrosky at the students' night program held in September.

LAKESHORE

SEPTEMBER 13
Activity: The Section members and guests toured Bay Shipbuilding Co. in Sturgeon Bay, Wis., to study its welding and construction techniques. **Dennis Mueller,** general foreman, conducted the program. Highlights were the semiautomatic submerged arc welding systems used in the fabrication of Great Lakes and ocean-going vessels, and a trip through a nearly completed 425-ft-long barge. The dinner and business meeting were held at Birmingham's Bar and Restaurant.

Shown at the Chicago Section's Brookfield Zoo outing are (from left) Jeff Stanczak, Chair Craig Tichelar, and Hank Sima, vice chair.

Chuck Moore (left) and Carl Ford are shown at the Mahoning Valley golf outing.

DISTRICT 13

Director: W. Richard Polanin
Phone: (309) 694-5404

CHICAGO

AUGUST 15
Activity: The Section held an executive board meeting to finalize plans for the upcoming year's activities. In attendance were Chair **Craig Tichelar, Peter Host, Chuck Hubbard,** Treasurer **Marty Vondra, Eric Krauss,** and **Cliff Iftimie.**

AUGUST 19
Activity: The Chicago Section hosted its annual outing to the Brookfield Zoo for 80 members and guests.

SEPTEMBER 12
Speaker: **David Griffith**
Affiliation: Alloy Welding Services, Inc.
Topic: Welding inspection
Activity: **Marty Vondra** received the past chairman's award from Chicago Section Chair **Craig Tichelar.** AWS Past President **Jim Greer** received the District Educator Award.

DISTRICT 14

Director: Tully C. Parker
Phone: (618) 667-7744

INDIANA

AUGUST 16
Activity: The Section held a planning and organizing meeting at Jonathan Byrd's Cafeteria in Greenwood, Ind. **Joe Daumeyer** received an award in recognition of his support for the Section's activities. See photo on next page.

Shown at the August 15 Chicago Section board meeting are (from left) Peter Host, Chair Craig Tichelar, Chuck Hubbard, Treasurer Marty Vondra, Eric Krauss, and Cliff Iftimie.

Shown September 12 at the Chicago Section program are (from left) speaker David Griffith, Vice Chair Hank Sima, Chairman Craig Tichelar, and Past Chair Marty Vondra.

Past AWS President Jim Greer (left) accepts the District Educator Award from Craig Tichelar, Chicago Section chair, at the September program.

Joe Daumeyer (left) receives an award from Gary Dugger, Indiana Section chair, for his support for the Section's activities.

DISTRICT 15

Director: Mace V. Harris
Phone: (952) 925-1222

DISTRICT 16

Director: David Landon
Phone: (641) 621-7476

DISTRICT 17

Director: Oren P. Reich
Phone: (254) 867-2203

NORTH TEXAS

SEPTEMBER 18
Speaker: **Pete Shabay**
Affiliation: Airgas, Brownwood, Tex.
Topic: Using oxyfuel technology for metal repair applications
Activity: Shabay offered a hands-on demonstration of various oxyfuel welding techniques for repairing and heat-treating steels.

Pete Shabay demonstrated oxyfuel welding techniques for the North Texas Section.

DISTRICT 18

Director: John L. Mendoza
Phone: (210) 353-3679

DISTRICT 19

Director: Neil Shannon
Phone: (503) 201-5142

DISTRICT 20

Director: William A. Komlos
Phone: (801) 560-2353

IDAHO/MONTANA

SEPTEMBER 6
Speaker: **Phillip Finck,** assoc. lab director for nuclear science and technology
Affiliation: Idaho National Laboratory
Activity: The Idaho Section of the American Nuclear Society invited the Section to learn the latest on the Department of Energy's new initiative, the Global Nuclear Energy Partnership (GNEP). This partnership advances peaceful uses of nuclear power through improved international collaboration. Recognized were the Section's 2007–2008 Section scholarship recipients: **Nolan McGhehey** of WyoTech, **Joseph Filler** of Lewis-Clark State College, and **Tanner Fike** of Montana Tech College of Technology.

DISTRICT 21

Director: Jack D. Compton
Phone: (661) 362-3218

DISTRICT 22

Director: Dale Flood
Phone: (916) 933-5844

AWS Foundation Prepares for Its Best Silent Auction at the FABTECH Int'l & AWS Welding Show

The AWS Foundation solicits gift cards and products to be sold during its 7th Silent Auction, to be held during the FABTECH International & AWS Welding Show, Nov. 11–14, in Chicago, Ill. These items will be available for bid at the Show, and all proceeds will go to benefit the AWS Foundation scholarship programs.

To participate in the Silent Auction, you may either purchase a gift card for $200 or $250 yourself, then donate the card to the Foundation. Or you may send a check for the amount of your donation to the Foundation, and a gift card will be purchased in your name.

With the holidays coming soon after the Show, these gifts can be a great way for Show attendees to do some of their holiday gift shopping early.

To learn more about the AWS Foundation or support the Silent Auction, contact Nazdhia Prado-Pulido, (800) 443-9353, ext. 250; *nprado-pulido@aws.org*.

Silent Auction Supporters

ABICOR Binzel Corp.
Home Depot gift card
AWS Chattanooga Section
Various restaurant gift cards
AWS Cincinnati Section
Nordstrom gift cards
AWS Dayton Section
Legal Sea Foods gift cards
AWS Drake Well Section
Bath & Body Works gift cards
AWS L.A./Inland Empire Section
Omaha Steaks gift cards
AWS Northwest Section
Various restaurant gift cards
AWS Northwest Pennsylvania Section
Bed, Bath & Beyond gift cards
AWS St. Louis Section
Honey Baked Ham Co. gift certificates
AWS San Antonio Section
Tony Roma's gift cards
AWS Tulsa Section
Coach gift cards
AWS Twin Tier Section
JC Penney gift card
Rick Polanin, District 13 director
Gibson Steak House gift card
Nancy and Barry Carlson
Cabela's gift card
Dengensha America Corp.
Calif. Pizza Kitchen, Giordano's cards
Wayne Engeron
Macy's and Tiffany & Co. gift cards
Sam Gentry
Bass Pro Shops gift cards
Hobart Brothers Company
Bass Pro Shops gift card
Hypertherm, Inc.
Green Mt. Coffee Roasters cards
IWDC, Inc.
Barnes & Noble gift cards
The Lincoln Electric Co.
Company store gift certificates
Mathey Dearman, Inc.
Godiva Chocolatier gift cards
Miller Electric Mfg. Co.
Arc Armor safety package
Carol and Tom Mustaleski
Victoria's Secret gift cards
Pferd, Inc.
Williams-Sonoma gift cards
Scotchman Industries
Ruth's Chris gift cards
Select-Arc, Inc.
1584-lb, Select 720 wire, E71T-1
Sellstrom Mfg. Co.
Autodarkening welding helmets
Sandy and Ray Shook
Target gift card
Jeff Weber
Framed wildlife photographs
WESCO Gas & Welding Supply, Inc.
Best Buy gift cards
Howard M. Woodward
Disney gift cards

How to Benefit Yourself and the AWS Foundation Too

A charitable gift annuity with the AWS Foundation will guarantee you a valuable tax benefit, a contracted fixed payment for you, or for you and another individual, while ensuring a gift to the AWS Foundation. The AWS Foundation, as the beneficiary of an irrevocable charitable donation, can enter into an agreement to pay you an income for life.

The rate of return is determined using tables provided by the National Committee on Gift Annuities based on the donor's age and the amount of the donation. The rate of return is fixed and does not vary for the life of the annuitant(s).

The donor may also delay the payments coming to the annuitant to a more convenient time, while enjoying the tax benefits at the time of the gift. This option is called a Deferred Gift Annuity. Payments with this type of annuity are started on the date the donor provides. Like the Charitable Gift Annuity, payments are made to the annuitant for life.

For complete information on the programs, request a copy of the *Donor's Guide.* Contact **Sam Gentry** at (800) 443-9353, ext. 331, or **Vicki Pinsky,** ext. 212. Invest in the AWS Foundation to show your support for welding education.♦

Be a Tech Volunteer

Share your expertise by contributing to the development of AWS standards. Volunteers are needed by the J1 Committee on Resistance Welding Equipment, to help prepare standards related to RW consumables, components, and machinery. Contact A. Alonso, (800) 443-9353, ext. 299; *aalonso@aws.org*.

Volunteers are also sought to serve on the D1I Subcommittee on Reinforcing Bars to help revise D1.4, *Structural Welding Code — Reinforcing Steel.* You can submit your membership application online at *www.aws.org/w/s/technical/*. To learn more about this committee's work, contact S. Morales, (800) 443-9353, ext. 313; *smorales@aws.org*.

The Christoffels Celebrate Golden Anniversary

Bob and Mary Christoffel are shown toasting each other at a party recently held in their honor by their family members to celebrate the couple's 50th wedding anniversary.

Bob Christoffel is an AWS Honorary Member and a Fellow of the Society.

He chaired the Northern New York Section (1957–1958), and currently chairs the Section's education committee, publicity committee, and program committee.

Christoffel is also a past chair of the AWS Technical Activities Committee and has served as an AWS director-at-large.

Guide to AWS Services

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

AWS PRESIDENT

Gerald D. Uttrachi
guttrachi@aol.com
WA Technology, LLC
4313 Byrnes Blvd., Florence, SC 29506

ADMINISTRATION

Executive Director
Ray W. Shook.. *rshook@aws.org* ....(210)

CFO/Deputy Executive Director
Frank R. Tarafa.. *tarafa@aws.org* ....(252)

Deputy Executive Director
Cassie R. Burrell.. *cburrell@aws.org* .....(253)

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

Executive Assistant for Board Services
Gricelda Manalich.. *gricelda@aws.org* ....(294)

Administrative Services

Managing Director
Jim Lankford.. *jiml@aws.org* ....(214)

IT Network Director
Armando Campana..*acampana@aws.org* ...(296)

Director
Hidail Nuñez..*hidail@aws.org* ....(287)

Human Resources

Director, Compensation and Benefits
Luisa Hernandez.. *luisa@aws.org* ....(266)

Manager, Human Resources
Dora Shade.. *dshade@aws.org* ....(235)

INT'L INSTITUTE of WELDING

Senior Coordinator
Sissibeth Lopez . . *sissi@aws.org* ....(319)
Provides liaison services with other national and international professional societies and standards organizations.

GOVERNMENT LIAISON SERVICES

Hugh K. Webster. . . *hwebster@wc-b.com*
Webster, Chamberlain & Bean, Washington, DC
(202) 466-2976; FAX (202) 835-0243
Identifies funding sources for welding education, research, and development. Monitors legislative and regulatory issues of importance to the industry.

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)

CONVENTION and EXPOSITIONS

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

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

PUBLICATION SERVICES

Department Information ....(275)
Managing Director
Andrew Cullison.. *cullison@aws.org* .....(249)

Welding Journal

Publisher/Editor
Andrew Cullison.. *cullison@aws.org* .....(249)

National Sales Director
Rob Saltzstein.. *salty@aws.org* ....(243)

Society and Section News Editor
Howard Woodward..*woodward@aws.org* .(244)

Welding Handbook

Welding Handbook Editor
Annette O'Brien.. *aobrien@aws.org* .....(303)
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

Director
Ross Hancock.. *rhancock@aws.org* .....(226)

Assistant Director
Adrienne Zalkind.. *azalkind@aws.org* ....(416)

MEMBER SERVICES

Department Information ....(480)

Deputy Executive Director
Cassie R. Burrell.. *cburrell@aws.org* .....(253)

Director
Rhenda A. Mayo... *rhenda@aws.org* .....(260)
Serves as a liaison between Section members and AWS headquarters. Informs members about AWS benefits and activities.

CERTIFICATION SERVICES

Department Information ....(273)
Managing Director
Peter Howe.. *phowe@aws.org* ....(309)

Director, Operations
Terry Perez.. *tperez@aws.org* ....(470)
Directs the department operations.

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.

Senior Manager, Certification Programs
Frank Lopez Del Rincon. *flopez@aws.org* (258)
Manages all national certification programs, including Accredited Test Facilities.

EDUCATION SERVICES

Managing Director
Dennis Marks.. *dmarks@aws.org* ....(237)

Director, Education Services Administration and Convention Operations
John Ospina.. *jospina@aws.org* ....(462)

Director, Education Product Development
Christopher Pollock.. *cpollock@aws.org* .(219)
Coordinates in-plant seminars and workshops. Administers the SENSE program. Assists Government Liaison Committee and Education Committees. Also responsible for conferences, exhibitions, and seminars. Organizes CWI, SCWI, and 9-year renewal certification-driven seminars.

AWS AWARDS, FELLOWS, COUNSELORS

Senior Manager
Wendy S. Reeve.. *wreeve@aws.org* ......(293)
Coordinates AWS awards and AWS Fellow and Counselor nominees.

TECHNICAL SERVICES

Department Information ....(340)
Managing Director
Andrew R. Davis.. *adavis@aws.org* ......(466)
Int'l Standards Activities, American Council of the Int'l Institute of Welding (IIW)

Director, National Standards Activities
John L. Gayler.. *gayler@aws.org* ....(472)
Personnel and Facilities Qualification, Computerization of Welding Information, Arc Welding and Cutting

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

Technical Publications
AWS publishes about 200 documents widely used throughout the welding industry.
Senior Manager
Rosalinda O'Neill.. *roneill@aws.org* .....(451)

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

Stephen Borrero.. *sborrero@aws.org* .....(334)
Welding Iron Castings, 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

Brian McGrath . *bmcgrath@aws.org* .....(311)
Methods of Inspection, Mechanical Testing of Welds, Welding in Marine Construction, Piping and Tubing

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

Kim Plank.....*kplank@aws.org* ....(215)
Machinery and Equipment Welding, Robotic and Automatic Welding, Sheet Metal Welding, Thermal Spray

Reino Starks...*rstarks@aws.org* ....(304)
Welding in Sanitary Applications, High-Energy Beam Welding, Aircraft and Aerospace, Friction Welding, Railroad Welding.

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 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 Damian J. Kotecki, chair, National Nominating Committee.

The next meeting of the National Nominating Committee is scheduled for November 2007. The terms of office for candidates nominated at this meeting will commence January 1, 2009.

Honorary Meritorious Awards

The Honorary-Meritorious Awards Committee makes recommendations for the nominees presented for Honorary Membership, National Meritorious Certificate, William Irrgang Memorial, and the George E. Willis Awards. These awards are presented during the FABTECH International & AWS Welding Show held each fall. The deadline for submissions is December 31 prior to the year of 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 the awards follow.

National Meritorious Certificate Award: This award is given in recognition of the candidate's counsel, loyalty, and devotion to the affairs of the Society, assistance in promoting cordial relations with industry and other organizations, and for the contribution of time and effort on behalf of the Society.

William Irrgang Memorial Award: This award is administered by the American Welding Society and sponsored by The Lincoln Electric Co. to honor the late William Irrgang. It is awarded each year to the individual who has done the most over the past five-years to enhance the American Welding Society's goal of advancing the science and technology of welding.

George E. Willis Award: This award is administered by the American Welding Society and sponsored by The Lincoln Electric Co. to honor George E. Willis. It is awarded each year to an individual for promoting the advancement of welding internationally by fostering cooperative participation in areas such as technology transfer, standards rationalization, and promotion of industrial goodwill.

International Meritorious Certificate Award: This award is given in recognition of the recipient's significant contributions to the worldwide welding industry. This award reflects "Service to the International Welding Community" in the broadest terms. The awardee is not required to be a member of the American Welding Society. Multiple awards can be given per year as the situation dictates. The award consists of a certificate to be presented at the awards luncheon or at another time as appropriate in conjunction with the AWS president's travel itinerary, and, if appropriate, a one-year membership in the American Welding Society.

Honorary Membership Award: An Honorary Member shall be a person of acknowledged eminence in the welding profession, or who is accredited with exceptional accomplishments in the development of the welding art, upon whom the American Welding Society sees fit to confer an honorary distinction. An Honorary Member shall have full rights of 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)
(305) 824-1177; FAX (305) 826-6195

Welding Journal Reprints

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

Custom reprints of *Welding Journal* articles, in quantities of 100 or more, may be purchased from
FosteReprints
Toll-free (866) 879-9144, ext. 121
sales@fostereprints.com

AWS Foundation, Inc.

The AWS Foundation 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.

Chairman, Board of Trustees
Ronald C. Pierce

Executive Director, AWS
Ray Shook

Executive Director, Foundation
Sam Gentry

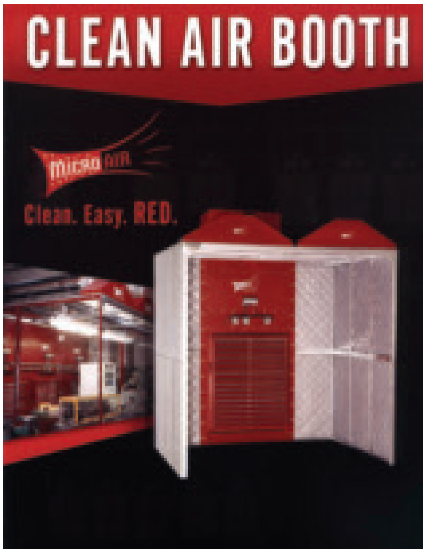
550 NW LeJeune Rd., Miami, FL 33126
(305) 445-6628; (800) 443-9353, ext. 293
general information:
(800) 443-9353, ext. 689; *vpinsky@aws.org*

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 possible. The Society welcomes your suggestions. Please contact any staff member or AWS President Gerald D. Uttrachi, as listed on the previous page.

Clean Air Booths Detailed in Brochure



A well-illustrated brochure includes facts and specifications on the company's entire line of modular clean air booths ranging from 8 ft on a side to 16 × 8 × 8 ft, and custom sizes from 4 to 120 ft wide. Detailed are the features of the company's high-capacity 4500 ft^3/min blower assembly, spark-arresting baffle inlet, and quiet operation. Described is the Roto-Pulse™ continuous-cleaning cartridge system offering maximum efficiency. Many photos and diagrams display various applications for the products.

Micro Air
www.microaironline.com
(866) 566-4276

Text Covers Metallographic Specimen Preparation

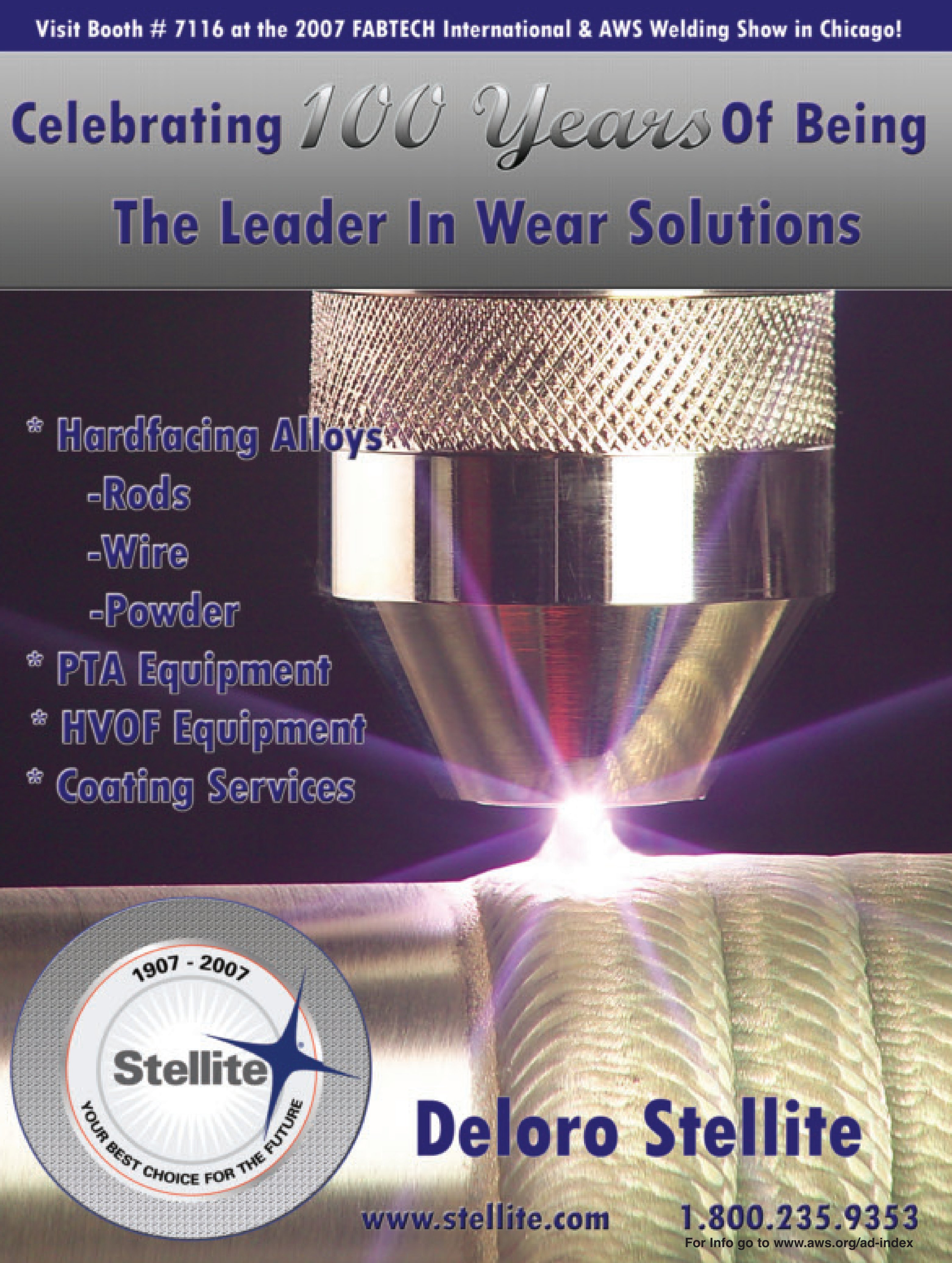
Manual 46, *Metallographic and Materialographic Specimen Preparation, Light Microscopy, Image Analysis and Hardness Testing,* covers the important aspects of the specimen preparation process, image analysis, and hardness testing, and provides directions for establishing a modern metallographic/materialographic laboratory. The 600-page, hard-cover, 6- × 9-in. manual lists for $117. Included is a CD-ROM with document summaries of 87 ASTM standards, plus E 2014, *Standard Guide on Metallographic Laboratory Safety;* E 140, *Standard Conversion Tables for Metals;* and *SI Quick Reference Guide: International System of Units (SI).*

ASTM International
www.astm.org
(610) 832-9585

Radio Earmuff Safety Discussed in Bulletin

A bulletin published by the company's Hearing Safety Group presents technical information on new earmuff models featuring built-in AM/FM radios that can be used in industrial settings for effective hearing protection. A table is provided showing typical total effective exposure for a radio earmuff worn in 90 and 100 dB of noise. Also described is the method used to calculate the effective noise level from the measured ambient noise and

— continued on page 170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AWS Hot Wire Welding and Cladding Conference
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November 13, 2007

Hot Wire Gas Tungsten Arc Welding–An Overview of Process Applications and Capabilities
Jonathan T. Salkin, President, Arc Applications, Inc., York, PA

The hot wire gas tungsten arc welding process has found increasing use over a wide range of groove welding, buildup and cladding operations. Commercially available and specialized hot wire equipment continues to promote application of the process for producing high-quality welds in industries including nuclear, power generation, pressure vessel and offshore oil.

Applications will be presented to show the process capabilities, characteristics, benefits and limitations. Examples of process control and variations to consider will be discussed based on welding requirements, materials, process variables, weld design and inspection.

Hot Wire Narrow Groove Welding and Cladding with Nickel-Based Alloys
Jeff M. Kikel, Manager, Weld Engineering, BWX Technologies, Inc., Nuclear Operations Division, Barberton, OH

Where a considerable amount of work is directed toward pressure vessel fabrication, hot wire gas tungsten arc welding is used extensively for the narrow gap welding of nickel-based alloys. The hot wire process is also used for buildups, butterings, and cladding of high-strength low alloy steel.

Hot Wire GTAW - Practical Considerations and Applications
Tom Rankin, Vice President and General Manager, ITW Jetline Engineering, Irvine, CA

This talk will cover the early development of the process along with basic theory and important variables. Justification for the use of hot wire process and equipment requirements will be presented. Application examples of successful cladding, joining, and deep groove using stainless and Inconel will be presented.

New Advances in Hot Wire Cladding Applications
Daniel Allford, President, ARC Specialties, Houston, TX
This presentation will be a discussion of recent advances in plasma, variable polarity, as well as new configurations for automatic cladding. New programming techniques for bore cladding will also be discussed.

Wire Surface Condition Impacts Hot Wire Weld Quality
Harry Wehr, Technical Director, Arcos Industries, LLC, Mt. Carmel, PA

The surface condition of the welding wire used to make hot wire overlay deposits can impact the quality and integrity of the weld in several ways. A detailed study of 625 welding wire used for hot wire applications has shown that there are three major areas where wire surface condition can impact deposit integrity: surface roughness, residual contaminants and wire cast. If the weld deposit must be clean and defect free, each of these areas must be addressed.

Observations from Gus Manz, Inventor of Hot Wire Welding
Gus Manz, President, A. F. Manz Associates, Union, NJ

Hear from the inventor himself, who was awarded a patent on the hot wire welding process on February 25, 1964.

Observations from Frtiz Saenger, Member of the Original Hot Wire Welding Research Team
Fritz Saenger, Consultant, Columbus, OH

Listen to the observations of a member of the original research team for the hot wire welding process.

Welding and Cladding in the Oil and Gas Industry
Don Schwemmer President, AMET Inc., Rexburg, ID and Galen Wright, President, Arc Innovations Inc., Edmonton, AB, Canada

In response to some of the requirements by the oil and gas industry in Canada, a company is narrow groove welding 1.5- to 2 in.-thick 2205 duplex stainless steel, and cladding 625 Inconel tubulars.

The Benefits of Hot Wire GTAW in the Orbital Welding Industry
Rob Pistor, Managing Director, Liburdi Engineering, Dundas, ON Canada

Several applications and issues will be discussed, including narrow groove welding, overlay cladding, nuclear canister closure welding, and 1G vs. 5G parameters.

Conference price is $345 for members of AWS, FMA, SME or NAM, $480 for nonmembers. To receive a descriptive brochure, call (800) 443-9353 ext. 455, (outside North America, call 305-443-9353), or visit www.aws.org

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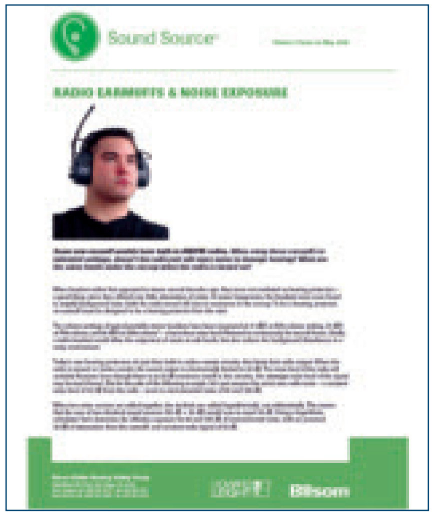

radio noise levels. Download the bulletin (PDF) from the Web site.

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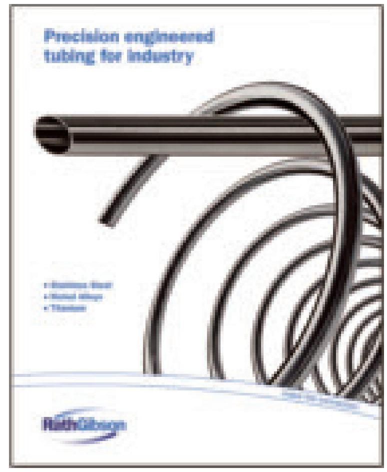
Pipe and Tube Detailed in Brochure

The 42-page corporate brochure provides complete technical information about pipe and tube products for the oil and gas, chemical, petrochemical, power-generation, food, pharmaceutical, and medical industries. Detailed are stainless steels, titanium, duplex stainless steel, superaustenitics, superferritics, and ferritic steels. Product tables include tube weight for austenitic stainless steels, weight conversion factors, general alloy specifications, pipe weights and size range, titanium tubing in lb/ft, physical properties of alloys in the annealed condition, estimated internal burst pressures for Types



304 and 316 stainless steel tubing at ambient temperature, and compositions (%) for stainless and duplex steels, nickel and titanium alloys, and superaustenitic and superferritics. The brochure (PDF) can be downloaded from the Web site.

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Arc Welding Guns Pictured

The company's complete line of Magnum® guns for semiautomatic gas shielded gas metal arc welding are illustrated and detailed in a 52-page, full-color, three-hole-punched brochure No. E12.10. Shown are guns rated from 100 to 600 A, for use with wire diameters from 0.25 to 0.12 in. Pictured and cataloged are numerous consumables, including contact tips, gas nozzles, gas diffusers, cable liners, and gun connectors.

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Hobart Institute Names Two to Key Posts


Janet Piechocki


Bob Fisher

Hobart Institute of Welding Technology, Troy, Ohio, has named **Janet Piechocki** admissions representative, and **Bob Fisher** campus security officer. Piechocki, a former student at the Institute, will present guided tours of the facilities and speak to students in Ohio, West Virginia, Kentucky, Indiana, Michigan, and Pennsylvania about careers in welding. Fisher was with Hobart Brothers Co. for 23 years in various positions before joining the Institute in 2002. Most recently he served as a staff instructor and admissions representative at the Institute.

Kotecki Retires from Lincoln Electric

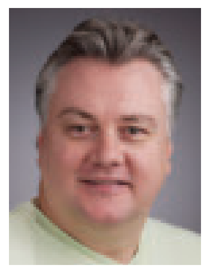

Damian Kotecki

Damian J. Kotecki retired August 31 from The Lincoln Electric Co., Cleveland, Ohio. He served the company for 18 years, most recently as technical director for stainless and high-alloy product development. Dr. Kotecki, a past president of the American Welding Society, intends to remain active with AWS, IIW, ISO, and other volunteer organizations, and to continue writing his Stainless Q&A column for the *Welding Journal*. Currently, he is establishing his own business, Damian Kotecki Welding Consultants, Inc., *damiankotecki@msn.com;* (440) 255-2065.

Bax Retires from Cee Kay

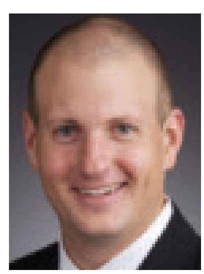
Hil Bax has retired after 47 years with Cee Kay Supply, Inc., St. Louis, Mo., a welding supplies and gases distributor. Bax served as AWS District 14 director 1998–2003, and served the St. Louis Section as chairman (1987–1989), vice chair, program chair, certification chair, and technical representative. During his career he held a variety of positions, including fill plant operator, truck driver, sales representative, director of contractor/technical sales, and most recently St. Louis sales manager. In his honor, the company has renamed its tech center the Hil Bax Tech Center.

Thermadyne Appoints VP and Marketing Manager


Terry Moody

Thermadyne Industries, Inc., St. Louis, Mo., has appointed **Terry A. Moody** executive vice president of global operations, and named **Tom Wermert** marketing manager for Americas Arc Welding. Previously, Moody served Videocon Industries as COO and senior vice president for sales in Europe and the Americas. Wermert previously served the company in various positions, including global product manager for filler metals and director for international marketing.

TurboTorch Names Marketing Manager


Paul Mueller

TurboTorch, St. Louis, Mo., has named **Paul Mueller** marketing/product/sourcing manager. Most recently, Mueller was product manager for Star Manufacturing, a cooking equipment manufacturer.

Thermal Dynamics Fills Key Post

Thermal Dynamics, St. Louis, Mo., has hired **Kent Swart** as market manager, Americas — plasma. Previously, Swart worked 12 years for Diagraph, an ITW company, where he most recently served as product manager for automated labeling.

President Named for New Welding Subsidiary

Air Industries Group, Inc., Bay Shore, N.Y., a holding company, has appointed **Gary Settoducato** president of its new Welding Metallurgy, Inc., subsidiary. Previously, Settoducato was senior executive of Air Industries Machining Corp., the company's primary operating subsidiary.

Doris Ann Buss Moore

Doris Ann Buss Moore

Doris Ann Buss Moore, 45, died October 1 following a courageous bout with cancer. Born in Miami, Fla., she joined the American Welding Society staff in January 1981. During her 26-year career as an office manager and receptionist at the Society's headquarters in Miami, she served as an inspiration to everyone who knew her. Over the years her sunny voice and bright smile greeted thousands of callers and visitors to the Society.

Ms. Moore was nominated by her peers for the prestigious Michael A. Rowland Exemplary Employee of the Year Award. Then AWS President Damian J. Kotecki and AWS Executive Director Ray Shook presented the award to her with the citation, "Doris has the best attitude of any employee. She is always willing to lend a hand and never complains. She does her job with a positive professional attitude and works with great attention to detail. She makes people feel welcome and at ease and never brings a negative attitude to her job, and has been a true inspiration to us all. No one deserves this Award more than Doris Moore."

A passionate NASCAR fan and expert, Ms. Moore will be remembered by many South Florida radio listeners as the First Lady of NASCAR, "Dangerous Doris." She loved spending time with her daughter, family gatherings, going to church, dancing to country music, and playing UNO® with her coworkers at lunch time.

She is survived by her daughter, Tabetha Ann; fiancé, Tom Wienecke; mother, Gaye Goodall; sister, Gini Buss; brother, Eddie Goodall Jr.; and father, Doug Buss.

The family requests donations be made to the Tabetha Ann Moore Trust.

Obituaries

Joel J. Moreau

Joel J. Moreau

Joel J. Moreau, 65, a resident of Thibodaux, La., died Sept. 18. He was the president and CEO of Global X-Ray and Testing Corp., with corporate offices in Morgan City, La. He was an AWS member since 1978.

Mr. Moreau is survived by his wife, Sue, two sons, three daughters, one brother, and ten grandchildren.

Robert B. Collins III

Robert B. Collins III

Robert "Robbie" B. Collins III, 56, of Mooresville, N.C., died April 27 in Statesville, N.C. For the last 22 years, he was president of Kincol Industries, Inc., Charlotte, N.C. He was an AWS member for 25 years, a member of the Gases and Welding Distributors Association (GAWDA), and served with the North Carolina National Guard.

Mr. Collins started his 40-year career in welding at age 16 working for building contractors of Piedmont Welding Supply.

His longtime love was midyear Corvettes. He attended many Corvette shows across the country and was a member of the National Corvette Restorers Society, Southeast Chapter.

Mr. Collins is survived by his mother Sammie, brother Mickey, and niece and nephew Katie and Austin Collins.

Richard McGuire

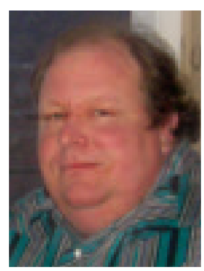
Richard McGuire

Richard McGuire, 62, died September 11. He was manager of training at the National Board of Boiler and Pressure Vessel Inspectors (NBBPVI), Columbus, Ohio. Born in Oklahoma and raised in southern California, Mr. McGuire joined the U.S. Navy at 17. He was discharged in 1970 as a first class petty officer.

Inspired by his father's welding career, he attended California Polytechnic State University where he earned a degree cum laude in welding technology. He worked with the American Society for Nondestructive Testing before joining the NBBPVI in 1987 as manager of training. He is credited with coordinating and expanding the training curriculum at the training center.

Mr. McGuire is survived by his wife, Pam, two children, and two grandsons.

Walter Andrew Zurcher



Walter A. Zurcher

Walter Andrew Zurcher, 47, died August 8. He was an AWS Certified Welding Inspector and a member of the AWS Portland Section where he held the posts of first vice chairman and publicity chair on its executive board. He worked on construction in the Oregon and Washington state area with Mayes Testing Engineers, Lynnwood, Wash.

Mr. Zurcher was born in Sacramento, Calif., and lived in Elk Grove, Calif. He worked in a variety of jobs in his youth, including working with a carnival. He was a journeyman carpenter before becoming a construction inspector, the trade that brought him and his family to the Portland, Ore., area in 1998.

Mr. Zurcher is survived by his wife, Ruth, a sister, and a brother.

TECHNICAL PROGRAM ABSTRACT SUBMITTAL
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Las Vegas, October 6-8, 2008
(Complete a separate submittal for each paper to be presented.)

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Answer the following about this paper
Original submittal? Yes ☐ No☐ Progress report? Yes ☐ No☐ Review paper? Yes ☐ No☐ Tutorial? Yes ☐ No☐
What welding processes are used?
What materials are used?
What is the main emphasis of this paper? Process Oriented ☐ Materials Oriented ☐ Modeling ☐
To what industry segments is this paper most applicable?
Has material in this paper ever been published or presented previously? Yes ☐ No☐
If "Yes", when and where?
Is this a graduate study related research? Yes ☐ No☐
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Keywords: Please indicate the top four keywords associated with your research below

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

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

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

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

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.

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

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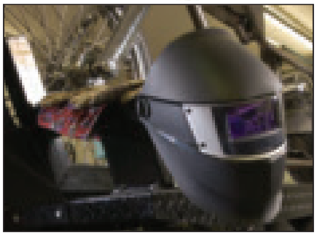

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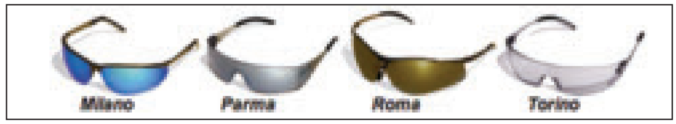

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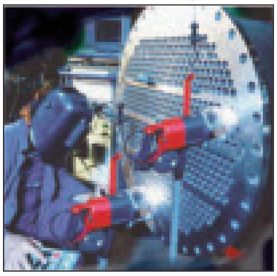

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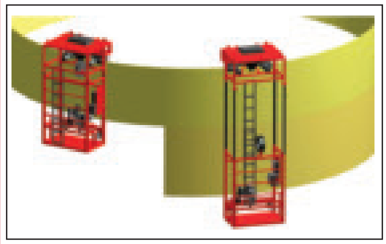

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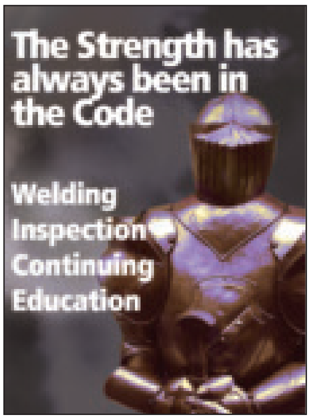

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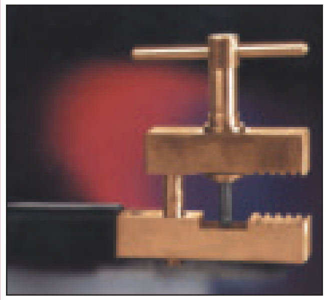

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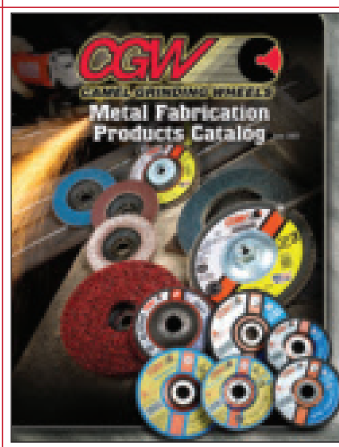

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Fax: (800) 447-3731
www.cgwheels.com

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ATC II™ Automatic Torch Height Control

Computer Weld Technology's new weld torch manipulator control system is capable of providing independent control of all torch movements in the vertical plane. Two modes (AVC/ACC) of Torch Height Control are provided using our patented Thru-Arc™sensing technology. A stepper motor driven Linear Slide Assembly provides the motion for weld torch manipulation with 7 inches of vertical motion and a weight capacity of 25 lbs.

Computer Weld Technology, Inc.
10702 Old Bammel N Houston Rd.
Houston, TX 77086
(713) 462-2118
Fax: (713) 462-2503
Website: www.cweldtech.com

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MicroADM™

Take your weld monitoring to the next level. This easy to use sensor provides part validation using weld count, volume, AAD (accumulated arc density) and total arc time. Features include multi-tier testing using advanced AAD algorithms, a simple user I/O allowing the user to identify testing levels and establish process limits. Using a single input, the advanced learn mode will establish process control limits and using the three levels of testing provides a pass/fail output.

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(713) 462-2118
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Fast and Accurate Hand-Held Solution for Measuring Ferrite

The rugged Feritscope® MP30, the fast and accurate hand-held solution for measuring ferrite content in constructional steels, welded claddings, austenitic stainless steels and duplex steels, is now available in a "R" Version. These units are equipped with an unidirectional radio interface that transfers measurement data to a computer using a measurement software program such as FISCHER PC-DATEX and opens the possibility to integrate this instrument into a powerful workstation with a full SPC/SQC capability. The "S" version has an RS232 interface for downloading measurement statistics to a computer, printer or data logger.

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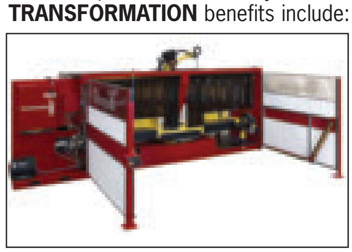
Website: www.fischer-technology.com

Prepare to TRANSFORM the way you manufacture... with TRANSFORMATION!

Genesis Systems Group is proud to introduce the **TRANSFORMATION** series — production flexibility never before possible.
TRANSFORMATION benefits include:



- Adjustable tool lengths of 1.5 – 3 meters.
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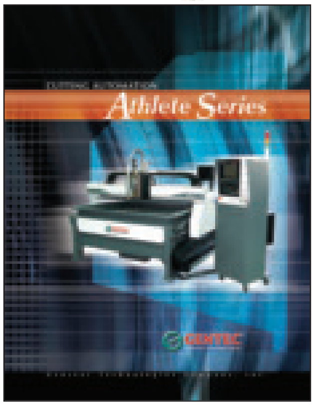

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Booth #1047

High Precision Cutting Machine

Athlete series high precision cutting machine can be integrated with high precision plasma cutting system to achieve unequal cutting quality. The drive mechanism uses a precision gear reducer that offers low-clearance with backlash less than 2 arc minutes. It can be equipped with other optional accessories such as laser point positioning pneumatic clamping device, torch height control, etc.

Genstar Technologies Co.
4525 Edison Ave.
Chino, CA 91710
(909) 606-2726
Website: www.genstartech.com

H&M Band-Type Pipe Cutting and Beveling Machine

H&M's band-type cutting and beveling machine leads the way in speed, accuracy, economy and versatility in its proven design. It is lightweight and compact for easy one-person setup and use. Seventeen stainless steel bands provide 10"- to 96" pipe-cutting capacity and are designed to overlap, automatically compensating for oversized, under-sized and out-of-round pipe. This rugged and dependable machine is protected by H&M's one-year warranty.

H & M Pipe Beveling Machine Co., Inc.
311 East Third Street
Tulsa, OK 74120-2417
(918) 582-9984
www.hmpipe.com

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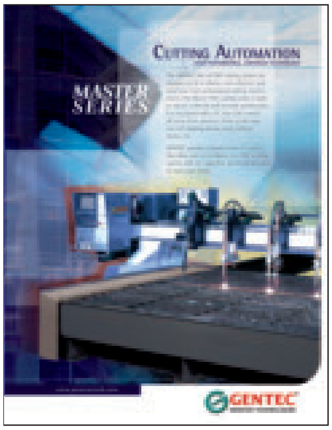

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Master CNC Cutting Series

The Gentec line of CNC cutting system is designed to be a reliable, cost-effective production machine to meet your high performance cutting requirements. The Master CNC cutting series is built to ensure smooth and accurate performance. It is equipped with PC based CNC controller. Gentec provides user-friendly broad choices and options that allow you to configure your CNC cutting system with the speed and accuracy to meet your needs.

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4525 Edison Ave.
Chino, CA 91710
(909) 606-2726
Website: www.genstartech.com

HIWT Virtual Tour

Take the tour at www.welding.org. Our website also explains in detail the wide range of welding classes offered by the Hobart Institute of Welding Technology. More than 25 separate welding courses are described with course objective, content and testing requirements. The 2007/2008 course schedule, training rates, and enrollment forms are all available.

Hobart Institute of Welding Technology
400 Trade Square East
Troy, OH 45373
(800) 332-9448
Fax: (937) 332-5200
www.welding.org

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Portable Weld Curtain

A & A Manufacturing's weld curtain is the most portable weld curtain on the market. Sets up and breaks down in seconds, the curtain can be transported to new working stations easily with its smooth, durable roller wheel. Suitable for all welding applications, the screen protects against the effects of near UV and UV Radiation emitted during the welding process. For more information, request WC-100.

A & A Manufacturing Co., Inc.
2300 South Calhoun Road
New Berlin, WI 53151
(262) 786-1500
Fax: (262) 786-3280
E-mail: sales@gortite.com
www.gortite.com

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Zirco™ Composite Welding and Locating Pin

Huys Industries, a world leader in cermets and ceramics, introduces the unique zirconium oxide steel composite pin that has the strength of steel and the insulating and wear characteristics of ceramics. Thus, the steal does not break in normal use nor will the ceramic show any wear against steel — keeping precision and accuracy.

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Weston, On M9L 1X9 CANADA
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Fax: (416) 747-7171
nscotchmer@HuysIndustries.com

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- 20 Ft. Hose, "B" Connections
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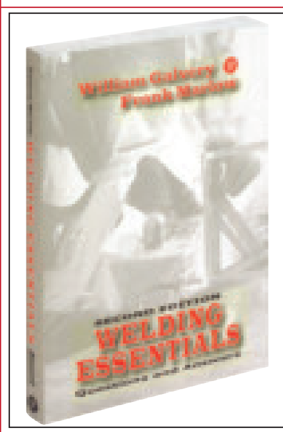

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New Edition Of Best-Selling Welding Resource

Industrial Press publishes essential references that will help you work efficiently and effectively. Now available…***Welding Essentials: Questions and Answers, Second Edition*** which makes welding easy for beginners and is a handy reference for professionals. Go to www.industrialpress.com or visit us at our FABTECH/AWS Welding Show booth to see all of our resources.

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Dissolving Purge Paper

Heavy-duty water soluble purge paper and tape are often the only available solution to a purge problem, and Intercon now carries these items in stock. This product is not only easy to use, but also easy to remove. It is strong enough to hold a purge, yet after welding, the dams can be flushed away with water or steam. Available in rolls or sheets.

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(604) 946-6066
Fax: (604) 946-5340
E-mail: sales@intercononline.com
www.intercononline.com

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TIGRIP Plate Clamps

Safety, design and a great price make the TIGRIP the overwhelming choice for your material handling needs. TIGRIP clamps have a unique multi-laminated design, which makes it light-weight but strong. A large square pad combined with a safety lever prevents the steel from slipping even with dynamic loads. This clamp is available in capacities from 1 ton up to 30 ton and also available with pivoting shackle. Please contact us for a TIGRIP catalog.

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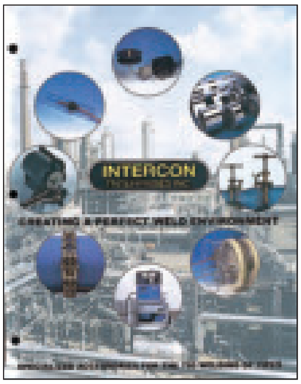
(800) 665-6655 or (604) 946-6066
Fax: (604) 946-5340
E-mail: sales@intercononline.com
www.intercononline.com



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New Purging Catalog for TIG Welding

Are you TIG welding, specifically stainless steel and titanium pipe? The updated Intercon purging catalog showcases not only purging systems, but also pipe alignment clamps and chains, tungsten electrode grinders, oxygen sensors, high-low gauge, silicone plugs and aluminum tape. This catalog is a must have. Fax us for a FREE 40-page, full-color catalog.

Intercon Enterprises, Inc.
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(604) 946-6066
Fax: (604) 946-5340
E-mail: sales@intercononline.com
www.intercononline.com

Hand-Held Integral Oxygen Indicator

The Intercon Hand-Held Integral Oxygen Indicator incorporates a non-depleting ceramic sensor that can accurately measure rest oxygen levels as small as 1 ppm (part per million) volume. Oxygen indicators with readout capabilities of only 0.1% (1000 ppm) or 0.01% (100 ppm) are not suitable for the welding industry as most precision welding is done below 70 ppm. Easy to use as well as robust, this oxygen sensor is designed for job sites as well as clean room work using a battery pack.

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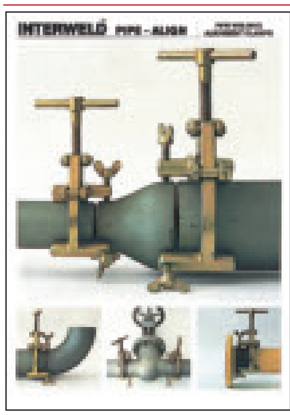

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Intercon Pipe Welding Clamps

Intercon pipe welding clamps ensure a quick and precise alignment, resulting in high quality weld placements. The wing bolts contain stainless ball bearings for minimal marring. These clamps are available in electro-plated forged steel or forged stainless steel. The "third arm" for every welder is available in 5 sizes. Contact us for FREE info and quote.

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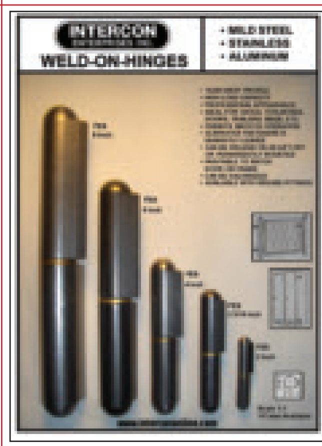
(604) 946-6066
Fax: (604) 946-5340
E-mail: sales@intercononline.com
www.intercononline.com



Intercon Weld-On Hinges

Intercon introduces its 40-page catalog on hardware. Featured are weld-on, lift-off, and butt hinges, as well as utility locks, draw latches and spring-loaded hinges for the sheet metal and fabrication industry. A large selection of stainless steel hardware is also available. Contact Intercon for a free catalog.

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(604) 946-6066
Fax: (604) 946-5340
E-mail: sales@intercononline.com
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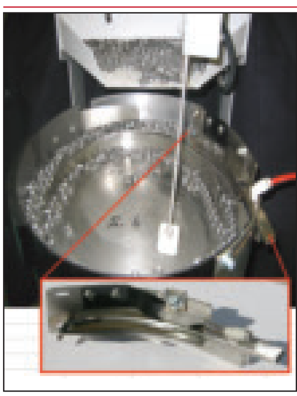

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The Next Generation of Feeder Systems

The Dengensha Cassette-Type Automatic Nut Feeder is the next-generation of Feeder systems introduced by Dengensha America. With the flexibility to feed 5mm, 6mm, 8mm and 10mm square nuts from the same vibratory bowl. The Cassette-Type feeder will allow you flexibility, increased productivity, and high speed selection today's manufacturing environment demands.

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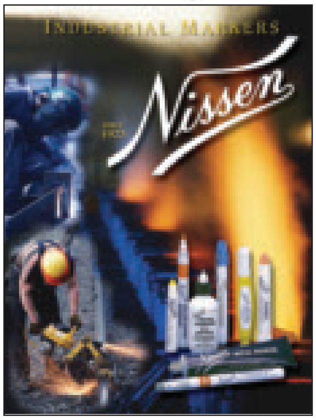
Fax: (440) 439-8217
www.dengensha.com

Inspection Plug Strategies Product Line.

Inspection Plug Strategies, LLC product includes the self-locking, self-sealing plugs for installation into jacketing covering insulated pipes, vessels and tanks. They provide easy access through the insulation system when performing UT inspections for mechanical integrity. The system saves installation time and materials since it does not require screws, sealants or special tools. The plugs are available in diameters of 1.5 in., 2.5 in., 3.5 in., and 5 in. We also manufacture Thickness Measurement Labels for uninsulated pipes, vessels and tanks.

Inspection Plug Strategies, LLC
2437 Bay Area Blvd., #147
Houston, TX 77058
(800) 914-4406
Fax: (281) 486-4363
www.inspectionplugstrategies.com



See Us at Fabtech/AWS Booth #8046

New Catalog From J.P. Nissen

J. P. Nissen's new full color catalog describes its full line of markers for all metalworking purposes. The markers will write on all surfaces: wet, dry, oily, or rusty. In addition to Nissen's permanent paint markers, they offer markers removable with water, detergent or in the pickling bath. All markers are guaranteed for life.

J.P. Nissen Co.
P.O. Box 339
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(215) 886-2025
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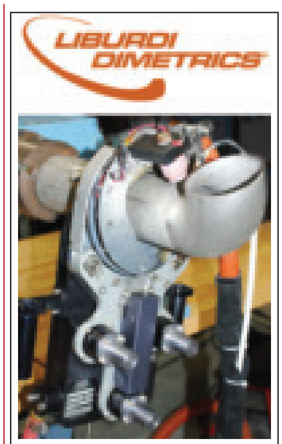
www.nissenmarkers.com



Factory Automation With Orbital Welding

Liburdi Dimetrics has offered orbital welding solutions to meet the industries high quality welding needs for over 30 years. The Full Function In Place "FFIP" welding heads convenient three-jaw clamping mechanism allows for easy installation to meet all your field and spooling shop requirements. The FFIP is fully equipped with AVC, oscillation and wire feed capabilities for the toughest jobs.

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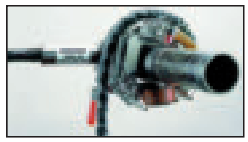
New Line Of Heads Welds Pipe "IN PLACE"



Two new models of weld heads are specifically designed for multipass pipe welds. Configured for fast and simple operation, the head is simply slipped over the pipe and clamped with a toggle lever. The Quickclamp weld head models are designed for GTAW circumferential butt welding of pipes and tubes. The models cover the size range from 1" OD tube to 6" (6.625" OD) pipe. The new models incorporate all necessary functions required for multipass welding including electronic Arc Gap Control (AGC), filler wire feed capability, torch rotation, and torch oscillation with adjustable stroke width, speed, and end point "dwell". The heads mount using an adjustable clamp - no guide rings or other separate components are required to use on specific pipe sizes. The wire feeder is mounted on the weld head. A standard 2 lb. wire spool, mounted directly on the head, provides precise and positive wire feeding, not possible with floor-mounted feeders.

Magnatech Limited Partnership
P.O. Box 260
East Granby, CT 06026
(860) 653-2573
Website: www.magnatech-lp.com

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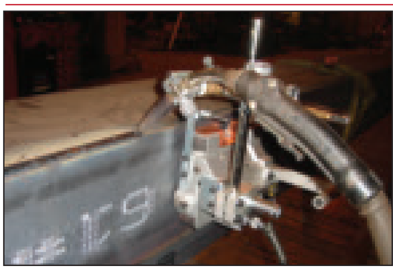

Perform Fillet Welds Without Track and With Less Fatigue

The **Wel-Handy Multi** is designed to perform fillet welds without track and with less fatigue to the welder. The welder can reduce wire, gas and fumes by more than 50%. New options allow the machine to perform more applications, including sub arc use, box welding, butt and lap joints.

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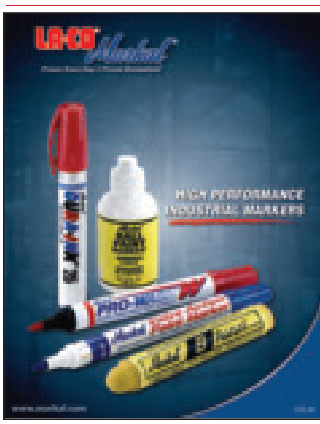

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Industrial Markers for Any Job

Markal® provides the welding trades with durable options for high performance industrial markers, ensuring the welder's needs are met, every time. Markers used by welders include B Paintstiks®, Valve-Action® Paint Markers, Silver Streak® and Red-Riter® metal markers, Dura-Ink® felt-tip ink markers, Thermomelt® Heat Stiks and an array of Paintstiks that address every type of surface.

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XR-Aluma-Pro™ Push-Pull Gun Optimizes Aluminum Welding

The new XR-Aluma-Pro solves problems related to burnback and arc fluctuations through an innovative, aluminum series-specific tension setting that optimizes feeding performance on 4000 and 5000 series aluminum. Visit MillerWelds.com for complete information.

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Booths #4071, #39029

The Titan FMB Direct Drive Saw

The Saw Company introduces the Titan Model from the FMB Pro Mitre Series of FMB Direct Drive Saws. These FMB saws combine the speed of an abrasive saw, the precision of a cold saw and the versatility of a band saw all in a small footprint. The Titan precision mitre cuts 0° to 60° with a 14 in. cutting capacity. The FMB Titan features a hydraulic control downfeed and rugged variable speed saw drive allowing the Titan to easily cut a wide range of material efficiently and accurately. The FMB Titan is ideal for thin wall tubes, profiles as well as heavy steel sections and hard solid material.

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Improved Plasma Cutting

Contaminants in your compressed air system — dust, scale, condensed moisture and oil mist — seriously affect the quality of your plasma cuts. Installation of a Motor Guard sub-micronic air filter on your plasma machine will effectively remove these contaminants; eliminating arc-sputter and producing cleaner, faster, smoother cuts. Motor Guard filters virtually pay for themselves by reducing wear and prolonging the life of expensive tips and electrodes. Ask your welding equipment supplier for a Motor Guard Filter today.

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Angle Grinder Giveaway

PFERD will give away one angle grinder every day during FABTECH /AWS Welding Show to a qualified booth visitor. Participate in field test of 5 in. variable speed electric grinder, and keep the tool for free! Hundreds of new money and time saving abrasives will be demonstrated in the PFERD booth.

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SHS 9700 is Your Alternative to Carbides

The NanoSteel® Company has released its new SHS 9700 alloy line for weld hardfacing and wear plate. Available as PTA powder and MIG / Open-Arc / Submerged-Arc wire, SHS 9700 features an ultra-refined grain structure that provides exceptional wear resistance and extreme hardness up to 69 Rc without the use of high-cost Ni, Mo or WC materials.

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(877) 293-NANO • (401) 270-3549
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Three Superior Matrix Wires

Postle Industries now offers three superior matrix wires to be used in the MIG tungsten carbide embedding process. These wires meet or exceed all standards on wires typically used for this process. Contact us at sparky@postle.com or 1-800-321-2978 for more information.

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Houston, TX 77280
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Email: sales@nbmmetals.com

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Booth # 7054

First Digital AC Drives Specially Designed For Small To Large Shape-Cutting Machines

ProMotion Controls is introducing a new digital AC Drive Amplifier System for shape-cutting machinery. ProMotion® AC iDrives are available in two- or three-axis configurations and fit easily inside any ProMotion® iCNC®. They work with a variety of motor sizes, small to large machines, and provide up to 2 kW power output.

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Booth #1085

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1484 Medina Road, Suite 118
Medina, OH 44256
(330) 721-1464
Fax: (330) 239-1531
E-Mail: sales@promotioncontrols.com

BSX™ Welding Jacket

Revco Industries announces the new BSX™ welding jacket featuring an optimal mix of style and features for welders. Constructed from 9 oz. FR cotton, the jacket features a stand-up collar, two inside pockets, and adjustable waist straps. See it in person at the Fabtech/AWS Welding Show.

Revco Industries, Inc.
(800) 527-3826
www.blackstallion.com

See Us at Fabtech/AWS Booth #4118

The New Impulse™ EMF 90 Has A Patented Opto-magnetic Detection System

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

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(847) 358-2000 • (800) 323-7402
www.sellstrom.com
E-mail: sellstrom@sellstrom.com

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Innovative Cost Saving Magnetic Fitting Tools

Introducing NO-MAR, advanced fitting tools born from the coalition of Fit Up Gear, innovators of fitting aids and Magswitch's revolutionary switchable permanent magnet technology. Simply position, switch the magnet on and you're ready to fit. Quick, easy and changing the mindset in the welding industry.

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www.fitupgear.com

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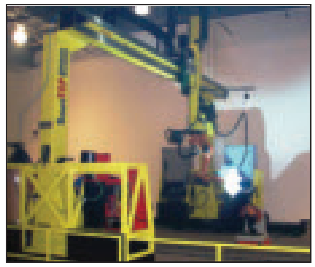

SmartTCP Automatic Welding for Complex Fabrications

SmartTCP automatic welding solution for complex fabrications in small batch production eliminates the need for expert welders, improves time to market, and increases production volume and quality. The gantry welding system is a turnkey solution that automates both the robot programming and the weld production, making it possible for job-shops and manufacturers to optimize the fabrication of high mix low volume parts.

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www.smarttcp.com

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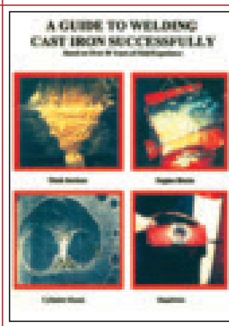

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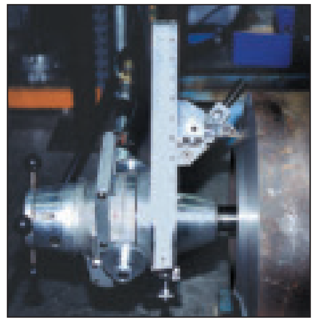

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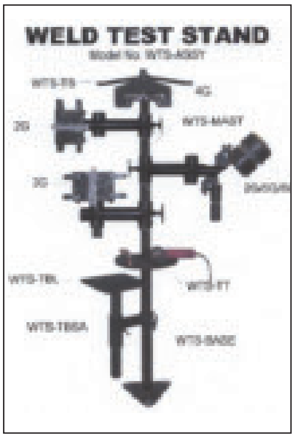

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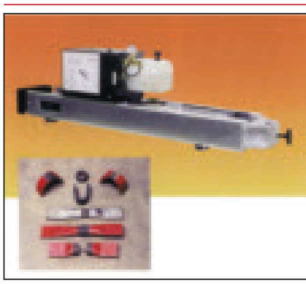

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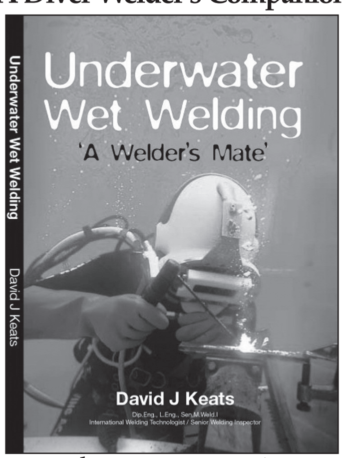

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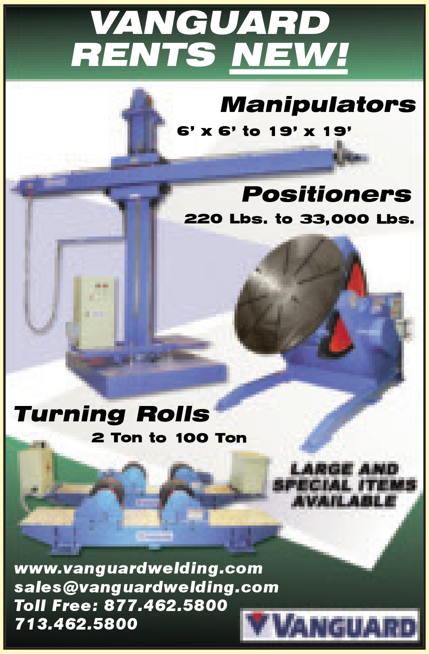

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Fusion-Boundary Macrosegregation in Dissimilar-Filler Metal Al-Cu Welds

Two recently proposed macrosegregation mechanisms have been verified by microstructure examination and composition measurements of Al-Cu welds

BY Y. K. YANG AND S. KOU

ABSTRACT. Dissimilar filler metals, that is, filler metals different from the base metal in composition, are routinely used in arc welding but macrosegregation can form and degrade the weld quality. Based on the liquidus temperatures of the weld metal (T_{LW}) and the base metal (T_{LB}) as well as the stagnant or laminar-flow layer of liquid base metal along the weld pool boundary suggested by Savage, two new mechanisms have been proposed recently for macrosegregation near the fusion boundary in arc welds made with dissimilar filler metals, one for $T_{LW} < T_{LB}$ and the other $T_{LW} > T_{LB}$. To verify the mechanisms, the binary Al-Cu system was selected, and gas metal arc welding was used. In the case of $T_{LW} < T_{LB}$, 1100 Al (commercially pure Al) was selected as the base metal because pure Al has the highest liquidus temperature and thus $T_{LW} < T_{LB}$ is met automatically. It was welded with filler metal 2319 Al (Al-6.3Cu) and Al/Cu composite filler metals of higher Cu contents. Features including beaches, peninsulas, and islands were found along the fusion boundary. The beaches were thin and discontinuous, and the peninsulas and islands roughly parallel to the fusion boundary. These features were pure Al, that is, they originated from the liquid base metal that solidified without mixing with the bulk weld pool. In the case of $T_{LW} > T_{LB}$, on the other hand, the Al-33Cu eutectic was selected as the base metal because the eutectic has the lowest liquidus temperature and thus $T_{LW} > T_{LB}$ is met automatically. It was welded with filler metal 1100 Al. The beach along the fusion boundary was significantly thicker and more continuous than those with $T_{LW} < T_{LB}$. It was intruded by the weld metal, with peninsulas, and islands randomly oriented in the space between the weld-metal intrusions. These beach, peninsulas and islands were eutectic, that is, they originated from the liquid base metal that solidified without mixing with the bulk weld pool. In either case, the filler-deficient zone was thicker in welds made with a larger difference between T_{LW} and T_{LB}. All these observations were consistent with and thus verified the proposed mechanisms.

Y. K. YANG, Graduate Student, and S. KOU, Professor, are with the Department of Materials Science and Engineering, University of Wisconsin, Madison, Wis.

KEYWORDS

Al-Cu Welds
Dissimilar Filler Metal
Filler Metal
Liquidus Temperature
Macrosegregation

Introduction

In arc welding the filler metal is often dissimilar, that is, different from the workpiece in composition, in order to prevent cracking or to develop desired physical or chemical properties. Macrosegregation can exist near the fusion boundary of welds made with dissimilar filler metals and degrade the weld quality (Refs. 1–17).

In addition to the stagnant or laminar-flow layer of liquid base metal along the weld pool boundary suggested by Savage (Ref. 3), Kou and Yang (Ref. 18) have recently considered the liquidus temperatures of the weld metal T_{LW} and the base metal T_{LB} and proposed two new mechanisms for fusion-boundary macrosegregation in arc welds made with dissimilar filler metals, one for $T_{LW} < T_{LB}$ and the other $T_{LW} > T_{LB}$. They described how filler-deficient peninsulas and islands as well as beaches can form along the resultant fusion boundary. The characteristics of the beaches, peninsulas, and islands formed by these two mechanisms can be distinctly different, as is described subsequently.

Experimental Procedure

The Al-Cu system was selected for the present study for the following reasons. First, it is a simple binary alloy system with a well-documented phase diagram for determining the liquidus temperature from the alloy composition. Second, Al-Cu alloys are useful light structural materials, such as 2219 Al (Al-6.3Cu) and 2214 Al (essentially Al-4.4Cu). Third, casting Al-Cu alloys is straightforward, requiring no special protection against oxidation or fire (as in casting Mg alloys). Fourth, pure Al and Cu wires are readily available and deformable.

Plates of both 1100 Al (commercially pure aluminum) and Al-33Cu eutectic were welded (all Cu contents in the present study in wt-%). They were both 9.5 mm (⅜ in.) thick, 102 mm (4 in.) wide, and 102 mm (4 in.) long. The eutectic alloy was prepared by casting. Predetermined quantities of 99.99% Al and a master alloy of Al-50.86Cu were induction melted in a graphite crucible and cast at 700° to 750°C into a graphite mold.

Filler metals of various Cu contents were used, including 1100 Al, 2319 Al (Al-6.3Cu), Al-30.5Cu, and Al-52.5Cu. The last two materials are not commercially available. The Al-30.5Cu welding wire was fabricated from a four-strand composite of three commercially pure Al (1100 Al) wires of 0.81 mm diameter and one 99.99% purity Cu wire of 0.51 mm diameter, twisted together and then pulled to straighten. The density of pure Al is 2.70

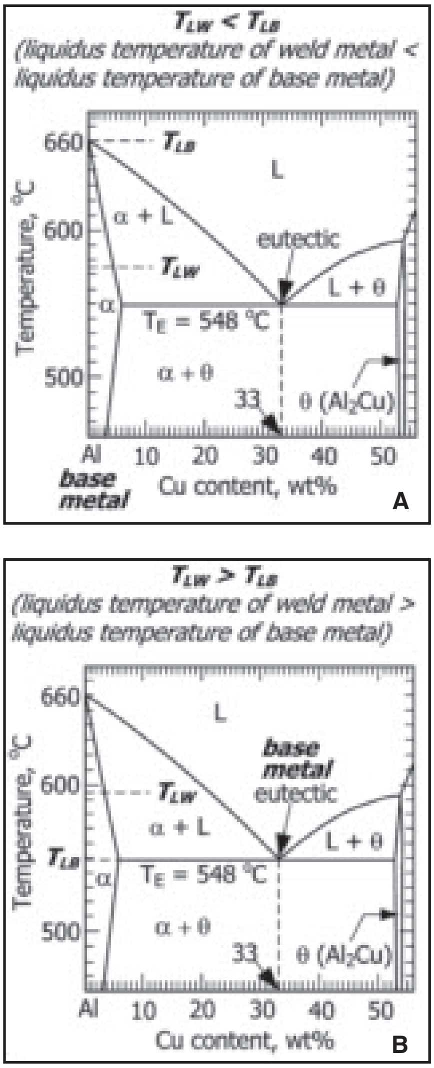

Fig. 1 — Aluminum-rich side of binary Al-Cu phase diagram (Ref. 20) and selection of base metal for welding. A — Pure Al as base metal and thus $T_{LW} < T_{LB}$; B — Al-33Cu eutectic as base metal and thus $T_{LW} > T_{LB}$.

g/cm^3 and that of pure Cu 8.96 g/cm^3. Thus, the Cu content of the composite welding wire $(wt\text{-}\%\ Cu)_{filler} = 100 \times 8.96\, A_{Cu} / (8.96\, A_{Cu} + 3 \times 2.70\, A_{Al})$, where A_{Cu} is the cross-sectional area of the pure Cu wire and A_{Al} that of the pure Al wire. Since $A_{Al} = \pi(0.81\ mm)^2/4 = 0.515\ mm^2$ and $A_{Cu} = \pi(0.51\ mm)^2/4 = 0.204\ mm^2$, $(wt\text{-}\%\ Cu)_{filler} = 30.5$.

The Al-52.5Cu welding wire was also fabricated from a four-strand composite made by twisting together three pure Al wires and one pure Cu wire, but all wires were 0.81 mm in diameter. Since $A_{Al} = A_{Cu} = 0.515\ mm^2$, $(wt\text{-}\%\ Cu)_{filler} = 52.5$. The overall diameter was about 1.9 mm for both composite wires.

The advantage of composite wires is that filler metals of high Cu contents can be prepared easily. The disadvantage of this approach, however, is that gas porosity is higher in the resultant weld metal probably because of some air trapped in the space between individual wires.

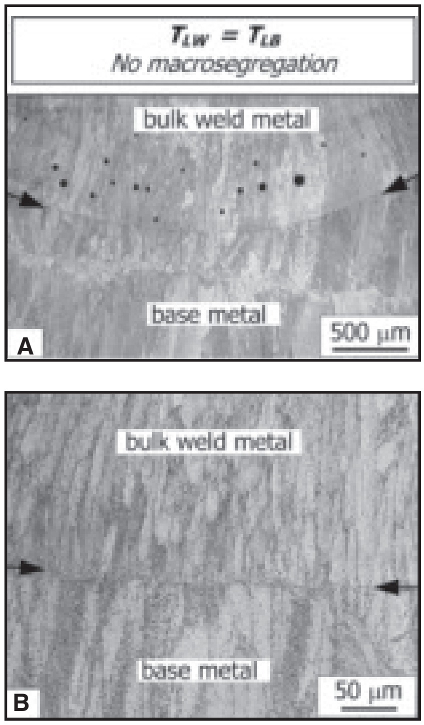

Fig. 2 — Transverse micrographs showing no macrosegregation when essentially $T_{LW} = T_{LB}$. A — Near weld bottom; B — enlarged. Both base metal and weld metal are essentially Al-33Cu (both eutectic when viewed at higher magnifications). Arrows indicate fusion boundary.

Bead-on-plate welds with partial penetration were made by gas metal arc welding (GMAW). Commercial filler metals 1100 Al and 2319 Al were used, the former for the Al-33Cu eutectic plates and the latter for the 1100 Al plates. The wire diameter was 1.2 mm (3/64 in.). The welding conditions were as follows: 25–28 V, 169–212 mm/s (400–500 in./min) wire feeding speed, 6.4–8.5 mm/s (15–20 in./min) travel speed, and 280–285 A average current. Composite wires Al-52.5Cu and Al-30.5Cu were used for welding the 1100 Al plates. The welding conditions were as follows: 25 V, 85–106 mm/s (200–250 in./min) wire feeding speed, 4.2–8.5 mm/s (10–20 in./min) travel speed, and 260–285 A average current. As compared to the commercial wires 1100 Al and 2319 Al, the wire feeding speed was lower with the composite wires because of their larger diameter. Regardless of which wire was used, the contact tube to workpiece distance was about 19.1 mm (¾ in.), and the torch was held perpendicular to the workpiece.

The resultant welds were cut, polished and etched with a solution of 0.5 vol-% HF in water for microstructural examination by optical microscopy. Macrographs of cross sections of the welds were taken with a digital camera.

The Cu content in a homogeneous Al-Cu weld can be calculated as follows (Ref. 19):

$$(wt\text{-}\%\ Cu)_{weld} = (wt\text{-}\%\ Cu)_{base} \times [A_b/(A_b + A_f)] + (wt\text{-}\%\ Cu)_{filler} \times [A_f/(A_b + A_f)] \quad (1)$$

where A_b and A_f are the areas in the weld transverse cross section that are below and above the workpiece surface, respectively. With macrosegregation limited to near the fusion boundary, such as the welds in the present study, the composition of the bulk weld metal can still be calculated using Equation 1, as an approximation. In Equation 1 areas A_b and A_f represent contributions from the base metal and filler metal, respectively. The ratio $A_b/(A_b + A_f)$ is the so-called dilution ratio. Areas A_b and A_f were determined by enlarging the transverse macrograph on a computer monitor and by using commercial computer software.

For welds with high Cu contents, the difference between the density of Cu ($\rho_{Cu} = 8.96\ g/cm^3$) and that of Al ($\rho_{Al} = 2.70\ g/cm^3$) can be significant. This density difference can be considered in the calculation of the weld-metal Cu content by using the following equation derived in Appendix A:

$$(wt\text{-}\%\ Cu)_{weld} = 100\, R\, \rho_{Cu} / [R\, \rho_{Cu} + (1 - R)\, \rho_{Al}] \quad (2)$$

where

$$R = \{(wt\text{-}\%\ Cu/\rho_{Cu}) / [(wt\text{-}\%\ Cu/\rho_{Cu}) + (100 - wt\text{-}\%\ Cu)/\rho_{Al}]\}_{base} \times [A_b/(A_b + A_f)] + \{(wt\text{-}\%\ Cu/\rho_{Cu}) / [(wt\text{-}\%\ Cu/\rho_{Cu}) + (100 - wt\text{-}\%\ Cu)/\rho_{Al}]\}_{filler} \times [A_f/(A_b + A_f)] \quad (3)$$

Again, with macrosegregation limited to near the fusion boundary, the Cu content of the bulk weld metal can be calculated using Equation 2 as an approximation. With $\rho_{Al} = \rho_{Cu} = \rho$, Equation 3 reduces to

$$R = (wt\text{-}\%\ Cu/\rho)_{base} \times [A_b/(A_b + A_f)] + (wt\text{-}\%\ Cu/\rho)_{filler} \times [A_f/(A_b + A_f)] \quad (4)$$

Upon substituting Equation 4 and $\rho_{Al} = \rho_{Cu} = \rho$, Equation 2 reduces to Equation 1. Thus, Equation 1 is a special case of Equation 2 when the densities of all elements involved are identical.

As mentioned before, the Al-33Cu eutectic plates were welded with filler metal

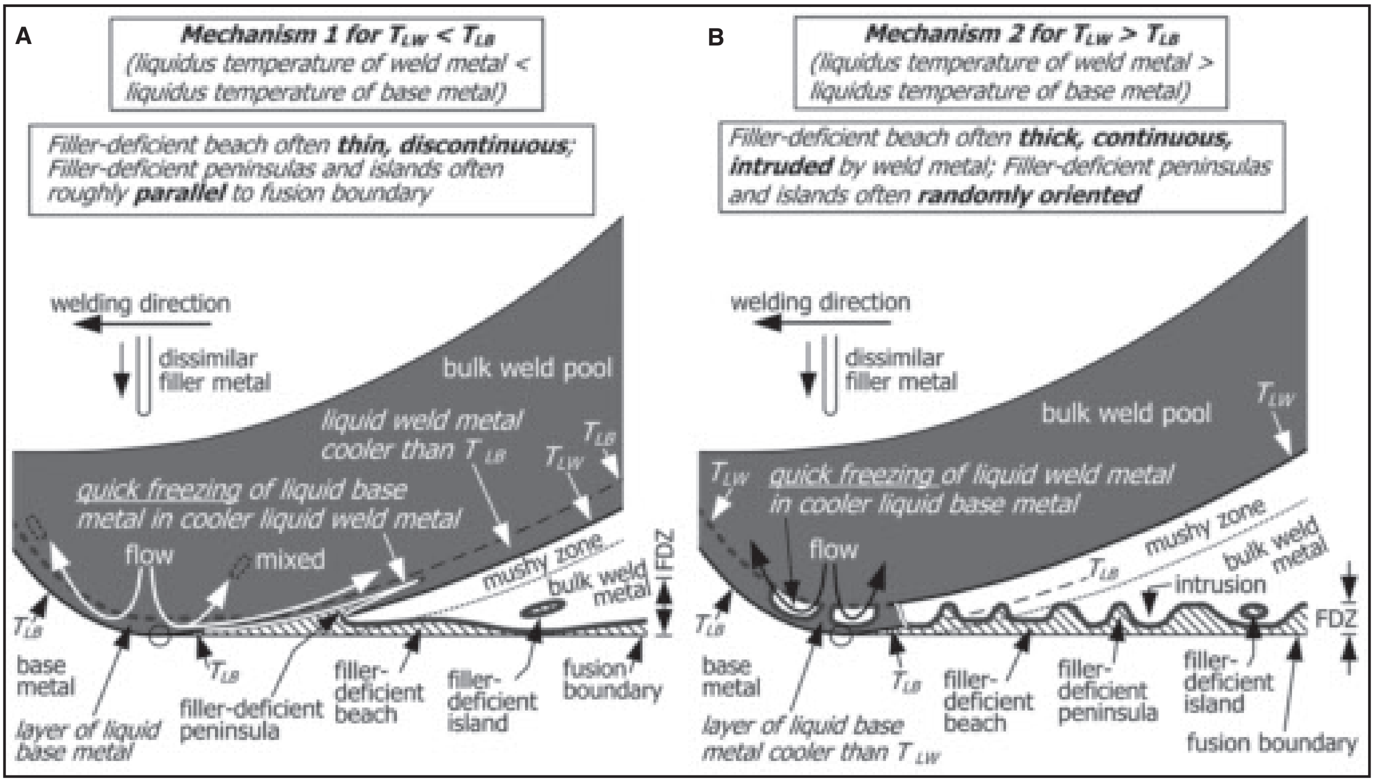

Fig. 3 — Mechanisms of fusion-boundary macrosegregation (formation of filler metal-deficient zone FDZ). A — Mechanism 1 for $T_{LW} < T_{LB}$; B — Mechanism 2 for $T_{LW} > T_{LB}$. Pool boundary is melting front before circle and solidification front after. From Kou and Yang (Ref. 18).

Equation 2 when the densities of all elements involved are identical.

As mentioned before, the Al-33Cu eutectic plates were welded with filler metal 1100 Al. In one experiment the weld-metal Cu content was further reduced by placing before welding a rectangular rod of 1100 Al in a rectangular groove at the workpiece top surface along the welding path. The rod and the groove were both 2 × 8 mm in transverse cross section. The rod was completely melted and mixed in the weld pool during welding.

The composition profiles across the fusion boundary were determined by EDS (energy-dispersive spectroscopy) during SEM (scanning electron microscopy).

Results and Discussion

For convenience of discussion, the Al-rich side of the binary Al-Cu phase diagram is shown in Fig. 1 (Ref. 20). Pure Al solidifies at the melting point 660°C and the eutectic, Al-33Cu, solidifies at the eutectic temperature 548°C, with a lamellar structure of α-Al and θ-Al_2Cu. Thus, the highest liquidus temperature is the melting point of pure Al 660°C, and the lowest one the eutectic temperature 548°C.

In order to test the proposed mechanisms, it is desirable to have a large difference between the liquidus temperature of the base metal T_{LB} and the liquidus temperature of the weld metal T_{LW} so that the effect of this temperature difference on solidification and macrosegregation can be significant enough to be examined clearly. The maximum possible difference between T_{LB} and T_{LW} for the binary Al-Cu system is 112°C (660°C – 548°C).

No Filler Metal-Deficient Zone in Welds with $T_{LW} = T_{LB}$

Figure 2 shows the transverse micrographs of a weld made on Al-33Cu eutectic with composite welding wire Al-31Cu. From Equation 2, the 60.8% dilution of the weld, and the compositions of the base metal and the filler metal, the weld metal composition was Al-32Cu. Dendrites of the Al-rich α phase were found occasionally in the bulk weld metal (but not in the area shown in Fig. 2) because Al-32Cu was just slightly lower in Cu than the eutectic composition Al-33Cu. Other than these, the weld metal was eutectic just like the base metal, and as an approximation, $T_{LW} = T_{LB}$.

Figure 2 indicates two things. First, the composite wire worked properly — no evidence of unmixed or unmelted Cu because of the much higher melting point of Cu (1085°C) than Al (660°C). Second, there was no evidence of beaches, peninsulas, or islands along the fusion boundary (indicated by two arrows) or elsewhere in the bulk weld metal. The weld metal grains appeared to grow normal to the fusion boundary.

Filler Metal-Deficient Zone in Welds with $T_{LW} < T_{LB}$

For convenience of discussion, the mechanisms proposed recently for fusion-boundary macrosegregation, that is, formation of the filler metal-deficient zone (FDZ), in dissimilar filler-metal welds are shown in Fig. 3 (Ref. 18). Here the filler metal mixes completely with the homogeneous bulk weld pool. The more complicated case where the filler metal mixes only partially with the bulk weld pool before reaching the bottom of the weld pool is considered in a follow-up paper (Ref. 21).

Mechanism 1, shown in Fig. 3A, is for filler metals that make $T_{LW} < T_{LB}$. According to fluid mechanics (Ref. 22), the velocity of a moving liquid is zero at a solid wall, that is, the so-called "no-slip" boundary condition for fluid flow. Thus, near the weld pool boundary convection is weakened, and a stagnant or laminar-flow layer of liquid base metal can exist as Savage

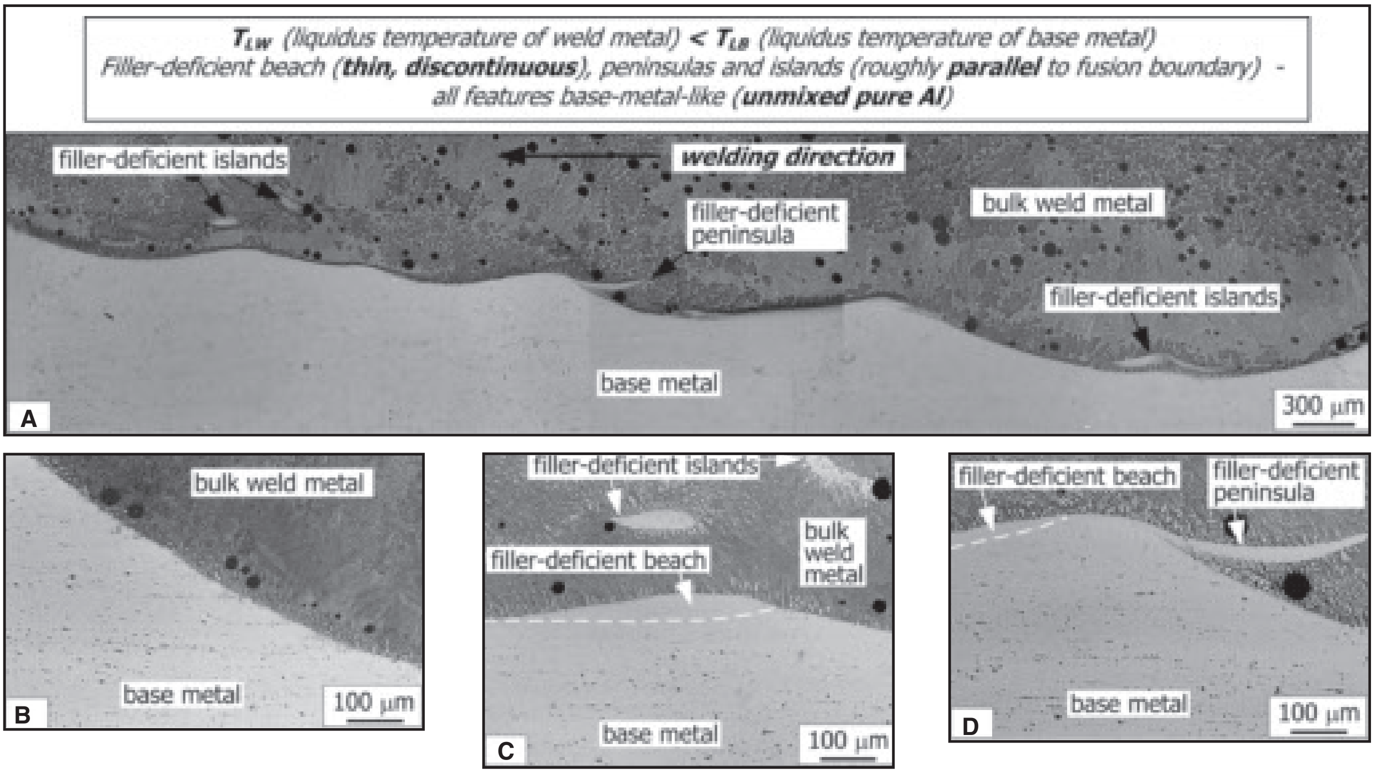

Fig. 4 — Longitudinal micrographs for $T_{LW} < T_{LB}$. A — Overview; B — melting front; C, D — weld bottom. Base metal: 1100 Al (pure Al); weld metal: Al-33Cu; T_{LW} = 548°C and T_{LB} = 660°C. Beaches, peninsulas, and islands all appeared pure Al like base metal, suggesting they originated from unmixed base metal.

suggested (Ref. 3).

The solidification front is no longer isothermal as in welding without a dissimilar filler metal. In Fig. 3 the portion of the weld pool boundary behind the circle is the solidification front and that ahead of it is the melting front. As shown, the solidification front is T_{LW} for the bulk weld pool but T_{LB} for the liquid base metal solidifying near the fusion boundary. The liquid weld metal in the region immediately ahead of the solidification front is below T_{LB}. This is only because of $T_{LW} < T_{LB}$ and not any undercooling. The liquid base metal in the stagnant or laminar-flow layer swept by convection into this cooler region can freeze quickly without much mixing with the surrounding liquid and form filler-metal-deficient peninsulas or islands. The peninsulas often tend to be roughly parallel to the fusion boundary. The islands can also be roughly parallel to the fusion boundary unless they happen to rotate before the surrounding liquid in the cooler region solidifies.

The liquid base metal remaining in the layer can solidify as a filler-deficient beach along the weld interface, often thin and discontinuous because of weld pool convection. These features of beaches, peninsulas, and islands are filler-deficient because of no or partial mixing with the bulk weld pool, in which the filler metal is uniformly distributed during welding. The larger the temperature difference (T_{LB} – T_{LW}) is, the thicker the resultant FDZ can be, but the actual thickness also depends much on the direction and strength of weld pool convection.

A number of factors are considered as follows. First, the liquid base metal is carried into the cooler region with sensible heat. However, the sensible heat is expected to be small because of the small amount of liquid base metal carried into the cooler region. Thus, the liquid base metal can freeze quickly before much mixing occurs. Second, the closer the solidus temperature of the liquid base metal is to its liquidus temperature, the more quickly freezing can progress appreciably. Third, a liquid base metal with a lower density than the bulk weld metal has a tendency to float upward into and mix with the bulk weld pool above it, for instance, a thin layer of liquid pure Al base metal under an Al-Cu bulk weld pool. This might contribute to the thin and discontinuous Al-rich beach in a pure Al weld made with Al-Cu filler metals. Fourth, the viscosity of the liquid base metal can differ from that of the bulk weld metal. The former can have a lower temperature and thus a higher viscosity though the composition difference between the two may also play a role. A higher viscosity may help the liquid base metal layer stick better to the unmelted solid base metal.

The condition of $T_{LW} < T_{LB}$, as shown in Fig. 1A, can be met automatically by using 1100 Al (essentially pure Al) as the base metal because the highest achievable liquidus temperature of aluminum alloys is the melting point 660°C. An advantage of using 1100 Al is that its microstructure is featureless (that is, without the cells or dendrites in Al-Cu alloys) and hence easy to recognize. To keep the temperature difference (T_{LW} – T_{LB}) large, T_{LW} can be kept low by using high-Cu welding wires to keep the weld-metal Cu content high.

Figure 4 shows longitudinal micrographs taken along the central plane of a weld made on 1100 Al with filler metal Al-52.5Cu. Figure 4A shows the overall microstructure along the bottom of the weld, the welding direction being from right to left. As shown, the peninsulas and islands are roughly parallel to the fusion boundary. Figure 4B shows the microstructure somewhere along the melting front. Figure 4C and D show, respectively, two islands and one peninsula in Figure 4A at a higher magnification.

The dilution of the weld was about 48%, and the weld metal composition was about Al-33Cu (from Equation 2), that is, the eutectic composition. From the Al-Cu phase diagram (Fig. 1A), the liquidus temperature of the weld metal, T_{LW}, was the eutectic temperature 548°C. Taking the base metal 1100 Al as pure Al as an approximation, the liquidus temperature of the base metal, T_{LB}, was the melting point of pure Al 660°C. Thus, T_{LW} was well below T_{LB} and the temperature difference ($T_{LB} - T_{LW}$) was 112°C.

The filler-deficient beaches, peninsulas, and islands in Fig. 4C and D were similar to the base metal in microstructure except without the particles of dark-etching Al-Fe intermetallic compounds in the base metal. Further etching (for minutes) and higher magnifications confirmed that these compounds were redistributed by solidification as very fine dots or short line segments lining up along the cell boundaries of the cellular structure in the beaches, peninsulas, or islands. The broken lines in Fig. 4C and D were drawn along the boundaries of the regions in which such dots or line segments existed, that is, the beaches. Unfortunately, long etching often degraded the overall quality of the micrographs significantly as can be seen subsequently in Fig. 5A.

The peninsula (Fig. 4D) is roughly parallel to the fusion boundary, especially the part of the fusion boundary to the left of the peninsula, where it originated during welding. The islands (Fig. 4C) are also roughly parallel to the fusion boundary. These findings are consistent with the proposed mechanism. The porosity in the weld metal was probably caused by some air trapped in the space between individual wires in the composite welding wire.

Figure 5 shows the transverse micrographs of welds made on 1100 Al with filler metals of various Cu contents. The first micrograph (Fig. 5A) was taken from a weld made with welding wire 2319 Al (Al-6.3Cu). The dilution was 51%, and the weld metal composition was Al-3.0Cu. From the Al-Cu phase diagram, T_{LW} = 653°C. Since T_{LB} = 660°C, T_{LW} was below T_{LB} and ($T_{LB} - T_{LW}$) = 7°C. The second micrograph (Fig. 5B) was taken from a weld made with filler metal Al-31Cu. The dilution was 29%, and the weld-metal composition was Al-23Cu. From the Al-Cu phase diagram, T_{LW} = 589°C. Thus, T_{LW} was below T_{LB} and ($T_{LB} - T_{LW}$) = 71°C. The last two micrographs (Fig. 5C and D) were taken at two different locations along the weld shown previously in Fig. 4, that is, 1100 Al welded with filler metal Al-52.5Cu. As mentioned before, T_{LW} = 548°C and T_{LB} = 660°C. Thus, T_{LW} was below T_{LB} and ($T_{LB} - T_{LW}$) = 112°C.

Three observations can be made regarding the filler metal-deficient zone (FDZ) in the micrographs in Fig. 5. The FDZ can be defined as the region of the weld metal along the fusion boundary that contains all the filler metal-deficient features present in the weld metal (such as beaches, peninsulas, and islands), between the fusion boundary and a boundary that is parallel to and just far enough from the fusion boundary to include all the features. First, these beaches, peninsula, and islands are light-etching just like the base metal, suggesting that they had originated from the base metal that was melted but not mixed with the bulk weld pool. In Fig. 5A the very fine dark-etching lines in the beach are somewhat normal to the fusion boundary (the white broken line). Likewise, in Fig. 5B, the dark-etching grain boundary in the beach is normal to the fusion boundary (the white broken line). These both indicate that the beaches are indeed solidification structure and that the dark-etching particles of Al-Fe intermetallic compounds originally in the base metal were redistributed during solidification along the cell or grain boundaries. Second, the peninsulas and island were roughly parallel to the fusion boundary, which is consistent with the mechanism proposed for $T_{LW} < T_{LB}$ — Fig. 3A. Third, the FDZ increased in thickness with increasing temperature difference ($T_{LB} - T_{LW}$), which is also consistent with Mechanism 1. Before leaving the present paragraph, it is worth mentioning that the bulk weld metal in Fig. 5A was overetched and became blurred because of the long etching needed to bring out the cellular structure of the beach.

Figure 6 shows a composition profile taken along path AE across the fusion boundary and the island shown in Fig. 5D. The Cu content at the core of the island was essentially zero, identical to that of the base metal. This confirms that the island originated from the liquid base metal that froze quickly without mixing with the liquid weld metal. This is consistent with the proposed theory. The measured weld-metal composition was about Al-35Cu, close to that of Al-33Cu calculated based on the dilution ratio and Equation 2. Composition gradients existed between the island core and the adjacent weld metal. The gradients are likely to be associated with diffusion or partial mixing between the liquid base metal and the liquid weld metal and with solute segregation during solidification, as suggested by Mechanism 1.

This composition profile shows another advantage of selecting pure aluminum as the base metal, that is, the composition profile in pure Al (including the base metal and the island) is easy to measure by EDS because it is uniform. If any alloy workpiece, for instance, Al-6Cu, had been used, the composition would have fluctuated wildly across the island due to

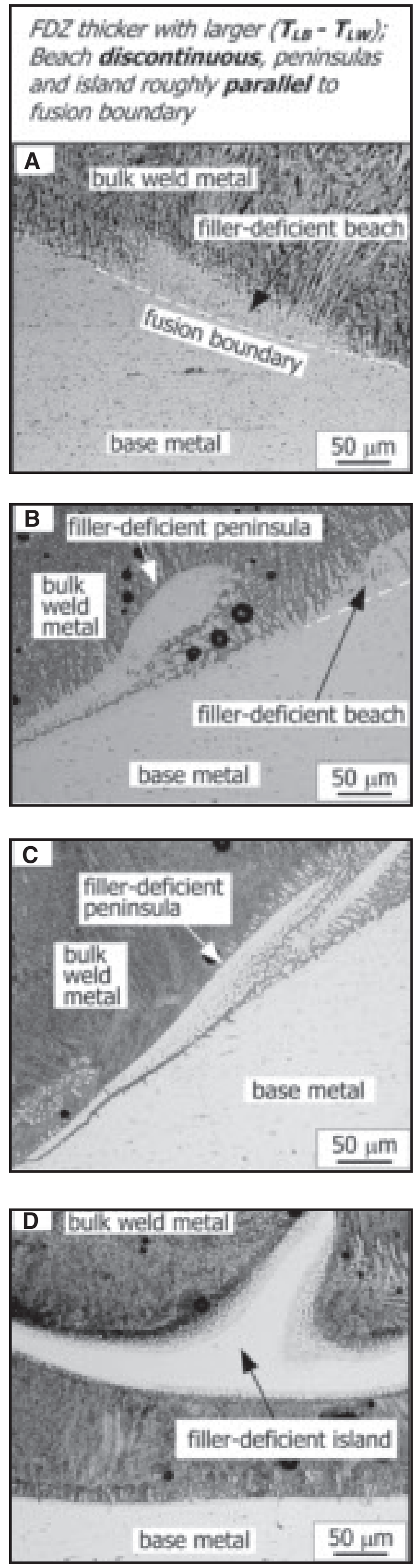

Fig. 5 — Transverse micrographs showing effect of ($T_{LB} - T_{LW}$) on thickness of filler metal-deficient zone (FDZ). A — ($T_{LB} - T_{LW}$) = 7°C; B — ($T_{LB} - T_{LW}$) = 71°C; C, D — ($T_{LB} - T_{LW}$) = 112°C. Base metal: 1100 Al (pure Al).

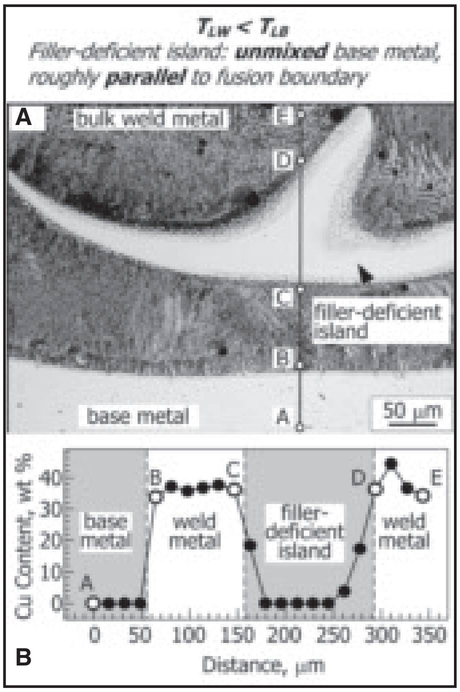

Fig. 6 — Macrosegregation across fusion boundary when $T_{LW} < T_{LB}$. A — Transverse micrograph; B — composition profile. Base metal: 1100 Al (pure Al); weld metal: Al-33Cu. Core of island identical to base metal in composition, i.e., unmixed base metal.

microsegregation across dendrite arms.

Filler-Metal-Deficient Zone in Welds with $T_{LW} > T_{LB}$

Mechanism 2, shown in Fig. 3B, is for filler metals that make $T_{LW} > T_{LB}$ (Ref. 18). The base metal next to the boundary of the homogeneous bulk weld pool (which is at T_{LW}) is above T_{LB} and thus must form a liquid layer because $T_{LW} > T_{LB}$ regardless of the extent of weld pool convection. Since the layer of liquid base metal near the fusion boundary is below T_{LW}, the liquid weld metal pushed by convection into this cooler region can freeze quickly as intrusions without much mixing with the liquid base metal. This also means that the liquid base metal in the layer solidifies without much mixing. The result is a filler-deficient beach with weld-metal intrusions. The liquid base metal that solidifies in the space between intrusions can appear as peninsulas or even islands near the fusion boundary. Since the flow of the liquid weld metal into the layer of liquid base metal during welding may be random, the peninsulas and islands can be randomly oriented instead of roughly parallel to the fusion boundary as in the case of $T_{LW} < T_{LB}$. The larger the temperature difference ($T_{LB} - T_{LW}$) is, the thicker the FDZ can be, but the actual thickness can also be affected by the direction and strength of weld pool convection.

The condition of $T_{LW} > T_{LB}$, as shown in Fig. 1B, can be met automatically by using Al-33Cu eutectic as the base metal because the lowest achievable liquidus temperature of aluminum alloys is the eutectic temperature 548°C. An advantage of selecting Al-33Cu eutectic as the base metal is that its lamellar microstructure is easy to recognize. 1100 Al was used as the filler metal to keep the weld-metal Cu content as low as possible, that is, T_{LW} as high as possible. In one experiment the weld-metal Cu content was further reduced by placing before welding a rectangular rod of 1100 Al in a rectangular groove at the workpiece top surface along the welding path.

Figure 7 shows longitudinal micrographs taken along the central plane of a weld made on Al-33Cu eutectic with filler metal 1100 Al. The eutectic had been heat treated at 540°C for 65 h before welding to develop a spherodized eutectic microstructure. This was intended to enhance the contrast between the base metal and the beach along the weld interface, which was expected to be also eutectic but much finer and lamellar, typical of an as-solidified eutectic.

Figure 7A shows the overall microstructure along the bottom of the weld, the welding direction being from right to left. Figure 7B shows the microstructure somewhere along the melting front, as can be seen from the rising fusion boundary from right to left. Figure 7C and D show, respectively, some peninsulas and one island at a higher magnification.

The dilution was 67.3%, and the composition of the bulk weld metal was Al-24Cu. From the Al-Cu phase diagram, T_{LW} = 586°C and T_{LB} = 548°C. An advantage for selecting Al-33Cu eutectic as the base metal is that the condition of $T_{LW} > T_{LB}$ is met automatically. Another advantage is that the eutectic is distinctly different from other Al-Cu alloys in microstructure and hence easy to recognize.

Figure 7B shows a beach thick and continuous along the fusion boundary at the melting front. At higher magnifications, the beaches exhibited a lamellar structure, typical of as-cast eutectic. According to the proposed mechanism (Ref. 18), complete mixing throughout the weld pool is impossible because $T_{LW} > T_{LB}$. Thus, a continuous layer of liquid base metal exists along the melting front, regardless of the extent of weld pool convection, and solidifies into a beach continuous along the resultant fusion boundary. The presence of the eutectic beach along the fusion boundary at the melting front is consistent with the proposed mechanism, in that complete mixing is impossible when $T_{LW} > T_{LB}$. The interface between the unmelted base metal and the eutectic beach was at the eutectic temperature, suggesting that the melting front was at the liquidus temperature of the base metal T_{LB} (the eutectic temperature in this case) instead of the liquidus temperature of the weld metal T_{LW}. This is also consistent with the proposed mechanism.

As shown in Fig. 7C, the weld metal intruded into the beach along the fusion boundary. The beach was continuous and the peninsulas were randomly oriented, instead of being roughly parallel to the fusion boundary as in the case of $T_{LW} < T_{LB}$. This is also consistent with the proposed mechanism. Both the island and the beach in Fig. 7D were eutectic, as confirmed by microstructure examination at higher magnifications.

Thus, the beach, peninsulas, and island in Fig. 7 were all eutectic just like the base metal itself. As such, they all originated from the liquid base metal near the pool boundary that did not mix with the liquid weld metal. The peninsulas and the island were the liquid base metal left in the space between the weld-metal intrusions that solidified without mixing, as suggested by Mechanism 2.

Before leaving Fig. 7, it is worth mentioning that, as shown in Fig. 7A, the weld penetration appears to fluctuate significantly. The so-called papillary penetration is common in partial-penetration welding of Al alloys with Ar as the shielding gas, such as in the present study. The penetration tip tends to fluctuate up and down along the weld (Refs. 23, 24).

Figure 8 shows the transverse micrographs of two welds made on as-cast Al-33Cu eutectic with filler metal 1100 Al. The first micrograph (Fig. 8A) was taken from the weld made with a 66.5% dilution, and the weld metal composition was Al-23.8Cu. From the Al-Cu phase diagram, T_{LB} = 548°C and T_{LW} = 586°C. Thus, T_{LW} was above T_{LB} and ($T_{LW} - T_{LB}$) = 38°C.

The beach was continuous along the fusion boundary but intruded by the weld metal at multiple locations along the fusion boundary. Peninsulas and islands of random orientations existed in the space between intrusions. The beach, peninsulas, and islands had a lamellar structure characteristic of the eutectic alloy just like the eutectic base metal (as can be seen in Fig. 9B). These observations are consistent with Mechanism 2.

The second micrograph (Fig. 8B) was taken from another weld made on as-cast Al-33Cu with filler metal 1100 Al. A rectangular rod of 1100 Al was placed in a rectangular groove machined at the top of the workpiece before welding in order to further reduce the weld-metal Cu content and raise the temperature difference ($T_{LW} - T_{LB}$). Microstructural examination of

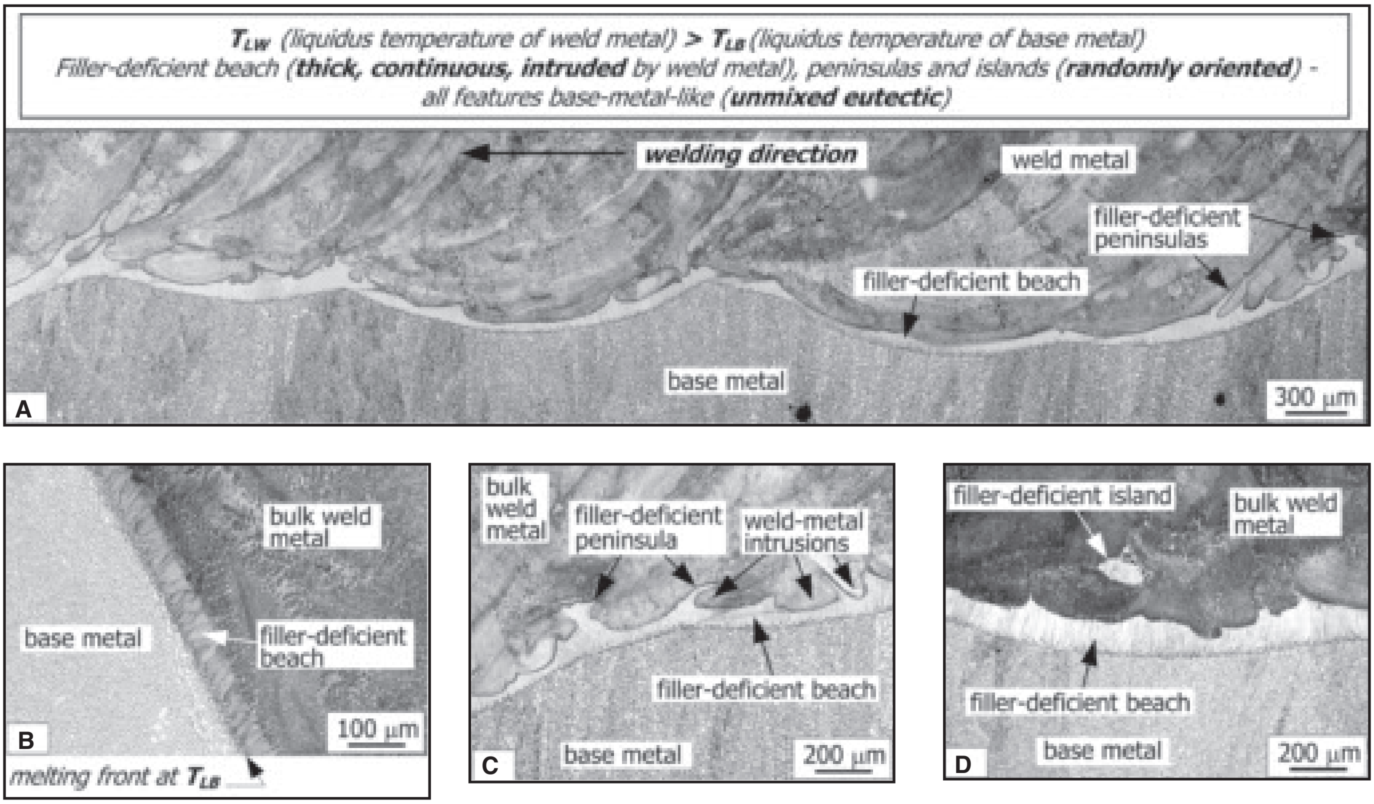

Fig. 7 — Longitudinal micrographs for $T_{LW} > T_{LB}$. A — Overview; B — melting front; C, D — weld bottom. Base metal: Al-33Cu (eutectic, heat-treated); weld metal: Al-24Cu. T_{LW} = 586°C and T_{LB} = 548°C. At higher magnifications, beach, peninsulas, and island all appeared eutectic (but lamellar) like base metal, suggesting they originated from unmixed base metal.

the resultant weld confirmed that the rod was completely melted and mixed with the bulk weld pool. The weld metal composition was Al-16Cu based on the compositions of the base and filler metals and the weld transverse cross section, which showed the contributions to the weld metal were 41.6% from the base metal (the dilution), 40.6% from the filler metal, and 17.8% from the rod. From the Al-Cu phase diagram, T_{LB} = 548°C, T_{LW} = 613°C, and thus, ($T_{LW} - T_{LB}$) was raised to 65°C.

The beach in the second weld (Fig. 8B) was also eutectic like that in the first weld but much thicker. This difference is consistent with Mechanism 2, which suggests that with a larger ($T_{LW} - T_{LB}$), a thicker unmixed zone is likely to exist. However, it is possible that the 1100 Al rod, with its higher liquidus temperature and hence greater resistance to melting, could have slowed down the velocity of the liquid weld metal induced by the filler-metal droplets and helped a thick layer of liquid base metal survive and thus further contributed to a thick filler-deficient beach.

Figure 9 shows the transverse micrographs of a weld made on as-cast Al-33Cu eutectic with filler metal 1100 Al. The dilution was 56.3%, and the weld metal composition was Al-20.7Cu. From the Al-Cu phase diagram, T_{LB} = 548°C and T_{LW} = 598°C. Thus, T_{LW} was above T_{LB} and ($T_{LW} - T_{LB}$) = 50°C. The beach is continuous along the fusion boundary but intruded by the weld metal — Fig. 9A. A section of the beach near the upper-right corner of the micrograph is shown at a higher magnification — Fig. 9B. The microstructure of the beach is lamellar, typical of as-cast eutectic just like the base metal itself. This clearly suggests that the beach originated from the layer of the liquid base metal along the pool boundary that solidified without mixing with the liquid weld metal.

In general, the lamellar structure in the beach was too fine to reveal clearly at a magnification level (e.g., 300×) that was kept low enough in order to include the beach, bulk weld metal, and base metal all in one micrograph. Only a few columnar eutectic grains were oriented such that their α-Al and θ-Al_2Cu layers were at the best angle to show the lamellar structure more clearly. At higher magnifications (e.g., 1000×), however, all grains in the beach exhibited a clear lamellar structure.

A composition profile (Fig. 9C) was taken along path A–D (Fig. 9B) across the fusion boundary. It shows that the Cu content was uniform at about Al-35Cu across the beach just like the base metal. This is essentially the eutectic composition of Al-33Cu. This further confirms that the beach was an unmixed liquid base metal.

This composition profile also shows another advantage of selecting eutectic Al-33Cu as the base metal, that is, the composition profile in the eutectic (including the base metal and the beach) is easy to measure by EDS because it is essentially uniform. On the contrary, the composition in the weld metal fluctuated wildly between the eutectic composition of about 33% Cu when the electron beam hit the interdendritic eutectic and the α-Al composition of about 6% Cu when the beam hit the dendrite arms. The dashed line represents the average weld metal composition of Al-20.7Cu mentioned previously.

Conclusions

The present study was conducted to verify the mechanisms proposed recently for fusion-boundary macrosegregation in arc welds made with dissimilar filler metals (Ref. 18). Al-Cu welds were made by gas metal arc welding with dissimilar filler metals. The filler metals made the liquidus temperature of the weld metal T_{LW} different from that of the base metal T_{LB}. Two groups of welds were made. In the first

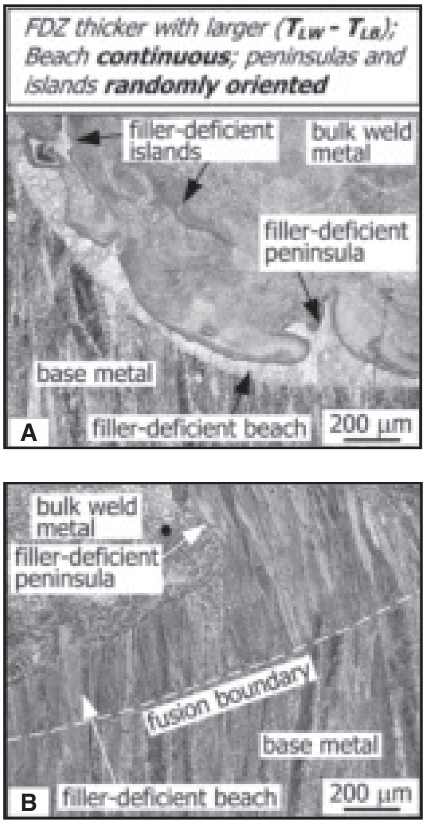

Fig. 8 — Transverse micrographs showing effect of (T_{LW} – T_{LB}) on thickness of filler metal-deficient zone (FDZ): A — (T_{LW} – T_{LB}) = 38°C; B — (T_{LW} – T_{LB}) = 65°C. Base metal: as-cast Al-33Cu (eutectic).

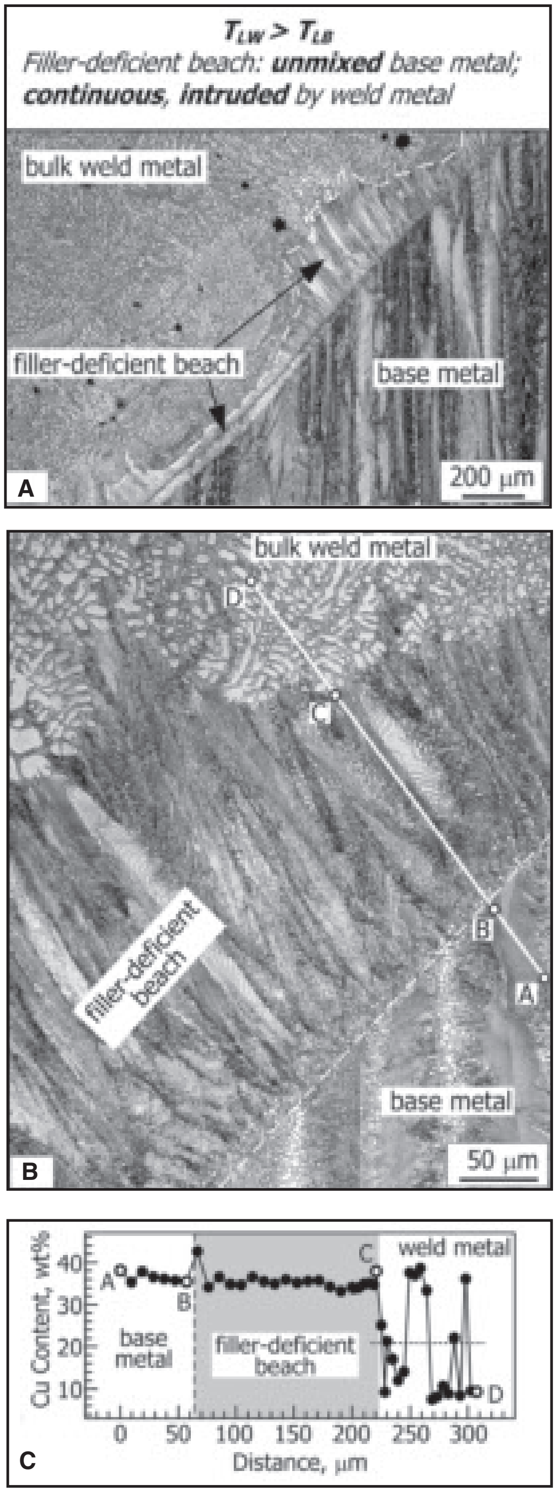

Fig. 9 — Macrosegregation across fusion boundary when T_{LW} > T_{LB}. A — Transverse micrographs; B — enlarged; C — composition profile. Base metal: as-cast Al-33Cu (eutectic). Beach identical to base metal in composition, i.e., unmixed base metal.

group, the dissimilar filler metal made $T_{LW} < T_{LB}$ and in the second group $T_{LW} > T_{LB}$. The microstructure and composition profiles near the fusion boundary of the resultant welds were examined. The conclusions are as follows:

1) The Al-Cu welds made with dissimilar filler metals have shown along the fusion boundary features including beaches, peninsulas, and islands essentially identical to the base metal both in microstructure and composition, both when $T_{LW} < T_{LB}$ and $T_{LW} > T_{LB}$. This demonstrates that these filler-deficient features originated from the liquid base metal that did not mix with the bulk weld pool, to which the dissimilar filler metal was added. According to the proposed mechanisms, such filler-deficient features can form due to lack of mixing between the layer of liquid base metal along the pool boundary and the bulk weld pool, both when $T_{LW} < T_{LB}$ and $T_{LW} > T_{LB}$. The layer can exist because convection is weakened near the pool boundary when $T_{LW} < T_{LB}$ but always exists regardless of convection when $T_{LW} > T_{LB}$.

2) The Al-Cu welds made with dissimilar filler metals have shown a thicker filler-deficient zone in welds made with a larger difference between T_{LW} and T_{LB}, both when $T_{LW} < T_{LB}$ and $T_{LW} > T_{LB}$. The proposed mechanism suggests that the filler-deficient zone can be thicker with a larger difference between T_{LW} and T_{LB}, both when $T_{LW} < T_{LB}$ and $T_{LW} > T_{LB}$, but the actual thickness can be affected by the strength and direction of convection in the weld pool.

3) The Al-Cu welds made with $T_{LW} < T_{LB}$ have shown filler-metal-deficient beaches thin and discontinuous along the fusion boundary, and filler-deficient peninsulas and islands roughly parallel to the fusion boundary. According to Mechanism 1 for $T_{LW} < T_{LB}$, the region of liquid weld metal immediately ahead of the T_{LW} solidification front is below T_{LB} and thus cooler than the liquid base metal and that the liquid base metal swept from the layer into the region can freeze quickly as peninsulas or islands without much mixing with the liquid weld metal. The liquid base metal remaining in the layer, which is thin and discontinuous because of weld pool convection, can solidify into a thin and discontinuous beach.

4) The Al-Cu welds made with $T_{LW} > T_{LB}$ have shown along the fusion boundary a thick continuous filler-deficient beach that is intruded by the weld metal, and filler-deficient peninsulas and islands that are randomly oriented. The proposed mechanism for $T_{LW} > T_{LB}$ suggests that the layer of liquid base metal is below T_{LW} and thus cooler than the liquid weld metal and that the liquid weld metal pushed by convection into the layer can freeze quickly into weld-metal intrusions without much mixing with the liquid base metal. The liquid base metal in the space between the intrusions solidifies in random orientations. Since the layer must exist regardless of weld pool convection, it can be thick and continuous and thus can solidify into a thick and continuous beach.

5) Conclusions 1–4 show that the proposed mechanisms have been verified by the Al-Cu welds made with dissimilar filler metals.

6) The present study can help guide the selection of filler metals to minimize macrosegregation near the fusion boundary in dissimilar-filler welding. First, a filler metal that makes a smaller change in the liquidus temperature of the weld metal is likely to

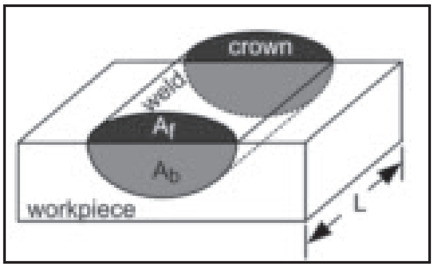

Fig. A1 — Schematic showing a section of the weld (L), the area representing the contribution of the base metal to the weld metal (A_b), and the area representing the contribution of the filler metal to the weld metal (A_f), that is, the transverse cross-sectional area of the crown.

cause less macrosegregation. Second, for the same absolute value of ($T_{LW} - T_{LB}$), a filler metal that lowers the liquidus temperature of the weld metal (that is, $T_{LW} < T_{LB}$) is likely to cause less macrosegregation than a filler metal that raises the liquidus temperature of the weld metal (that is, $T_{LW} > T_{LB}$).

7) The Al-Cu system is a useful alloy system for studying solidification and macrosegregation in dissimilar-filler welds. The easy-to-recognize microstructures and easy-to-measure compositions of pure Al and Al-33Cu eutectic are particularly helpful.

Acknowledgments

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Appendix A

Figure A1 shows L the length of the weld, A_b the area representing the contribution of the base metal to the weld metal, and A_f the area representing the contribution of the filler metal to the weld metal.

$$\text{Weight of Cu in weld from base metal} = (\text{vol-\% Cu})_{base} A_b L \rho_{Cu} = \{(\text{wt-\% Cu} / \rho_{Cu}) / [\text{wt-\% Cu} / \rho_{Cu} + (100 - \text{wt-\% Cu}) / \rho_{Al}]\}_{base} A_b L \rho_{Cu} \quad (A1)$$

$$\text{Weight of Cu in weld from filler metal} = (\text{vol-\% Cu})_{filler} A_f L \rho_{Cu} = \{(\text{wt-\% Cu} / \rho_{Cu}) / [\text{wt-\% Cu} / \rho_{Cu} + (100 - \text{wt-\% Cu}) / \rho_{Al}]\}_{filler} A_f L \rho_{Cu} \quad (A2)$$

$$\text{Weight of Cu in weld} = (\text{vol-\% Cu})_{weld} (A_b + A_f) L \rho_{Cu} = \{(\text{wt-\% Cu} / \rho_{Cu}) / [(\text{wt-\% Cu} / \rho_{Cu}) + (100 - \text{wt-\% Cu}) / \rho_{Al}]\}_{weld} (A_b + A_f) L \rho_{Cu} \quad (A3)$$

$$\text{Weight of Cu in weld} = \text{weight of Cu in weld from base metal} + \text{weight of Cu in weld from filler metal} \quad (A4)$$

Equations A1–A4 can be solved simultaneously, and the result is Equation 2.

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Sulfide-Induced Corrosion of Copper-Silver-Phosphorus Brazed Joints in Welding Transformers

A source of moisture was traced to leaking brazed joints within the transformer's secondary winding

BY D. R. SIGLER, J. G. SCHROTH, Y. WANG, AND D. RADOVIC

ABSTRACT. Failures of welding transformers were traced back to leaking brazed joints on the secondary winding within the transformer case. The leaks were caused by extensive corrosion of both the Cu-Ag-P braze metal and the adjoining copper tube and/or casting that formed the secondary winding. The corrosion consisted of selective attack of copper within the braze metal as well as the adjoining copper tube and casting. The existence of extensive copper sulfide scale in the winding and particularly at the brazed joint along with the presence of high phosphorus levels within the corrosion products suggests that the corrosion mechanism was sulfide-induced corrosion that led to formation of phosphoric acid within the joint. This acid selectively attacked copper either within the joint or adjacent to it. This mechanism was reproduced in the laboratory by exposing brazed joints to sulfide-contaminated deionized water at elevated temperature. A long-term solution to the corrosion problem was identified: replacement of the Cu-Ag-P braze with a phosphorus-free Ag-Cu-Zn-Sn braze.

Introduction

Transformers used for resistance spot welding of vehicle structures can fail for a variety of reasons. Since the transformers are water cooled, water entering the transformer case from any number of sources can provide a low-resistance current path or short between the transformer secondary and primary windings. In this work, a source of moisture was traced to leaking brazed joints contained within the transformer case as part of the construction of the transformer's secondary winding.

The secondary winding is typically constructed from both wrought and cast parts fabricated from electronic-grade copper. The components are joined during assembly with a torch brazing process and a filler metal from the copper-phosphorus-silver braze metal family. These alloys have been used extensively for more than 30 years in welding transformers. They are economical and can be self fluxing when used to braze copper. The copper phosphide family of braze metals is widely recommended for joining copper and high-copper alloys in a variety of applications (Refs. 1–6), particularly copper-to-copper tube including copper piping in cooling systems. Although similar brazed transformers have shown good durability, the occurrence of failed transformers from water leaks has been observed often enough to warrant further investigation. Ultimately, more durable braze joints may be required to survive specific operating conditions.

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Experimental

Damaged transformers were examined to determine the root cause of failure for the brazed joints. Failure analyses consisted of visual examination, optical examination, and scanning electron microscopy (SEM) examination with energy-dispersive spectroscopy (EDS). SEM EDS analyses were performed using a Zeiss EVO SEM with a Noran EDS system adapted to the microscope. In addition, personnel in the Chemical Analysis group at the GM R&D Center examined brazed joints with a field emission scanning electron microscope (FESEM) and x-ray photoelectron spectroscopy (XPS).

KEYWORDS

Braze Filler Metal
Brazing
Copper Phosphide
Corrosion
Resistance Welding
Secondary Winding
Transformer

Results and Discussion

Failure Analyses

Secondary Winding Design: Components and Braze Filler Metal

Figure 1 shows a portion of a typical winding of a transformer removed from an assembly plant. The winding consists of a thick-walled copper tube with cast copper pads brazed to the ends of the tube. The tube and pads are both pure copper conforming to the Copper Development Association Specification C11000, which is an electrolytic tough pitch copper alloy consisting of 99.9% copper with some residual oxygen. While the C11000 specification refers to wrought material, the same alloy was used to cast the winding pads. The brazing alloys used to join the transformer winding components are from a family of high-phosphorus-content alloys that require no fluxing to wet the copper substrate. The alloys used were either a Cu-18Ag-6.25P alloy (all values in wt-%) or a Cu-6Ag-6.1P alloy.

A cross section through a brazed joint made from the Cu-6Ag-6.1P alloy is shown in Fig. 2A. The left side of the joint is the side exposed to the atmosphere while the right side of the joint has cooling water running through it during use. Figure 2B shows the as-polished microstructure of the joint. Several phases are visible including primary pro-eutectic copper, which appears as light-gray particles, dark-gray copper-phosphide (Cu_3P) particles, and a eutectic consisting of lamellae of copper and Cu_3P.

A typical microstructure for the Cu-18Ag-6.25P alloy is shown in Fig. 2C. In addition to the microstructural constituents found in the Cu-6Ag-6.1P alloy,

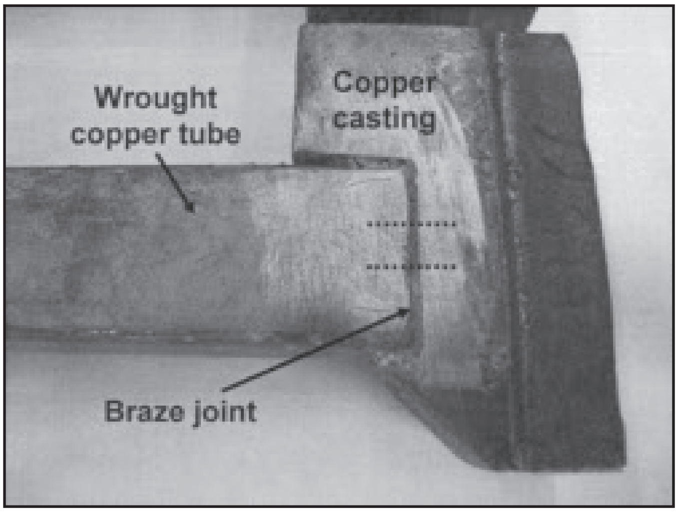
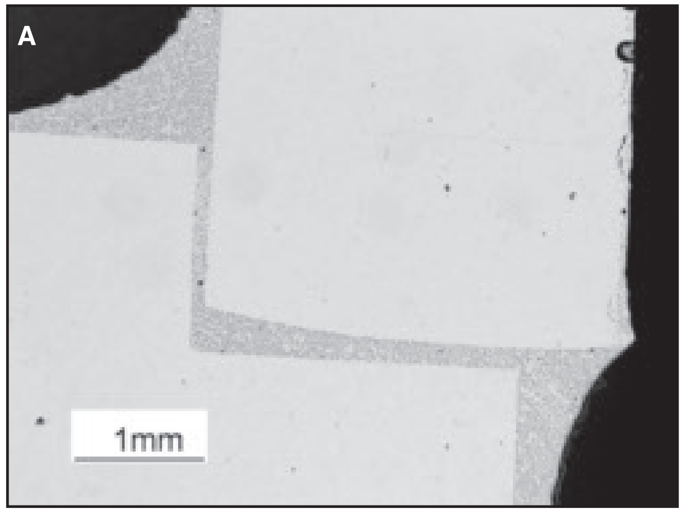


Fig. 1 — A portion of a secondary winding removed from a failed transformer. Dotted lines indicate section taken for braze joint evaluation.



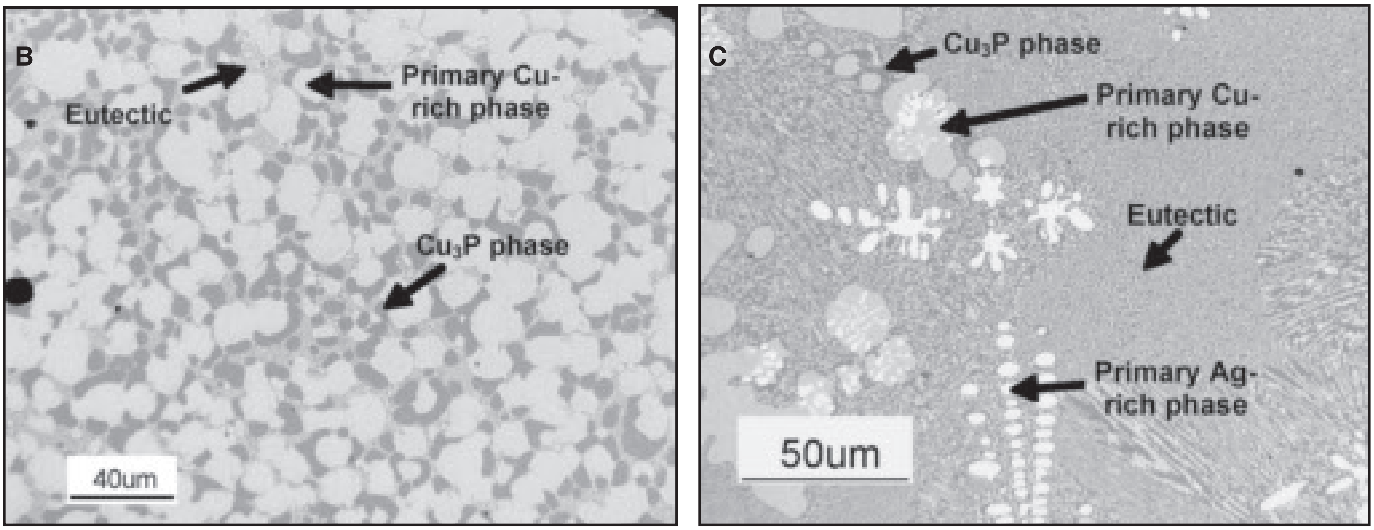


Fig. 2 — Cross sections of typical undamaged braze joints. A — An overview of a Cu-6Ag-6.1P braze metal joint; B — microstructure of brazed joint; C — microstructure of a higher Ag filler metal, Cu-18Ag-6.25P, that contains globular primary Ag particles in addition to the constituents of the 6Ag alloy.

the higher-Ag braze metal contains primary Ag-rich particles deposited early in the solidification process. Those Ag-rich regions have the lightest color in Fig. 2C. The composition of this high-Ag alloy is close to the ternary eutectic so that the greatest volume fraction of the microstructure consists of copper and Cu_3P lamellae in eutectic form. Some Cu_3P particles are also visible.

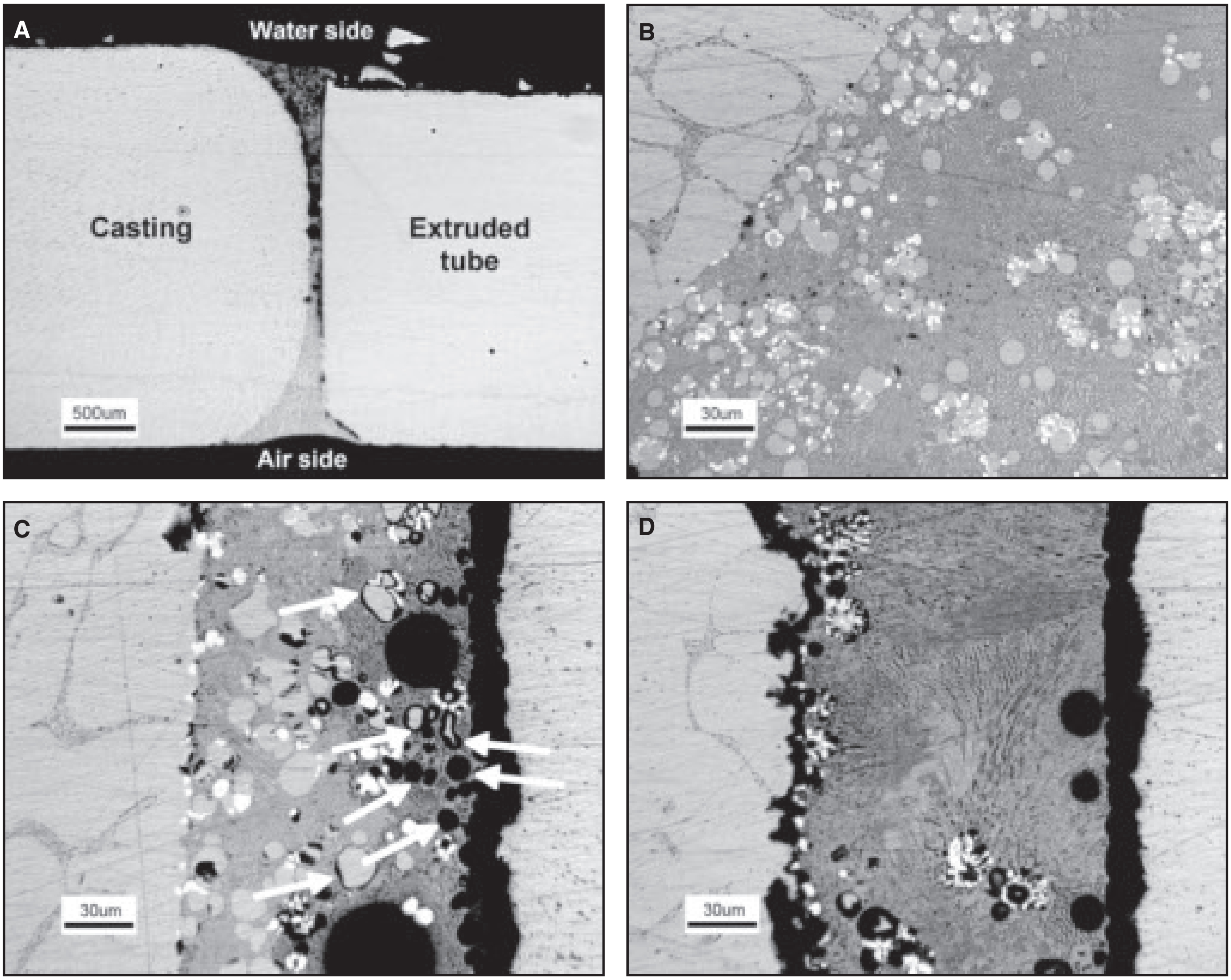
Selective Copper Attack

Numerous braze joints from corroded windings were evaluated in metallographic cross section. Figure 3 shows a butt joint brazed with the Cu-18Ag-6.25P alloy. The water side and air side of the joint are indicated. The braze metal itself appears dark toward the water side of the joint. In addition, dark areas define much of the braze/tube and braze/casting interfaces.

Figure 3B illustrates a typical joint microstructure near the undamaged "air-side" of the braze filler metal adjacent to the winding's cast pad. Features of the braze microstructure include a large volume fraction of Cu/Cu_3P eutectic as well as Cu-rich and Ag-rich particles. The casting shows a large grain size of ~50 µm with Cu-oxide particles outlining the grain boundaries. Toward the center of the braze joint is an area with significant damage — Fig. 3C. The two very large, round pores are likely gas porosity carried over from the brazing operation. Degradation of the joint has produced a large gap between the braze filler metal and the copper tube. Also, selective attack of copper lamellae in the braze has occurred and turned the eutectic dark in color. Finally, the primary copper particles were also attacked as shown by some dark areas surrounding some of the particles and other particles missing completely (see arrows).

Figure 3D shows an area located closer to the water passage. In this micrograph, attack of both the copper tube and copper casting is apparent. In addition, extensive attack of copper particles as well as copper lamellae in the braze filler metal has occurred. Figure 3E shows a microstructure of the brazement adjacent to the water flow passage. With a few exceptions, the microstructure is nearly devoid of Cu-rich phases.

These micrographs illustrate a form of selective Cu attack that leaves the Cu phosphide phase intact, while dissolving/reacting/damaging any copper metal in contact with the copper-phosphide. The at-risk copper constituents include the copper eutectic lamellae, primary Cu-rich



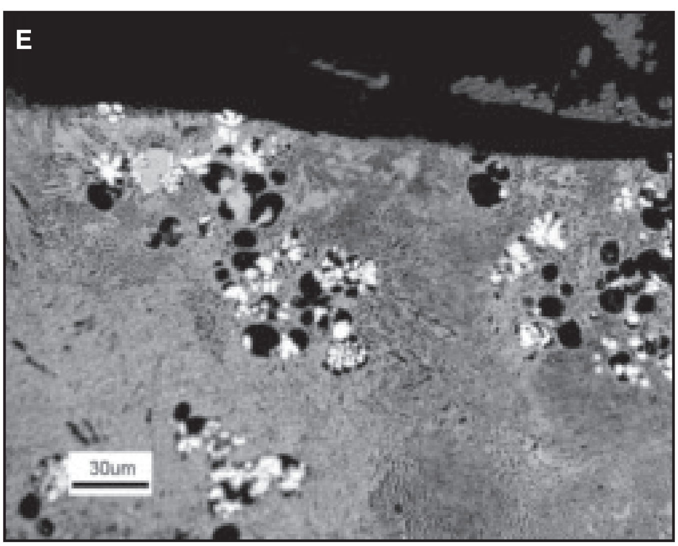


Fig. 3 — Cross-sectional views of a damaged brazed joint. A — An overview; B — a location with no damage near the air side of the joint; C–E — locations with progressively more severe damage approaching the water side of the joint.

particles, and the wrought copper tube and copper casting.

Attack of the braze joint has been observed to take somewhat different forms as illustrated in Figs. 3 and 4. Figure 3 shows attack of copper in the braze metal as well as attack of the copper tube and copper casting in contact with the braze metal. In this case the attack appears to progress inward from the water flow passage. Figure 4A shows an excellent example of interfacial attack occurring along both the casting and tube boundaries as well as copper attack within the braze metal itself. Joints observed to date include some exhibiting severe attack of all copper constituents (Fig. 4A), while others show enhanced reactivity at the base metal components with lesser attack of the braze-filler-metal copper constituents — Fig. 4B.

Corrosion Product Analyses

Metallographic Examination

A closer examination of damaged joints showed what appeared to be several types of corrosion product within the joints. Figure 5 shows a joint taken from a transformer where both interfacial attack and attack within the braze metal have progressed from the water-flow side of the joint toward the air side of the joint.

Corrosion products in both Fig. 5B and 5C were analyzed with SEM energy-dispersive spectroscopy (EDS). Figure 5B shows analyses for a light-gray corrosion product that typically forms during the

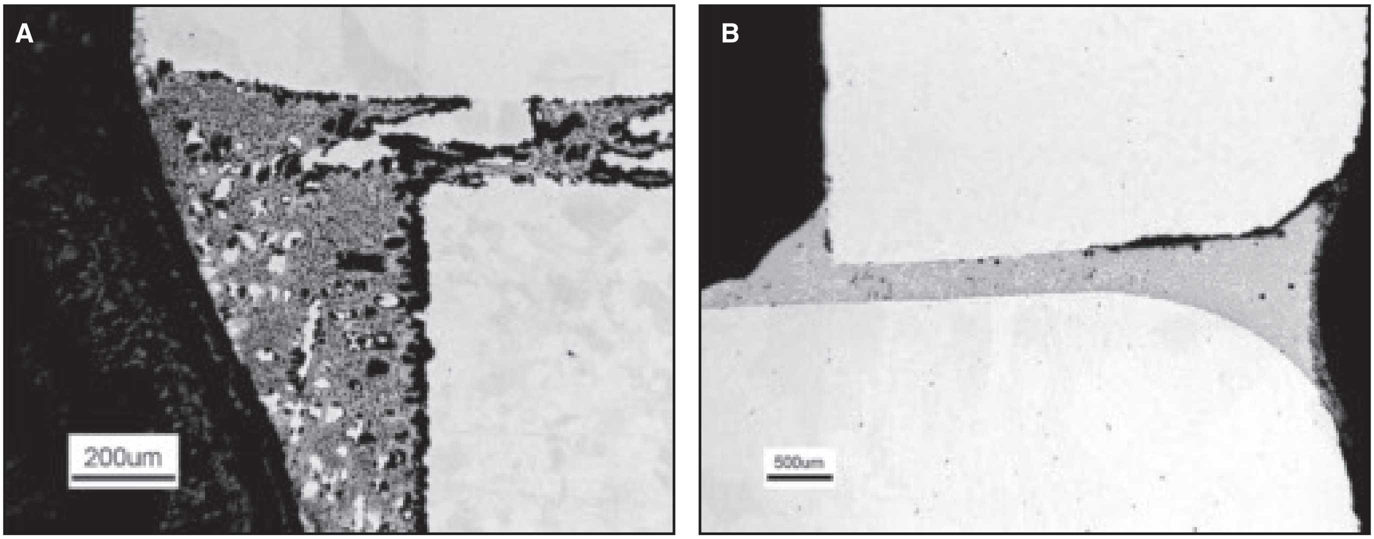
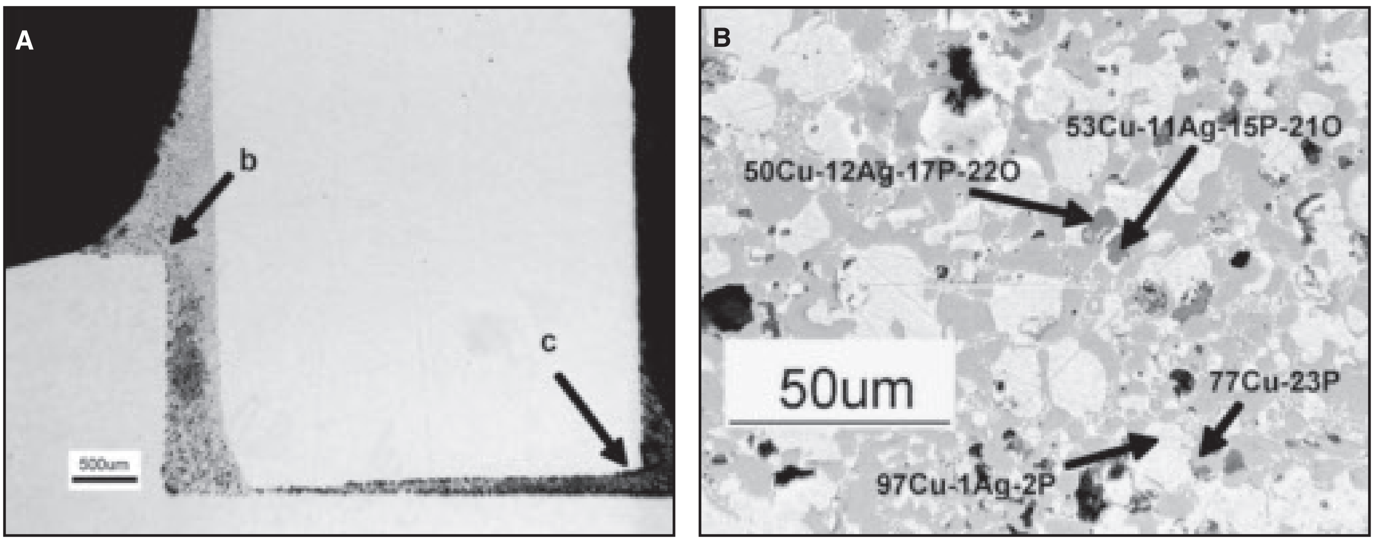


Fig. 4 — Cross-sectional views of damaged brazed joints. A — Severe interfacial attack and attack within the braze; B — severe interfacial attack from the air side with limited interfacial and braze metal attack from the water passage.



early stage of joint degradation. Also shown for comparison are compositions of the primary copper and Cu_3P phases. The primary copper phase contained approximately 1 at-% Ag and 2 at-% P, while the phosphide phase showed no Ag. Compositions of the corrosion products displayed the expected high levels of O, but also contained (unexpected) high levels of both Ag and P: ~12 at-% Ag and ~16 at-% P. Hence, although the microstructural evidence most clearly showed attack of the copper, elemental analyses indicate that both Ag and P are involved in the corrosion process. Cu is also clearly removed from the joint area since the primary copper, which was once 97 at-% Cu, is replaced with a corrosion product containing only ~50 at-% Cu.

Figure 5C shows compositions of corrosion products located in a more severely damaged area of the joint. Several types of morphologies are evident. These include a smooth dark-gray product (A), a porous dark-gray product (B), and a granular product (C) that is red in color. Relative to that found for the light-grey corrosion product in Fig. 5B, analyses of the dark-gray corrosion products revealed lower Ag and P levels, higher Cu levels, and the presence of about 2 at.-% S. The granular red corrosion product (C) had higher oxygen levels as well as sulfur and is suspected of

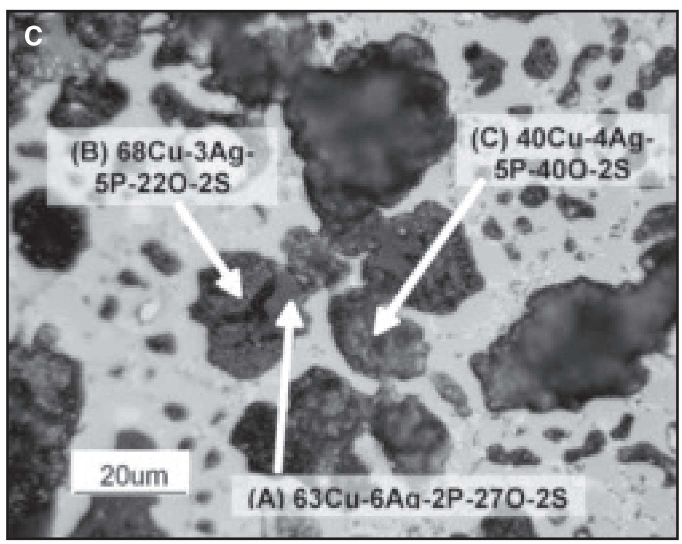


Fig. 5 — Cross-sectional views of a damaged brazed joint. A — Low magnification; B — high magnification in an area with less severe attack; C — high magnification in an area with more severe attack. Compositional analyses done by SEM EDS with results expressed in at.-%.

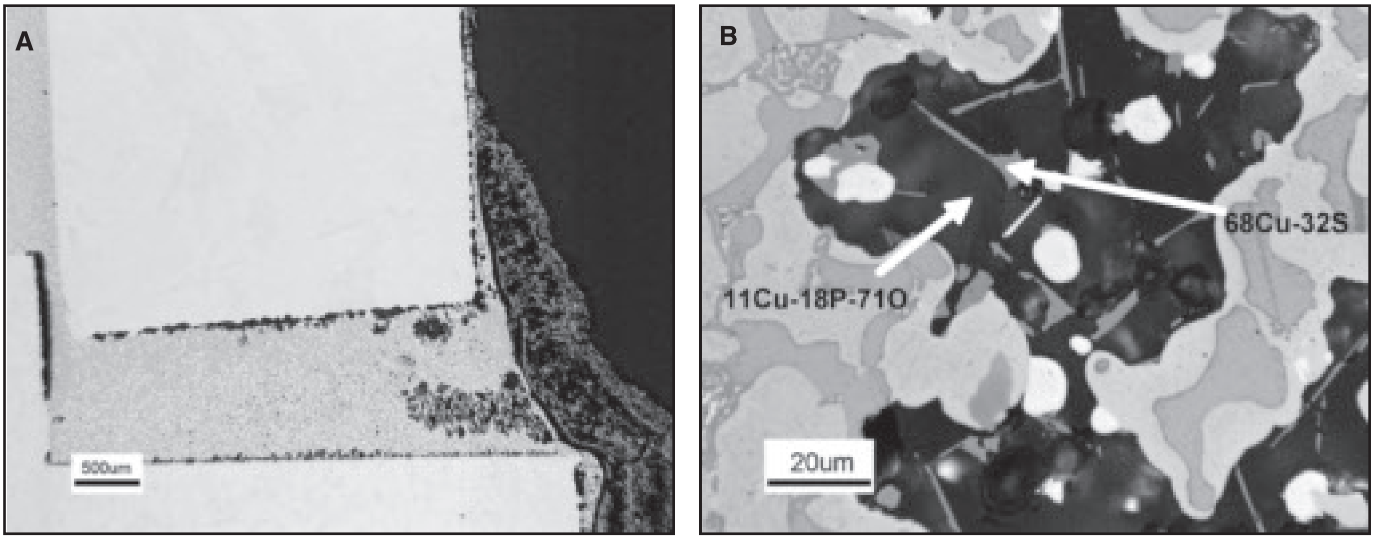


Fig. 6 — Cross-sectional views of a severely damaged brazed joint. A — Low magnification; B — high magnification. Compositional analyses were done by SEM EDS and expressed in at.-%.

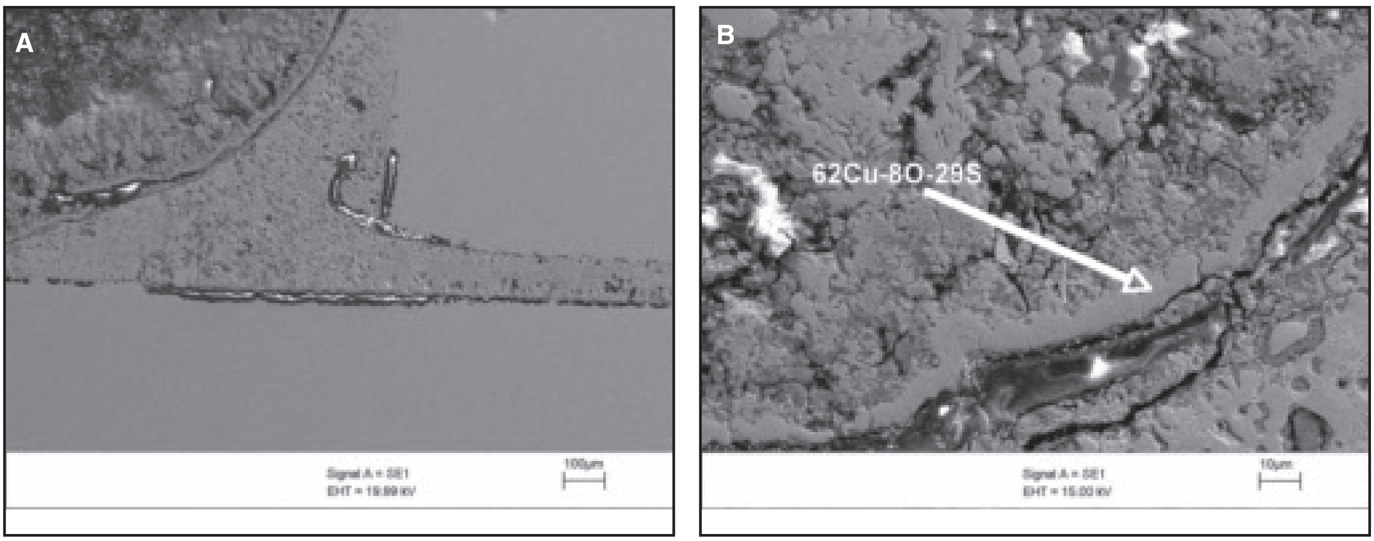


Fig. 7 — Cross-sectional views of a damaged brazed joint showing a heavy layer of copper sulfide on the braze metal surface in contact with the water passage. A — Low magnification; B — high magnification. Compositional analyses were done by SEM EDS and expressed in at.-%.

being predominantly CuO.

An even more severe form of attack was found in one winding joint. Figure 6A shows a metallographic overview of the joint while Fig. 6B shows a high-magnification view along with results of EDS analyses. The joint cross section reveals angular particles that were identified as copper sulfide, Cu_2S. The dark phase surrounding the particles contained Cu and P with very high levels of O, and was thought to be a copper phosphate compound.

Another characteristic feature of the attacked brazed joints is that they all showed a thick layer of copper sulfide, Cu_2S, on the braze surface exposed to the water flow passage. Figure 7 shows an SEM image of braze metal area in contact with the water passage for a joint removed from a failed transformer. An EDS analysis determined that it was copper sulfide.

Fracture Surface Examination

To further understand the corrosion mechanism, joints were deliberately fractured and examined. Joint integrity was so poor that sections of the joints approximately 6 mm wide could easily be fractured manually. The exposed surface of the braze metal was typically found to be covered by a blue film or coating. EDS analyses of these coatings found that they consisted of Cu, P, and O, which suggests that it is a form of copper phosphate similar to that shown in Fig. 5. XPS analysis performed on one of the joints identified the film on the braze metal as copper phosphate with a composition containing up to 5 at.-% sulfur.

In many instances there was no residue on the surface of the adjacent copper component. Figure 8 shows an example of this for a cast copper pad removed from the adjacent tube. Braze metal had covered the cast pad within the water flow passage. Severe attack of the pad had occurred beneath the braze metal. Because of the extent of the damage, the braze metal was weakly attached and easily removed by hand. The figure reveals a strongly etched structure with the grain boundaries clearly revealed. No residue was obvious in this area.

Literature Descriptions of Similar Copper Corrosion Phenomena

While literature data concerning the corrosion of Cu-P brazed joints are some-

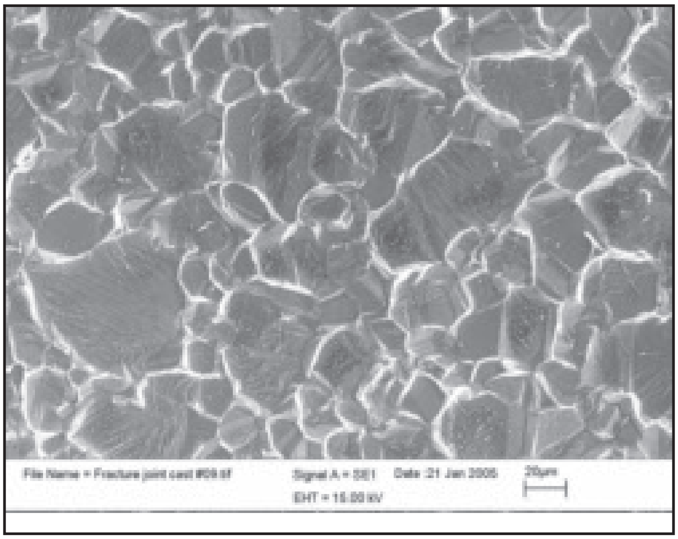


Fig. 8 — SEM micrograph of the brazed joint showing the surface of the cast pad beneath corroded braze metal clearly revealing the grain structure.

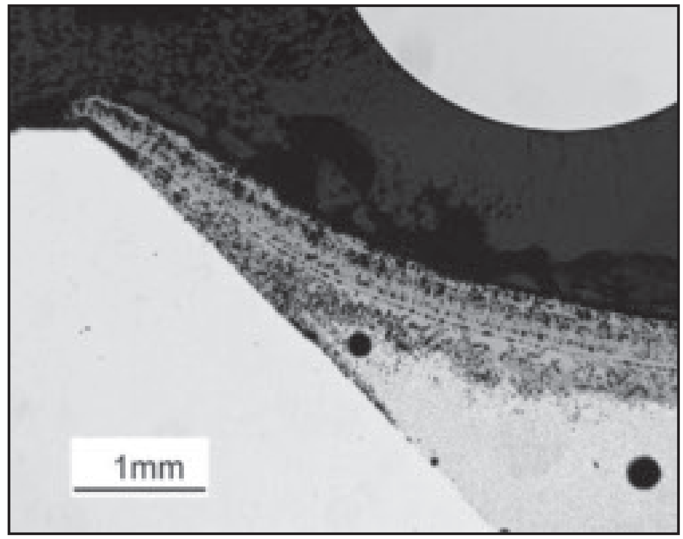


Fig. 9 — Simulated transformer brazed joint fabricated by torch brazing electronic-grade C11000 copper plate and Cu-6Ag-6.1P braze alloy after exposure to water at 60°C containing 160 ppm sulfide for three weeks. Joint damage, including penetration into the braze and interfacial attack, mirror that from damaged plant transformers.

what limited, the type of corrosion that selectively attacks copper both within the braze joint as well as adjacent to the braze material has been documented previously in a variety of environments. B. Upton found extensive interfacial corrosion of copper phosphide and corrosion of the copper-rich phase for joints exposed to seawater in Langstone Harbor, U.K. (Ref. 7). K. Nielsen found extensive interfacial corrosion of copper adjacent to the copper phosphide braze for copper tubes that contained hot (60°C) drinking water obtained from Copenhagen, Denmark (Ref. 8). A British Engine failure analysis showed both interfacial corrosion at the joint and selective copper attack within the braze joint that was located within a heating system (Ref. 9).

The above examples exhibited the same failure mode seen in the brazed weld transformers. However, the critical issues leading to the failures were not clearly identified. It is known that the copper phosphide phase is more noble than the copper phase in Cu-P filler metals. Hence the more active copper will always tend to be attacked preferentially during galvanic corrosion. However, the AWS brazing manual specifically notes that copper-phosphorus filler metals have excellent corrosion resistance except when "exposed to sulfurous gases, compounds or solutions (Ref. 3)." The Brazetec GmbH Web site provides documentation of a copper phosphide corrosion failure where copper within the braze is selectively attacked and converted to copper sulfide and copper oxide (Ref. 10). The reason for the attack was given as exposure of the braze joint to media containing sulfur and/or sulfur compounds.

There is additional literature data to support the role of sulfur in the degradation of Cu-P brazements, although most of it is related to corrosion in atmospheres containing H_2S gas. T. Takemoto et al. found that copper joined with copper phosphide braze metal experienced selective corrosion of copper, particularly at the braze/copper interface when exposed to moist air containing H_2S gas (Ref. 11). P. C. Wingert investigated the corrosion of copper connectors brazed with a copper phosphide alloy and found that high-temperature, high-humidity atmospheres containing sulfur attacked copper within the braze as well as adjacent to it (Ref. 12). In this case, however, the primary corrosion product was copper sulfide.

H. Matsuoka et al. described selective copper attack for copper phosphide joints that appears more closely related to that found in the weld transformers (Ref. 13). Attack included both interfacial corrosion between the joint and braze as well as selective copper attack in the braze metal. Those joints were exposed to a moist atmosphere containing H_2S gas that produced phosphoric acid from the copper phosphide braze metal. This acid then attacked the copper phases within and adjacent to the braze metal in a galvanic corrosion reaction. Copper sulfide was present, but only on the surface of the braze metal. This description closely matches the transformer winding failure mode wherein copper sulfide is found along interior water passages covering the braze metal (Fig. 7) and copper phosphate compounds are found in the corrosion product within the braze joint (Figs. 5 and 6). The production of phosphoric acid has also been postulated to occur in copper-phosphide braze joints exposed to water at room temperature, but in this case sulfide was not introduced into the system and the phosphoric acid resulted in the formation of protective scales (Ref. 14). In addition, during electropolishing, phosphoric acid is known to produce both the faceted grain structure found on some brazements (Fig. 8) (Ref. 15) as well as copper phosphate residue (Refs. 16, 17).

Weld Transformer Winding Corrosion Mechanism

The selective attack of copper within and adjacent to copper phosphide joints is postulated to be caused by sulfide-containing species in the water that form a sulfide scale on the braze and copper component surfaces. Beneath the sulfide scale, the local solute environment changes, which catalyzes the formation of phosphoric acid in the braze joint. Phosphoric acid then begins to selectively attack copper either in the joint or adjacent to it. Corrosion products consist primarily of copper-phosphate-related compounds, with evidence of sulfur within much of the corrosion product. Copper within the corrosion product is transported away from the joint out to the water passage where it encounters sulfide within the weld water and adds to the sulfide deposit on top of the braze metal. As corrosion along the interfaces advances, the attack reveals the grain structure of the adjacent copper tube or casting and eventually produces a large gap between the braze metal and the copper component.

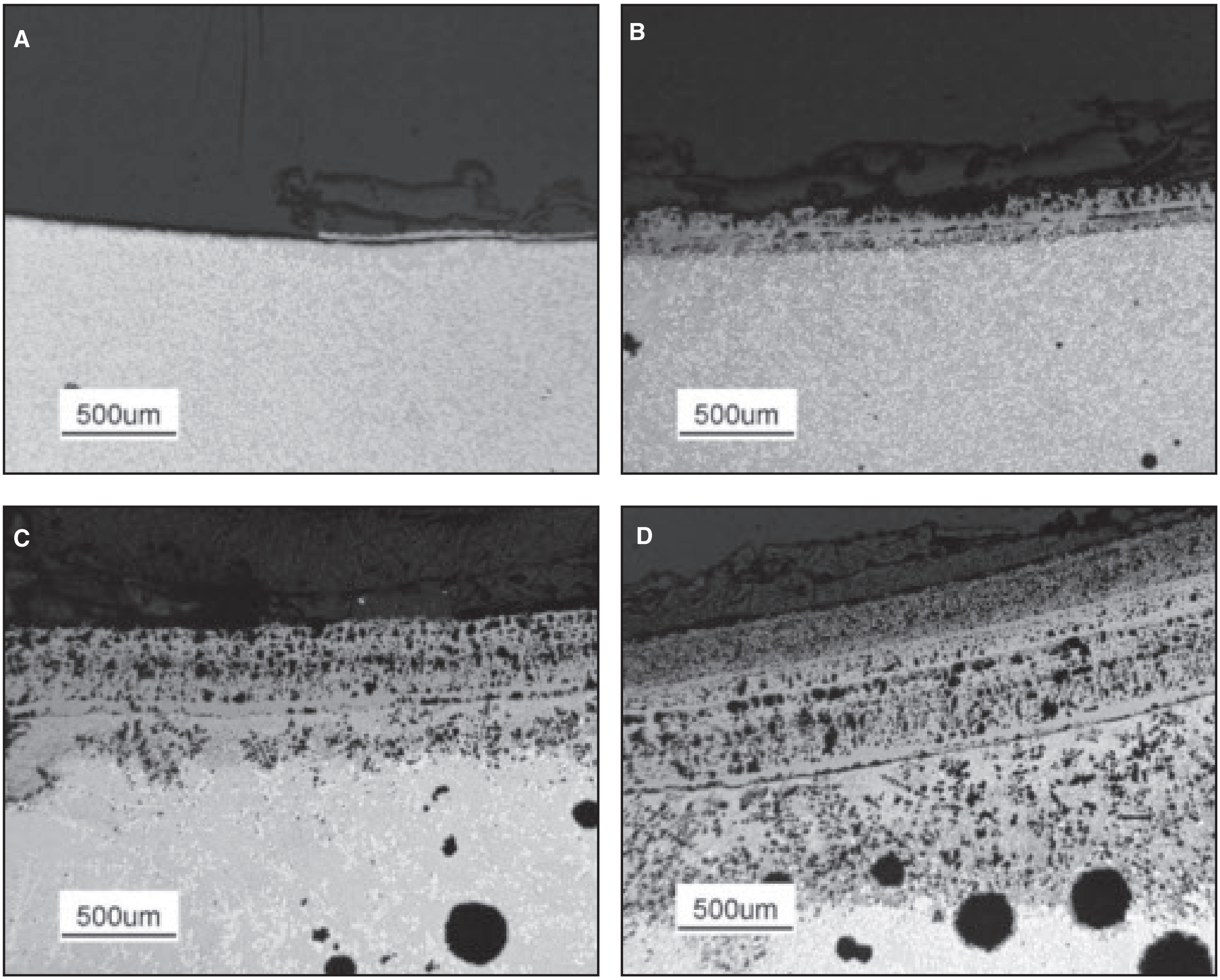


Fig. 10 — Simulated brazed transformer joint fabricated by torch brazing electronic-grade C11000 copper plate with Cu-6Ag-6.1P braze alloy after exposure to water containing 160 ppm sulfide at 60°C. A — 1 week; B — 2 weeks; C — 3 weeks; D — 5 weeks.

To verify the corrosion mechanism and gain an understanding of the corrosion kinetics, corrosion tests on specially prepared brazed samples were performed in water containing a high sulfide level. The Cu-6Ag-6.1P braze alloy was deposited in grooves machined into a 9.53-mm-thick C11000 plate by torch brazing. The geometry of the groove and plate thickness were designed to provide both a similar joint geometry to that found in the transformer joints and a similar as-brazed microstructure. Samples ~10 mm wide cut from the plate were exposed to specially prepared deionized water. The deionized water was treated with $Na_2S \bullet 9H_2O$ to give a sulfide level of 160 ppm. The sulfide level was monitored daily and sulfide additions were made to the water each day to maintain a level of 160 ppm. Temperature was controlled to 60°C with a hot plate with thermocouple control. To simulate the high water velocity in a welding transformer, the solution was stirred magnetically at a high rev/min using digitally controlled stirrers. The test was carried out for seven weeks with samples removed at 1, 2, 3, 5, and 7 weeks.

After exposure, samples were sectioned metallographically for assessment of the corrosion damage. Figure 9 shows an example of the sulfide-induced corrosion damage. Its appearance replicates damage observed in transformer joints. Figure 10A–D shows cross sections taken at 1, 2, 3, and 5 weeks, respectively. The sulfide scale thickness, depth of attack into the braze metal, and depth of attack along the copper/braze metal interface were all measured from micrographs of joint damage. Figure 11 gives the measurement data as a function of time exposed to the sulfide-containing water. It is apparent from the micrographs in Fig. 10 and the measurement data in Fig. 11 that the corrosion reaction begins slowly, but once underway, proceeds at an exceptional rate.

Sources for sulfide contamination of weld water systems have been under investigation. Closed-loop weld water systems are uniquely vulnerable to the action of sulfate-reducing bacteria (SRBs) that can grow in anaerobic environments. These bacteria can act to reduce innocuous sulfate ions into aggressive sulfide species that could promote the corrosion observed in transformers. Measured levels of sulfate in more than one of the affected systems indicated levels much below those of the make-up water used to refill the system after a water-loss event. This is indirect evidence that the sulfate present had been converted to another species.

While little is known regarding the mechanism of sulfide-induced corrosion specifically for the braze alloys under discussion, considerable work has been done

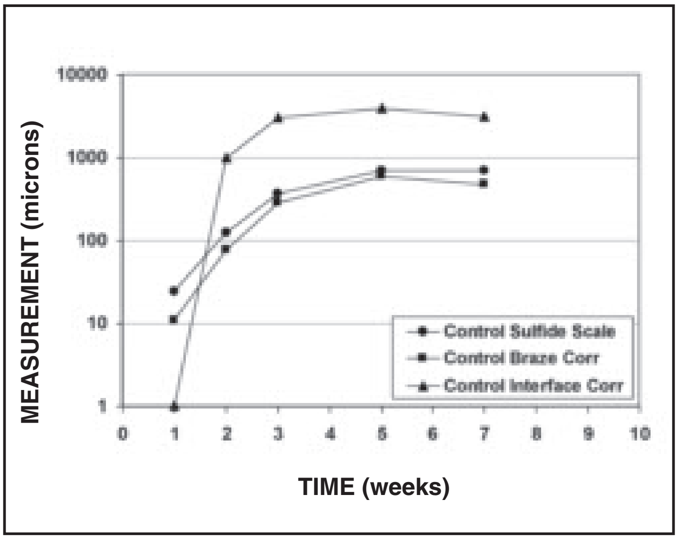


Fig. 11 — Corrosion penetration into the brazed joint after exposure to simulated weld water at 60°C containing 160 ppm sulfide.

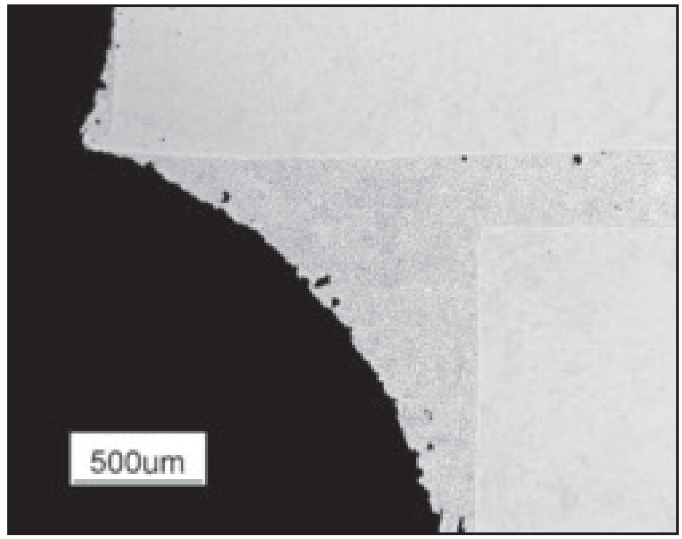


Fig. 12 — Brazed joint taken from a transformer that utilized a high-silver, phosphorus-free braze alloy. The joint shows no discernible corrosion after five months of exposure in a plant whose weld water system suffered from sulfide contamination.

to study the effects of sulfide on copper and copper-nickel alloys (Refs. 18–22). These studies all report that sulfide in the water, most likely as hydro-sulfide ions (HS^-), greatly accelerates the corrosion of copper by acting as a catalyst for both the anodic and cathodic reactions. Very little sulfide is needed in the water: as little as 10 ppb can accelerate corrosion (Ref. 18). Also, once the sulfide scale is established on the metal surface, removing sulfide from the water does not return the corrosion rate back to that of sulfide-free metal in clean water, but rather the accelerated corrosion rate will remain. Thus, if the sulfide scale found on certain transformer braze joints is acting as a catalyst as it does for ordinary copper corrosion, its removal may be necessary to stop the accelerated attack. However, once phosphoric acid is formed deep inside the joint along the crevices and within the phosphide braze metal itself, corrosion may possibly continue at a rapid rate despite correcting the water composition and removing the sulfide scale. In view of this possibility, more work is needed to assess the effectiveness of possible treatments to arrest sulfide-induced corrosion once a significant amount of corrosion product has already formed in an existing manufacturing system.

Corrective Actions

Solutions to controlling the sulfide-initiated corrosion problem have taken multiple forms. First, steps have been taken to minimize the presence of sulfide ions in cooling water, i.e., limiting sulfate-reducing bacteria through the addition of biocides effective against these bacteria. Second, water treatments to limit such corrosion have taken the form of changes in recommended practices to increase levels of copper corrosion inhibitors. Third, a long-term solution has been implemented whereby transformers are not put at risk for this type of corrosion by replacing the Cu-Ag-P braze by a sulfide-resistant braze filler metal.

At this time, a replacement braze metal has been identified and implemented. The Ag-Cu-Zn-Sn braze family was developed in response to the need for low-melting-point filler alloys that have low solidus temperatures, narrow melting ranges, and good corrosion resistance, but do not contain Cd. These alloys, though more expensive than the Cu-Ag-P family, have shown excellent corrosion resistance in practice. Because they are P-free, the catalytic presence of copper phosphide within the braze metal is removed. The specific alloy recommended is BAg-7, which is nominally 56% Ag, 22% Cu, 17% Zn, and 5% Sn, and is close to the eutectic composition. Figure 12 shows a joint from a transformer installed for five months in a plant with a history of sulfide contamination and corrosion. The joint shows no sulfide buildup and no corrosion whatsoever.

The Ag-Cu-Zn-Sn family of alloys is compatible with the torch brazing process when the proper flux is used. Braze filler metals of appropriate melting points are also available to manufacture complex assemblies that require successive processing with filler metals of decreasing melting point. These alloys all have compositions close to the ternary eutectic of Ag-Cu-Zn, and thus all have low melting points. Tin acts as a melting point depressant and improves flow (Ref. 23). The alloy is typically recommended for brazing steel, copper, and nickel alloys and has good corrosion resistance, good flow characteristics, high ductility, and a low melting point (Refs. 5, 24, 25). We recommend use of these and similar alloys as a solution to sulfide-induced corrosion. Their use in weld transformers should protect the transformers against accelerated corrosion in the presence of sulfide ions. Until additional work is done, it is further suggested that alloys of this family with high Zn contents (>20–25%) be avoided to maximize corrosion resistance.

Conclusions

1) Failure analyses of numerous joints brazed with Cu-Ag-P braze alloys revealed that joint leaks were caused by the selective attack of the copper within the brazed joint as well as the copper components in contact with the joint. Within the braze deposit, copper subject to corrosion is distributed as primary copper particles and copper lamellae in a eutectic structure. The copper components attacked by the corrosion process included the wrought copper tubes and castings that were used to fabricate the transformer winding.

2) Scale formed in the internal water passages of the secondary winding at the braze metal location was found to contain large amounts of copper sulfide. The presence of copper sulfide indicates that sulfur previously existed within the water cooling system in the form of sulfide S^{2-} or hydrosulfide HS^- ions, or H_2S gas (rather than as innocuous sulfate SO_4^{2-}). This hypothesis has been anecdotally corroborated by plant personnel, who reported "black water" and sulfurous odors, two signs of

sulfide contamination.

3) Corrosion products were found both within the braze metal and at the interfaces between the braze filler and the copper components. These products contained high levels of oxygen and phosphorus. Analyses of corrosion product by XPS found phosphorus to be in the form of a phosphate. This is evidence that sulfide in the water promoted the formation of phosphoric acid that, in turn, caused the joint corrosion.

4) Preliminary laboratory tests exposed coupons of Cu-Ag-P braze metal deposited on copper plate to sulfide-containing deionized water at elevated temperature. This procedure successfully reproduced the corrosion mechanism, i.e., formation of a thick sulfide scale under which selective copper attack resulted in interfacial corrosion and corrosion products containing phosphorus. Depth of corrosion penetration within the braze and along the braze metal/copper interfaces showed that the corrosion begins slowly and rapidly accelerates to consume millimeters of metal within several weeks.

5) Brazed joints fabricated from a high-Ag, Ag-Cu-Zn-Sn braze that contained no phosphorus exhibited no corrosion when exposed to the same plant environment that produced extensive corrosion of Cu-Ag-P joints. This observed behavior is supported by literature data and indicates that a long-term solution to sulfide-induced corrosion will be the replacement of the phosphide braze in new transformers with an Ag-Cu-Zn-Sn alloy.

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Response of Exothermic Additions to the Flux Cored Arc Welding Electrode — Part 2

Investigating the exothermically reacting stoichiometric mixtures of aluminum, magnesium, and aluminum/magnesium (50/50 wt-%) flux additions in the flux cored arc welding process

BY S. H. MALENE, Y. D. PARK, AND D. L. OLSON

ABSTRACT. In Part 1 of this investigation, exothermically reacting magnesium-type flux additions to the flux cored arc (FCA) welding consumable electrode have resulted in measurable increases in the arc process efficiency. In Part 2 of this investigation, the manufacture and heat delivery of stoichiometric mixtures of aluminum, magnesium, and aluminum/magnesium (50/50 wt-%) flux types, with the mineral form of Fe_2O_3 termed hematite systematically displacing iron powder, were studied in an experimental self-shielded FCA flux formulation. All welds made using Part 2 electrodes were acceptable at the same preassigned welding schedule indicating an increase in usable weld parameter space. The Al/Mg (50/50 wt-%) electrodes were significantly more effective than aluminum or magnesium flux additions in net gain value. Since a reduction in the electrical power consumed, brought about for a given welding condition by the addition of chemical heating components, is as beneficial as a directly measurable increase in heat input (in joules) over the baseline condition, a composite normalized energy scale, in relative percent, is composed. By subtracting the percent electrical power (difference from the baseline value) from the percent measured heat input (also the difference from the baseline value) for each welding condition, a net gain value is calculated. The aluminum reactive addition at up to 20 wt-% was found to have a 32% increase over the baseline in specific deposit (g/kW consumed). The magnesium-reactive addition at 40 wt-% yielded a 38% increase in specific deposit and the Al/Mg (50/50 wt-%) electrode exhibited a 49% increase in specific deposit at only 10 wt-% reactive addition. Consequently, the investigation of Part 2 electrodes with the FCA welding process has shown that a maximum gain value occurs between the 10 and 20 wt-% electrodes of the Al/Mg (50/50 wt-%) flux additions. Much less electrical power was used for these electrodes than was consumed in the baseline comparative.

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Introduction

Field repair welding traditionally requires bulky dedicated electrical equipment or gas bottles with attendant torches, hoses, and regulators along with considerable operator skill. This type of welding can be enhanced through the use of exothermic flux additions to the FCA welding process (Refs. 1, 2). The self-shielding nature of the process precludes the need for gas systems while a reduction in electrical energy dependence of the welding parameter schedule as measured through voltage and amperage levels broadens the user appeal and applicability. Part 1 of this investigation (Ref. 3) showed that the exothermic reactions caused by the magnesium flux additions of the FCA welding consumable electrode demonstrated significant increases in the arc process efficiency. When the process efficiency was corrected for an apparent reduction in electrical power consumed in addition to the increase in measured heat input, the maximum benefit occurred at around 30 wt-% magnesium flux rather than at the 20 wt-% level for the measured heat input variable alone (uncorrected for a reduction in electrical power consumed). There was no evidence of uncontrolled reaction, which was observed in the unconstrained exothermic chemical additions to the flux formula of the shielded metal arc (SMA) welding process (Ref. 2).

KEYWORDS

Flux Cored Arc (FCA) Welding
Aluminum
Magnesium
Electrode
Electrical Power
Heat Input
Shielded Metal Arc (SMA) Welding

Two pure metallic elements that reduce iron oxide, aluminum and magnesium, are used in the production of steel to deoxidize or kill the steel. These elements have been added to the flux in various flux-related arc welding processes to kill the weld pool, and the reactions are exothermic. In addition, these elements, in large enough quantities, are known to be able to provide significant heat for welding (Ref. 4). Karpenko (Ref. 5) reported the effects of exothermic additions (aluminum + iron oxide) on the melting characteristics of SMA electrodes. The results show that aluminum additions increase the weld deposition rate and enhance welding parameters to achieve improved productivity. Also, Glushchenko (Ref. 6) studied the effects of exothermic additions in submerged arc welding fluxes on deposition rate and melting efficiency. Allen et al. showed that exothermic flux additions, such as aluminum and Al/Mg (50/50 wt-%) flux additions to SMA welding electrodes can assist in the generation of heat and increase the rate of electrode melting. Applying Hess's law and integrating the heat capacity from room temperature to that of the molten steel weld pool temperature gives the quantity of heat produced by the aluminum or magnesium reactions with hematite. Table 1 shows the calculated amount of heat released during the proposed reactions. These reactions are extremely violent if only the metal oxide and the pure reducing metal are used without mitigating chemical compositional control.

Part 2 of this investigation focuses on the revised (stoichiometric) exothermic flux formulations — aluminum, magnesium, and Al/Mg (50/50 wt-%) flux additions. Aluminum plus hematite, magnesium plus hematite, and a 50-50 mix of the Al/Mg types of exothermic reactions were prepared and evaluated. Also, this investigation was aimed at finding the potential effectiveness of such exothermic flux ad-

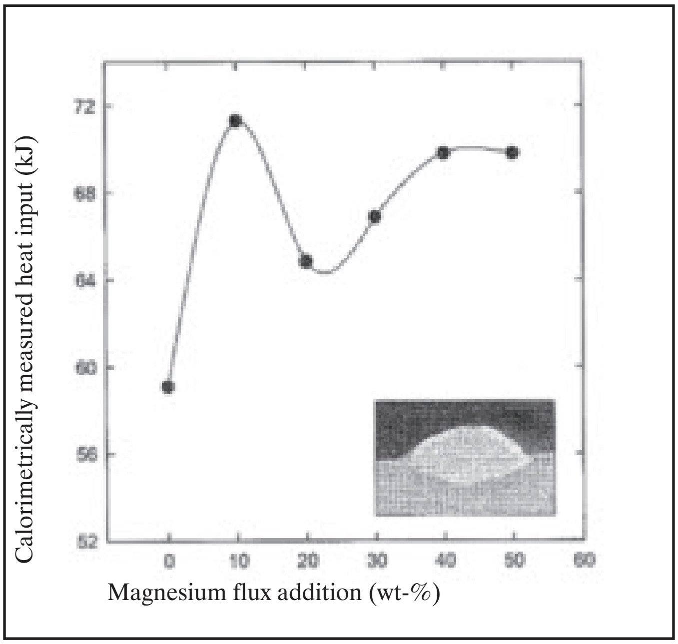

Fig. 1 — Measured heat input as a function of wt-% magnesium flux addition at 110 in./min (47 mm/s) melting rate. The insert photography is bead morphology of weldment with 40 wt-% of magnesium flux type electrode.

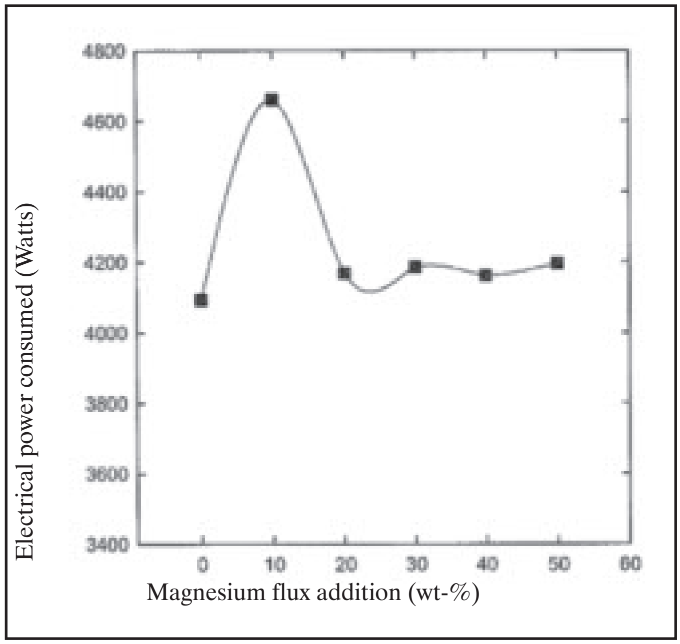

Fig. 2 — Electrical power consumed as a function of wt-% magnesium flux addition at 110 in./min (47 mm/s) melting rate.

Table 1 — Enthalpy Heats of Reaction for Aluminum and Magnesium Plus Hematite Flux Additions

Addition Reaction	Enthalpy ($kJ/mol O_2$)
$2Al + Fe_2O_3 = Al_2O_3 + 2Fe$	850
$3Mg + Fe_2O_3 = 3MgO + 2Fe$	1060
Al/Mg (50/50) mix with Fe_2O_3	Quantity of heat between 850 and 1060

Table 2 — Flux Composition for Part 2 Electrodes, Parts by wt-%

Flux Compound	Baseline Electrode	Aluminum-Type Electrode	Magnesium-Type Electrode	Al/Mg (50/50) Type Electrode
CaF_2	15	15	15	15
TiO_2	15	15	15	15
$CaCO_3$	6	6	6	6
SiO_2	4	4	4	4
Fe	60	50 ~ 10	50 ~ 10	50 ~ 10
$2Al + Fe_2O_3$	—	10 ~ 50	—	—
$3Mg + Fe_2O_3$	—	—	10 ~ 50	—
Al/Mg (50/50) + Fe_2O_3	—	—	—	10 ~ 50

ditions to the flux cored arc welding consumable electrode, and the effect of exothermic additions on the weld deposit and the arc/electrode extension environment were studied.

Experimental Procedures

As with investigation by Allen et al. (Refs. 1, 2) of the SMA welding system, three types of exothermic reaction powders were studied: the aluminum plus hematite, the magnesium plus hematite, and a 50/50 mixture of the magnesium and aluminum plus hematite mixtures. A self-shielding flux formulation containing 60 wt-% iron powder was selected as the baseline. The iron powder was systematically displaced with stoichiometric mixtures of the exothermic metal(s) and hematite in batch ratios from 0 to 50% in steps of 10% (±1.0 %) and a fixed fill ratio of 15%. The Part 1 electrode wires were produced with 17 to 18 wt-% flux fill to steel sheath ratios. Initial drawing difficulties led to all of these later Part 2 electrodes being manufactured to a more reasonable and commercial-like 15 wt-% fill. The set of 15 welding wires plus a new baseline electrode produced were made with stoichiometric mixtures of black, crystalline (granular) hematite (of between 100 and 140 mesh) and evaluated as to relative heat input and reduction in electrical power consumed to produce the weld.

The coarse-grained hematite was used in stoichiometric concentration levels with aluminum, magnesium, and Al/Mg (50/50 wt-%). Each of the three types of exothermic additions was added to the flux in place of the iron powder base in 10 wt-% increments up to 50 wt-%. The linear densities for all of these electrodes show much less variation than in the previous study and measure about 0.12 g/cm. The lower packing density of the flux and the change to a coarse-grained hematite allows for a more constant linear density value as a function of exothermic concentration level. These flux compositions are presented in Table 2.

Table 3 lists the welding parameters used in this study. The actual voltages recorded were about one volt higher, on average, than the set voltage. No slope-in, slope-out, or crater fill times were used. The torch head was adjusted to vertical with respect to the baseplate samples to be welded, and the travel direction was parallel to the length of the sample and centered along the surface. The wire feed speed was held constant at 110 in./min. All data points represent an average of a minimum of at least three identical weld trials.

In addition to machine current and voltage recordings for each 20-s timed weld sample, the wire electrode was cut off even with the guide tube following the weld and was bagged, tagged, and measured for length and mass. While most electrode extension remnants did not

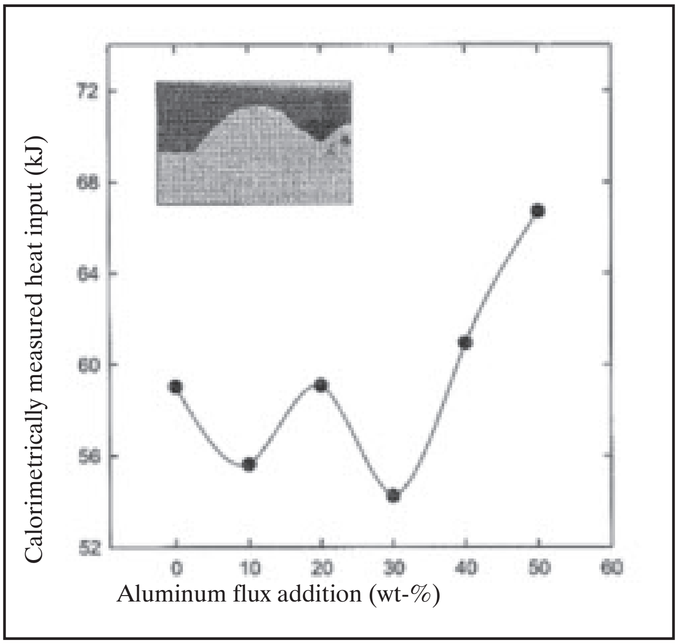

Fig. 3 — Measured heat input as a function of wt-% aluminum flux addition at 110 in./min (47 mm/s) melting rate. The insert photography is bead morphology of weldment with 20 wt-% of aluminum flux type electrode.

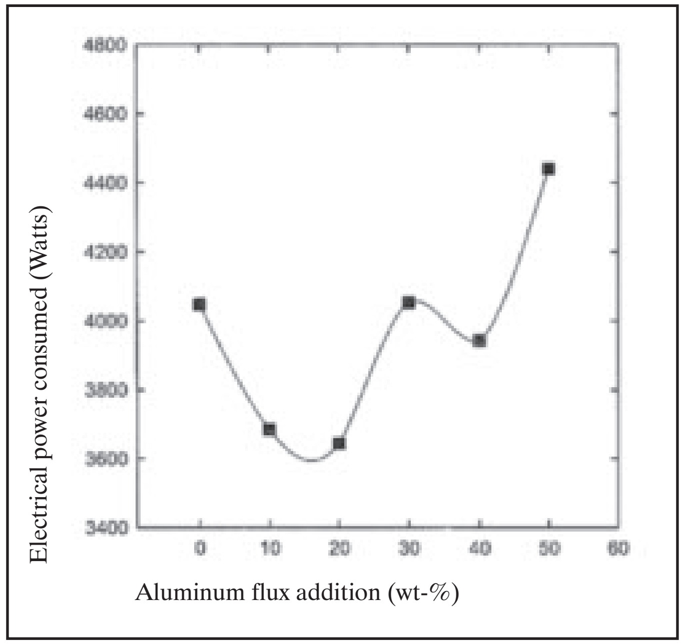

Fig. 4 — Electrical power consumed as a function of wt-% aluminum flux addition at 110 in./min (47 mm/s) melting rate.

show evidence of the formation of a solidified ball on the arc end, indicative of operation within the spray transfer mode, some electrodes had what appeared to be the beginnings of a ball that may have been formed after the electrical current was shut off. The ball-like protrusions were noted but ignored in the length and mass measurements for electrode extension. While this method of shutting off the welding machine and then snipping the electrode that was left sticking out from the guide tube may not be precisely representative of the steady-state weld electrode extension, it was performed in this manner as a matter of convenience strictly for comparative purposes.

A liquid nitrogen calorimeter was used to measure the amount of heat that was transferred into the base metal when welding with exothermically assisted consumables. The detailed description of the calorimetric measurement is in Part 1.

The weld deposits were cut, ground, polished, photographed, and measured with an image analysis system. The deposited slags and weld beads were visually examined, and welding was uniform and free of porosity as determined with sectional metallography.

Table 3 — Welding Parameter Schedule for Part 2

Welding Set Parameters	Set Voltage	Set Wire Feed Speed	CTWD (in.)	Travel Speed	Welding Time	Electrode Polarity
Part 1*	28 V	200 ~ 300 in./min (25 in./min step)	0.75	12 in./min	20 s	DCEN
Part 2	25 V	110 in./min	0.75	12 in./min	20 s	DCEN

*Welding parameters for Part 1 are shown for comparison.

Results and Discussion

All welds made in this part of the study resulted in acceptable weld bead morphologies and a stable arc with a fixed weld parameter schedule. Remarkably, the welding was successful for all welding wires with virtually no parametrical explorations by simply using the mid-range values suggested in a commercially available welding schedule published by the American Welding Society (Ref. 7).

Calorimetrically Measured Heat Input and Electrically Consumed Energy

Figure 1 shows the overall drop in measured heat input values of these Part 2 electrodes compared to one of the Part 1 electrodes, which is due primarily to the reduced wire feed rate setting and hence current used for all of the Part 2 study, but also reflects an approximately 25% reduction in total flux content. The lowered melting rate of the Part 2 study is believed to provide ample time for the self-regulation aspect of the welding process to occur to the fullest extent possible. The exothermic additions in the flux also have more time to react, and perhaps to a greater extent, within the arc, for the lower melting rate. The result is a reduction in electrode extension length that in turn leads to a longer, less efficient arc length for a fixed contact tube-to-work distance (CTWD). The effect of average electrode extension lengths as a function of exothermic flux concentration for Part 2 electrodes are discussed later. The maximum heat input was observed at the 10 wt-% magnesium addition.

The electrical energy consumed must also be considered when looking at the effect of the exothermic additions on the calorimetrically measured heat input values. The electrical power consumed is plotted in Fig. 2. A minimum is recorded at the 20 wt-% level (ignoring the value of the 0 wt-% magnesium addition) that helps explain the minimum in measured heat input at that same level. The obvious maximum in electrical power consumed at the 10 wt-% concentration level corresponds to the maximum in measured heat input with calorimetry and confounds the ability to make simple heat input assessments directly for exothermic concentration levels. Recall that all Part 2 test welds were performed with identical welding parameters at a single melting rate. The variation in electrical power consumption is mainly the result of the electrical properties of the arc on the welding current. The

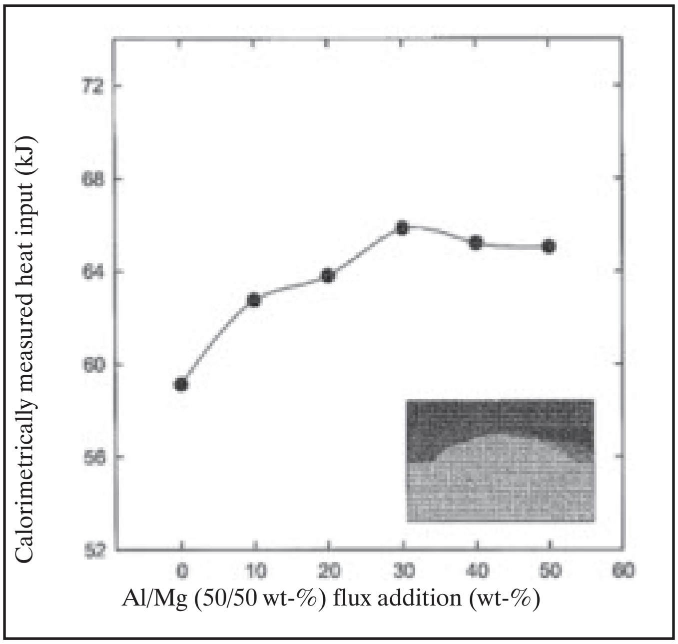

Fig. 5 — Measured heat input as a function of aluminum/magnesium (50/50 wt-%) flux addition at 110 in./min (47 mm/s) melting rate. The insert photography is bead morphology of weldment with 20 wt-% of Al/Mg (50/50) flux type electrode.

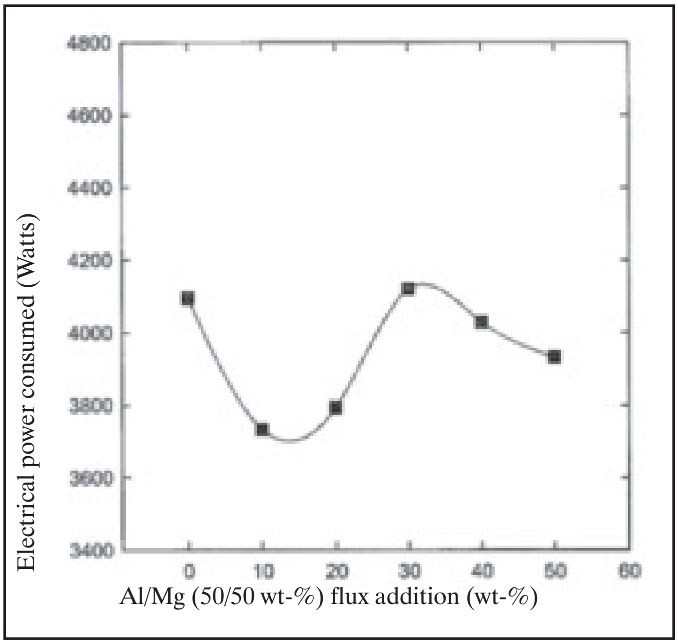

Fig. 6 — Electrical power consumed as a function of aluminum/magnesium (50/50 wt-%) flux addition at 110 in./min (47 mm/s) melting rate.

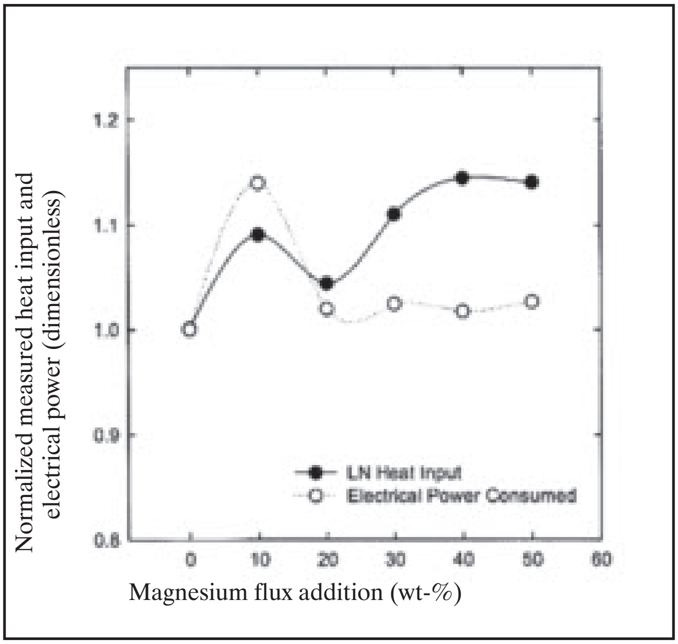

Fig. 7 — Normalized measured heat input and electrical power consumed as a function of magnesium flux addition at 110 in./min (47 mm/s) melting rate.

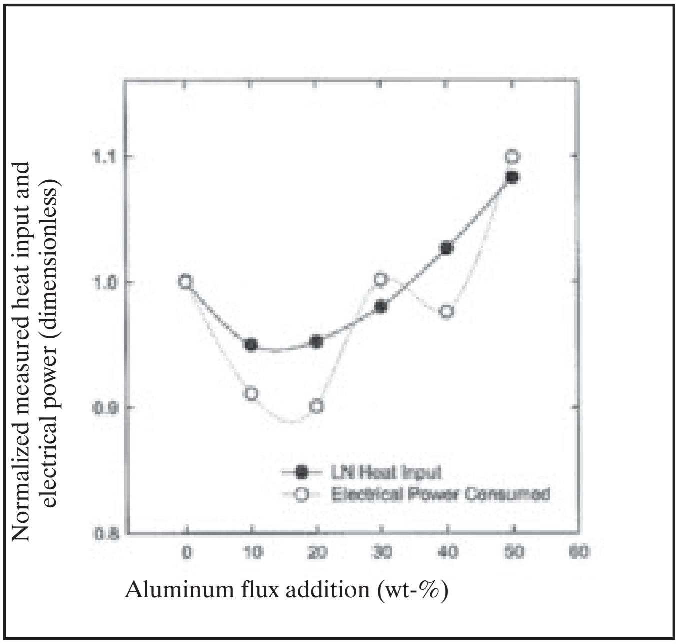

Fig. 8 — Normalized measured heat input and electrical power consumed as a function of aluminum flux addition at 110 in./min (47 mm/s) melting rate.

observed deviations between wires are ultimately due to the presence of the exothermic constituents introduced into the arc environment.

The measured heat input as a function of exothermic addition results for the aluminum-type flux are presented in Fig. 3. A minimum is recorded at the 30 wt-% level (below the 59 kJ posted for the 0 wt-%) aluminum addition electrode. Also, the measured heat input at 10 wt-% is below that measured for the 20 wt-%. The 10 wt-% value and the 30 wt-% value measured less than that of the baseline, while the 20 wt-% value measured about the same. Beyond the 30 wt-% level the measured heat input appears to be linearly increasing. The gains in measured heat at the 40 and 50 wt-% value are likely due primarily to the increases in electrical power consumption measured at these concentration levels.

The power consumed in welding, as shown in Fig. 4, went way up with the 50 wt-% aluminum-type flux addition. These values were repeatedly measured. The measured heat input also correspondingly increased to a high value, although percentage-wise the increase was not nearly as extreme. The minimum power consumed occurs between the 10 and 20 wt-% flux levels and coincides with the minimum recorded in measured heat input.

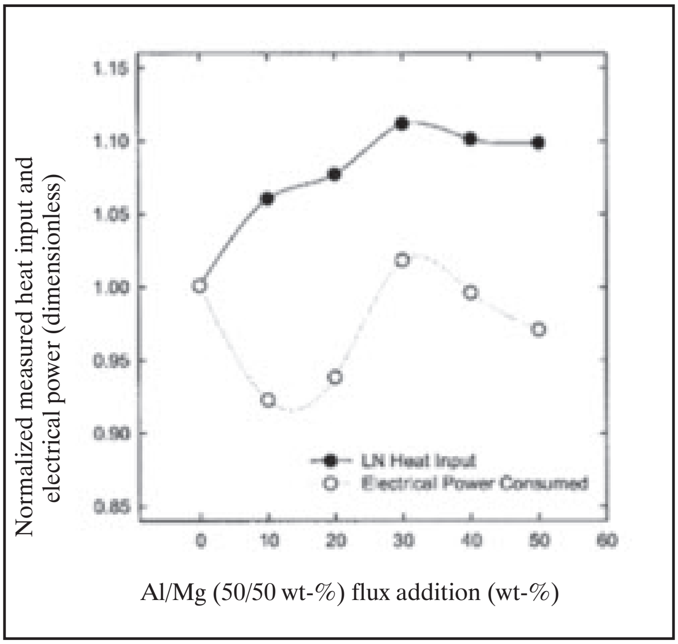

Fig. 9 — Normalized measured heat input and electrical power consumed as a function of Al/Mg (50/50 wt-%) flux addition at 110 in./min (47 mm/s) melting rate.

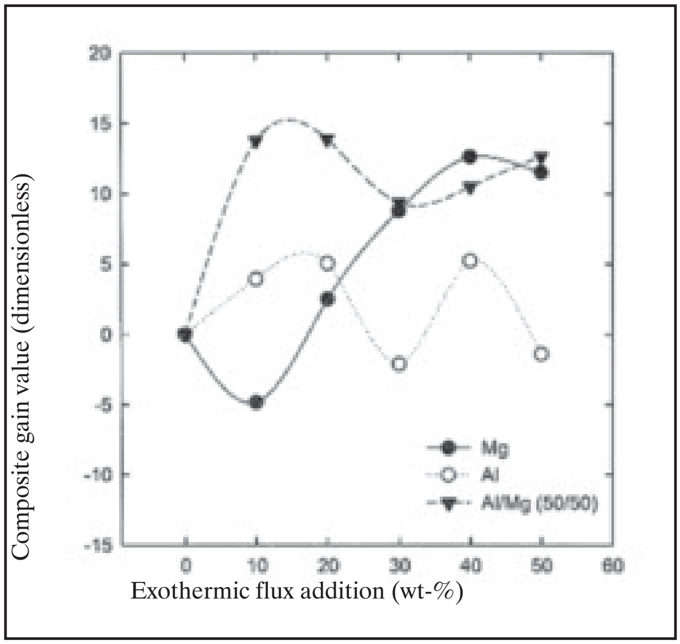

Fig. 10 — Net composite gain value or difference in normalized percentages between measured heat input and electrical power consumed as a function of exothermic flux addition.

For the fixed wire feed rate and voltage used, the consumed welding current is approximately proportional to the wire feed speed and should therefore be constant for these electrodes. Given the constant welding and setup parameters, any deviations in electrical power consumed must be due to a fundamental change in the electrical properties of the welding arc/electrode extension system brought on through the presence of the exothermic flux additions.

The measured heat input and electrical power consumed results for the Al/Mg (50/50 wt-%) type flux additions are presented in Figs. 5 and 6, respectively. All of the Al/Mg (50/50 wt-%) electrodes (Fig. 5) produced measured heat inputs greater than the 59 kJ posted for the baseline electrode. A maximum of 66 kJ, occurring at the 30 wt-% flux concentration, was recorded. The results appear much smoother through the concentration value range than for the singular aluminum- or magnesium-type flux addition cases. The arc behavior was subjectively smoother as well. The individual 20-s current and voltage traces for this type of electrode were uncharacteristically smooth and unvarying as compared with those of the other types of electrodes studied.

In the presence of both traditional types of exothermic additions, the burning of magnesium may make the ignition of the aluminum easier and/or more complete via catalytic reaction path kinetics within the welding arc of the FCA welding process. The lower combustion temperature of aluminum is, therefore, perhaps better suited for welding than the hotter-burning magnesium alone, while the presence of magnesium ensures more complete ignition and combustion of the aluminum. The presence of both types of metals in the welding arc may also enhance the electrical properties of the arc.

While the measured heat input as a function of exothermic concentration is smoothly increasing for the Al/Mg (50/50 wt-%) type flux, the electrical power consumed, as shown in Fig. 6, is not. A minimum of about 3700 W between the 10 and 20 wt-% concentration levels, below the 4100 W posted for the baseline weld, is exhibited. The apparent maximum of only 4115 W was observed at the 30 wt-% of Al/Mg (50/50) reactive addition, and this maximum was followed by exhibiting linearly decreasing electrical power with the 40 and 50 wt-% exothermic additions rather than increasing as with the other two (single exothermic component) flux types. The significant result here is that the measured heat inputs for the Al/Mg (50/50) type flux electrodes were strictly increasing from the baseline value with increasing concentration while the electrical power consumed dipped down below the baseline value. Then, the consumed power recovered to a mere 15 W above the baseline level (0.3% of the total average value) at 30 wt-% before dropping off again. The maximum measured heat input and the maximum electrical energy consumed points do coincide, however, at the 30 wt-% level for these Mg/Al-type flux-filled electrodes. Subjectively, all of the Al/Mg (50/50) mix electrode types welded very smoothly. The arc was stable with only normal amounts of spatter, especially in the lower concentration levels.

Normalized Measured Heat Input and Electrically Consumed Energy

Dimensionless "normalized" heat input values are obtained by simply dividing out the heat input values, either calorimetrically measured or calculated from the electrical power, by those values taken from the baseline condition. Figure 7 depicts the normalized heat input and electrical power consumed as a function of wt-% magnesium-type flux addition. At the 10 wt-% level the large current draw, obviously, carries with it the large value for the measured heat input. The art of making sound welds in the spray mode with a continuous consumable electrode of experimental nature seemed to often result in unexpected electrical responses from the power supply. The real benefit, when corrected for the electrical energy consumed, appears to be around the 40 wt-% level. At the low wt-% of exothermic additions, it appears that the flux core has less ability to melt-back the electrode any additional amount than normal with the small amount of chemical heat available. Here the normal self-regulation current-voltage interaction is essentially unmitigated by the presence of such a small percentage of exothermic chemical addition.

The physical length of the electrode extension may not be so affected at low concentration levels as perhaps would be the

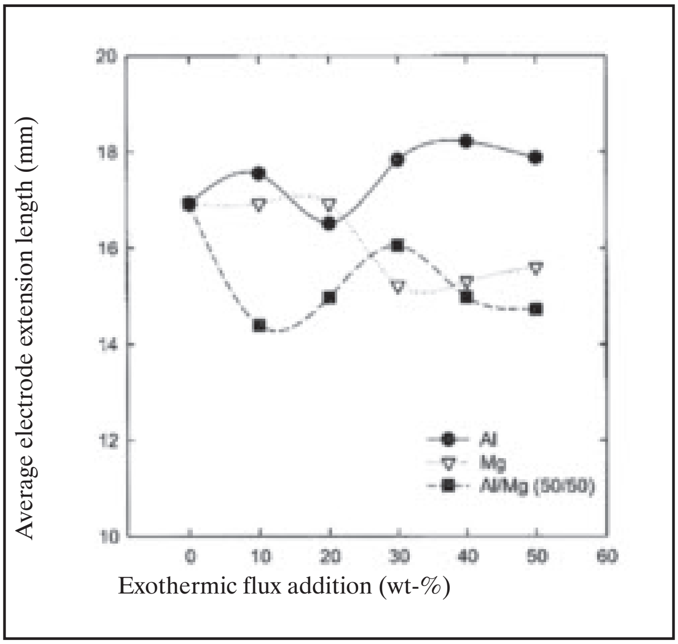

Fig. 11 — Average electrode extension length as a function of exothermic flux addition.

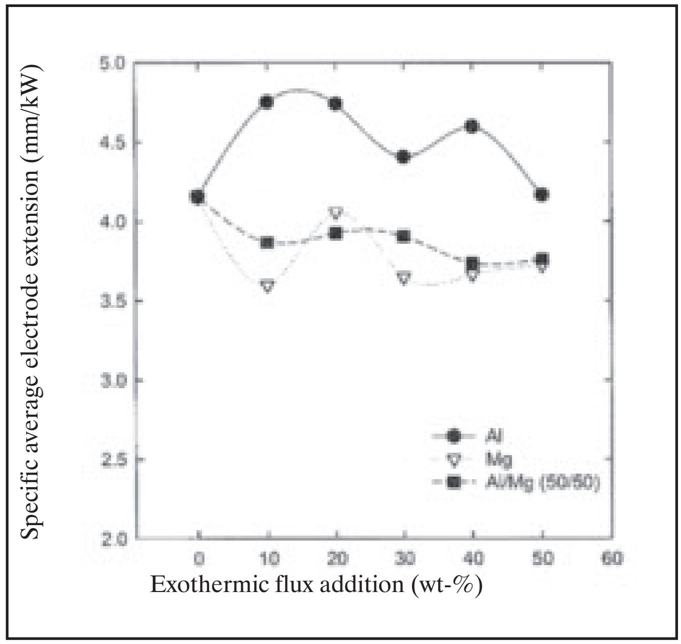

Fig. 12 — Average specific electrode extension length as a function of exothermic flux addition (specific electrode extension data are normalized values by the welding power from Fig. 11).

Table 4 — Percent Normalized Difference in Calorimetrically Measured and Heat Input from the Baseline Value

Wt-% Flux	10	20	30	40	50
Flux Addition Type					
Magnesium	9.1	4.4	11.1	14.4	14.1
Aluminum	–5.0	–4.8	–2.0	2.7	8.4
50-50 Al-Mg	6.0	7.7	11.2	10.1	9.8

Table 5 — Percent Normalized Difference in Electrical Power Consumed from the Baseline Value

Wt-% Flux	10	20	30	40	50
Flux Addition Type					
Magnesium	14.0	2.0	2.3	1.7	2.5
Aluminum	–9.0	–10.0	0.2	–2.6	9.8
50-50 Al-Mg	–7.8	–6.2	1.7	–0.5	–2.9

effects brought on through the electrical characteristics of the arc. A drop in arc resistance would cause a rise in current from the CP power supply for a constant power setting. At higher exothermic concentration levels, the shortening of the electrode extension dominates the electrical properties of the electrode extension/arc system. Both the aluminum and the 50/50 wt-% Al/Mg mix electrodes also display electrical extremes at the lowest concentration levels; however, the results are in the opposite direction from the magnesium-only case. Apparently, at the lower concentration levels the flux modification affects the current-carrying ability of the arc, whereas at the higher levels the electrode extension shortening dominates the electrical behavior of the electrode extension/arc couple.

Figure 8 shows the normalized heat input and electrical power consumed as a function of wt-% aluminum flux addition. It shows a minimum in normalized electrical power consumed and measured heat input at between the 10 and 20 wt-% addition levels. The effect is just the opposite observed with the magnesium flux filled electrode but perhaps to less extreme. It is speculated that the arc resistance is raised so that the current response from the CP power supply is negative. The normalized measured heat input from calorimetry is of course brought down by the electrical power minimization at the lower concentration levels. Again, at the higher levels of exothermic flux addition, the shortening of the electrode extension length maintains a dominant roll, and the measured heat input increases smoothly with the additional effects of chemical heating.

Figure 9 depicts the normalized heat input and electrical power consumed as a function of 50/50 wt-% Al/Mg-type flux addition. Results reveal the unexpected 8% rise in measured heat input opposite the 8% reduction in electrical power consumed in the area of 10 and 20 wt-% additions. The excess heat can only be explained by the generation of chemical heat. The other anomaly is the linear decrease in both the measured heat input and the electrical power consumed at 30 wt-% and beyond. The slope in the reduction of measured heat input is less than the slope for the electrical power decrease. This indicates that chemical heating in the higher concentration levels is still significant and at the least measurable. The peak in measured heat input at the 30 wt-% level does, however, coincide with the peak in electrical power consumed. The additional current draw carries with it at this point a corresponding increase in measured heat input characteristic of welds performed without the benefit of exothermic chemical heat generation.

Composite Gain Values for Normalized Heat Input Benefit Plus Electrical Power Reduction

The benefits of utilizing exothermic flux additions appear through two mechanisms. The first is the creation of chemical heat directly via the intended chemical reactions while the other mechanism appears to be through a reduction in electrical energy consumed, as compared to the baseline condition. As with the electrodes of Part 1, a net composite gain value is calculated for the electrodes of Part 2. In the earlier study, decreases in normalized electrical power consumed with increases in wire feed speed (or melting rate) were recorded. This relationship is likely to hold for the Part 2 electrodes as well, although various melting rates were not investigated here. A reduction in arc resistance, brought on by the broadening influx of additional pure metal species of the

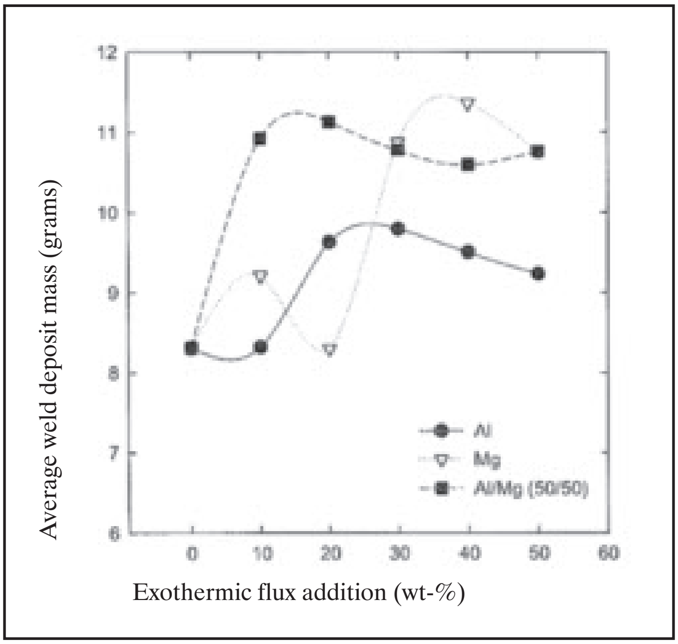

Fig. 13 — Average weld deposit mass as a function of exothermic flux addition.

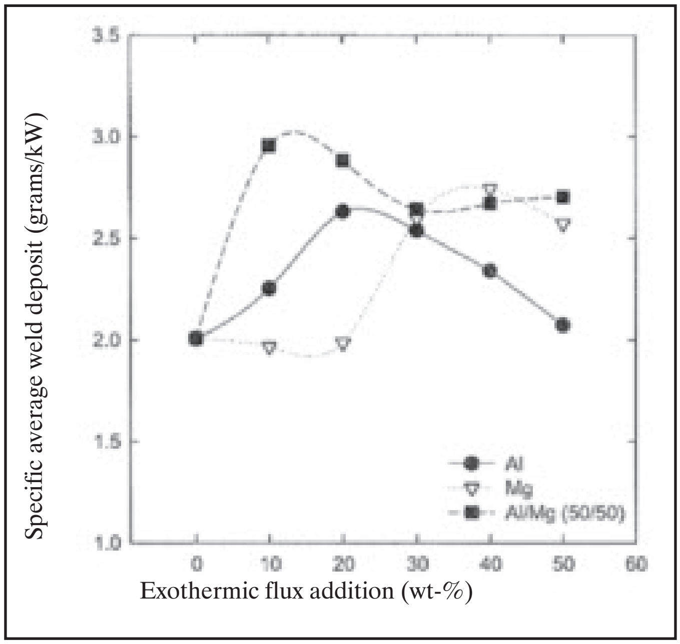

Fig. 14 — Specific average weld deposit mass as a function of exothermic flux addition (specific weld deposit data are normalized values by the welding power from Fig. 13).

exothermic flux components (with lower resistivities compared to iron) and a shortening of the arc with increasing melting rate, could account for the apparent reduction in expected electrical power consumed. The normalized dimensionless parameter values are presented in tabular form. Table 4 lists the percent normalized difference from baseline in measured heat input of the Part 2 electrodes.

The highest increase in measured heat input occurs with the magnesium-type flux at 40 wt-% flux concentration. The value posted represents about a 14.5% increase over the baseline. The 50 wt-% magnesium-type electrode produced slightly less measured heat input at about 14% over the baseline. The apparent anomaly with the magnesium-type flux is at the 20 wt-% flux concentration level of only 4% above the measured heat input for the baseline. The 20 wt-% level is precisely the concentration level of the early magnesium-type flux that resulted in an overall experimental maximum of slightly more than a 22% increase from the Part 1 study. The Part 1 electrodes contain twice the magnesium as required by stoichiometry and were filled to 20% higher flux-to-sheath ratios. Also, the 200 in./min melting rate of the Part 1 electrode is just about twice the 110 in./min used in Part 2. These reasons may explain the differences in absolute measured heat values but do not explain the relative maximum/minimum difference.

The aluminum-type flux posted a maximum measured heat input at the 50 wt-% level of about 8% over the baseline. The –5% measured heat input at the 10 wt-% was a minimum for all of the Part 2 electrodes. The trend of increasing relative measured heat input with aluminum-type flux addition is smoothly varying but when compared to the baseline value a minimum extreme occurs somewhere between the 10 and 20 wt-% levels and coincide with a large drop in electrical power consumed.

The percent normalized difference in calorimetrically measured heat input from the baseline value for the 50/50 wt-% Al/Mg-type flux shows a maximum of slightly more than 11% at the 30 wt-% concentration level. The minimum is recorded at the 10 wt-% level with a 6% increase in measured heat over the baseline. The smooth all positive responses of the 50/50 wt-% Al/Mg electrode and the smooth largely negative responses of the aluminum-type electrode contrast with the extremes of the magnesium-type electrode.

The percent normalized difference in electrical power consumed from the baseline condition is presented in Table 5. The noticeable result is the obvious spike in relative electrical power consumed of the magnesium-type electrode at the lowest wt-% tested. Magnesium, like aluminum, has a higher electrical conductivity value than iron, and like aluminum, the oxide formed via the exothermic reaction leads to a rather effective electrical insulator. When introduced in powdered form into the arc environment at the expense of the iron, one might expect that the arc resistance should either be raised or lowered compared to the baseline condition. An interesting fact concerning power transfer through a variable load resistor is that the power absorbed by this resistor is maximized when the load resistance happens to equal the instantaneous internal power source resistance (see Appendix). Also, power cannot be absorbed whenever the load resistance is infinite (open circuit) or zero (short circuit), and all of the energy absorbed by the load resistor is dissipated and converted to heat by the resistor. Practically no other "work" is being performed by this energy. The point is that whenever the load resistance, in this case the arc resistance, passes through an ohmic value precisely equal to the internal resistance of the CP power supply, then the power dissipated and converted to heat in this load resistor will pass through a maximum. Perhaps the combination of easily ionized, highly conductive pure metal powders and the rapid creation of metal oxides of negligible electrical conductivity within the arc are modifying the arc resistance such that a peak in power consumed occurs. If this situation is indeed the case, then one could calculate the arc/electrode extension resistance at this point knowing the source voltage and source resistance values. The source resistance could be modulated for a given welding condition until the power consumed, as measured by the welding current, was maximized. That this measured peak in relative power consumed for the magnesium-type electrode is, in fact, the maximum recorded throughout this study lends credence to the idea of a resonant arc (load) resistance value being encountered.

The arc resistance can never be negative and as such the electrical power con-

Table 6 — Net Composite Gain Value (Dimensionless Normalized Energy Scalar)

Wt-% Flux	10	20	30	40	50
Flux Addition Type					
Magnesium	–4.9	2.5	8.8	12.7	11.5
Aluminum	3.9	5.1	–2.2	5.3	–1.5
50-50 Al-Mg	13.8	13.9	9.5	10.7	12.8

Table 7 — Average Welding Electrical Consumption Values, Electrode Extension Lengths, and Specific Deposit Masses for Part 2 Electrodes

Electrode Type	Avg. Voltage (V)	Avg. Current (A)	Avg. Power (kW)	Avg. Electrode Extension (mm)	Specific Electrode Extension (mm/kW)	Avg. Deposit (g)	Specific Deposit (g/kW)
Baseline	26.1	154.9	4.05	16.9	4.2	8.1	2.0
Al flux additions							
10% Al	26.2	140.4	3.7	17.5	4.8	8.3	2.3
20% Al	26.0	133.8	3.5	16.5	4.8	9.3	2.6
30% Al	26.1	155.0	4.1	17.8	4.4	10.3	2.5
40% Al	26.2	150.2	4.0	18.2	4.6	9.3	2.2
50% Al	26.3	162.5	4.3	17.8	4.2	8.9	2.1
Group Avg.	26.2	148.2	3.9	17.5	4.5	9.2	2.2
Mg flux additions							
10% Mg	26.3	177.6	4.7	16.8	3.6	9.2	2.0
20% Mg	26.2	159.1	4.2	16.8	4.0	8.3	2.0
30% Mg	26.3	159.6	4.2	16.8	3.6	10.8	2.6
40% Mg	26.2	158.9	4.2	15.2	3.7	11.4	2.7
50% Mg	26.2	160.0	4.2	15.2	3.7	10.8	2.6
Group Avg.	26.2	163.0	4.3	15.9	3.7	10.1	2.4
Al/Mg (50/50) flux additions							
10% Al-Mg	26.0	143.8	3.7	14.5	3.9	11.1	3.0
20% Al-Mg	26.1	145.3	3.8	15.0	3.9	11.0	2.9
30% Al-Mg	26.2	157.0	4.1	16.1	3.9	10.1	2.7
40% Al-Mg	26.2	153.8	4.0	15.1	3.8	10.8	2.7
50% Al-Mg	26.1	150.3	4.0	14.7	3.8	10.6	2.7
Group Avg.	26.1	150.0	4.0	15.1	3.8	10.9	2.8

sumed cannot be negative, but the difference in normalized electrical power consumed compared to the baseline value can be, as is the case for the aluminum and 50/50 wt-% Al/Mg type electrodes. The 50 wt-% aluminum-type flux electrode shows a high value for relative power consumed, similar to but slightly less than the maximum recorded for the 10 wt-% magnesium electrode. It is speculated that the arc resistance here is also approaching that of the power supply, resulting in a relative peak in power consumed. It does not matter from which side of this supply resistance value that the arc (load) resistance approaches, only that a maximum power transfer condition results when they are equal and a relative local maximum is encountered when the absolute difference is minimal.

The net composite gain values are tabulated in Table 6 and plotted in Fig. 10. The maximum net composite gain value occurs between the 10 and 20 wt-% electrodes of the 50/50 wt-% Al/Mg type flux. These electrodes used much less electrical power than the baseline comparative while posting positive gains in relative measured heat input values. With both aluminum and magnesium metal powder additions, each with a lower electrical resistivity value than iron, the electrical resistance of the electrode extension is likely less than that of the pure iron powder baseline. With more than one possible reaction path available over a large temperature range within the arc, the resulting kinetics is perhaps most favorable with this type of flux as well. The arc is known to have regions of constant temperature, both spatially within the arc volume and quantitatively over a wide range of current values. Some regions may favor the reactions that associate themselves with the "best" temperature of combustion in the cooler outermost regions of the arc and near the boundary layers surrounding the superheated molten droplets. These "mixed" type electrodes were subjectively the smoothest welding electrodes of the combined studies.

The next-highest net composite gain value occurs with the 40 wt-% magnesium-type electrode. At this concentration level, this type of electrode posted the highest normalized measured heat input (Table 6) in spite of the large spike in electrical power consumption at the 10 wt-% level.

The aluminum-type electrode shows two peaks in net composite gain value of about 5% occurring at the 20 and 40 wt-% levels. In between, at the 30 wt-% level, a spike in relative electrical power consumed (as shown in Fig. 4) happens to occur. The dip might be due to a resonant arc/electrode extension resistance value being encountered, and when the equivalent electrical heat is subtracted from the measured heat value, a local dip between the bordering net value results.

Electrode Extension Lengths and Weld Deposit Mass

When considering the arc as a variable load resistor in a simple circuit, the property of electrical conductivity or the inverse, electrical resistivity, of the changing components of the arc/electrode extension system (namely the exothermic flux additions) must be considered. The exothermic flux additions are the only constituents being systematically changed that can alter the properties of the arc/electrode extension environment. Table 7 lists the average voltages, current, electrical power consumed, and average measured electrode extension lengths along with average deposit mass and normalized (specific) electrode extension and deposit masses.

Although the set machine voltage for all welds was 25 V, the measured results were consistently 26 V. The higher voltage realized may be due to a shorter average electrode extension length than normally achieved with commercial FCA welding electrodes, a result of the exothermic additions, even for the baseline. Figure 11 shows the average electrode extension lengths as a function of exothermic flux concentration. Very little variation is noted. At the 30 wt-% and above level, the aluminum-type electrode extension is about 2 mm longer than the magnesium and 50/50 wt-% type electrodes and only about 1 mm longer than the baseline. Figure 12 shows the electrode extension data normalized by the welding power. In this case all of the aluminum-type electrodes have longer normalized electrode extension lengths than the baseline electrode while all of the magnesium and 50/50 wt-% type electrodes have shorter lengths.

Aluminum has a lower resistivity than the magnesium so the resulting joule heating of the electrode extension might be less for this type of electrode. At the time that this research was conducted in the late 1990s, all of the available GMA welding electrode extension computer models reported a predicted length to no better than plus and minus the electrode diameter. For the 1⁄16-in.-diameter electrodes used for this research that error equates to about 1.6 mm. The "shut off and snip" method employed appears valid to the same tolerance level or better if the diameter of the ball forming at the end, if present, or any hint of the formation of the ball is ignored. While the measurements and the accounting data are recorded to one or two decimal places, this practice was carried out in an effort to maintain precision for comparative purposes internal to this study and is, obviously, not meant to imply such a high level of absolute accuracy. Room-temperature measurements with a digital ohm meter of the welding machine apparatus taken from a representative electrode tip and work surface (with the system shut down) were inconclusive suffice to say that it was less than 500 mΩ. The suspected arc load resistance variation and its effect on the power consumption through the power supply along with the self-regulation aspect on electrode extension length precludes direct assessment of exothermic flux additions on electrode extension length at this time.

The average weld deposit mass as a function of exothermic flux addition concentration level is given in Fig. 13. All of the electrodes recorded deposit masses greater than the baseline electrode except for the 10 wt-% aluminum and 20 wt-% magnesium type flux electrodes, which at least matched the baseline deposit mass. The highest deposit values were recorded with the 10 and 20 wt-% reactive additions in 50/50 wt-% Al/Mg flux type electrodes at around 11 g. The 40 wt-% magnesium flux type recorded the maximum deposit mass of 11.35 g. The 30 wt-% aluminum type flux electrode recorded a group maximum of 10.3 g. Not surprisingly, maximum deposit values of this group coincide with overall arc process efficiency maxima in 50/50 wt-% Al/Mg flux. Worth noting, however, is the fact that small adjustments to the welding parameter schedule might well optimize any specific Part 2 electrode. Higher melting rates, for instance, would likely result in higher exothermic heat benefits along with higher deposit masses.

Figure 14 shows the average weld deposit mass normalized by the welding power consumed as a function of wt-% exothermic flux addition. The results clearly show the benefits of the exothermic additions in average mass of weld deposit per kW electrical energy consumed. The 10 wt-% of Al/Mg flux type electrode recorded a specific deposit of 3 g deposit per kW consumed. The result represents a 50% increase over the 2 g/kW of the baseline average. Second highest of all the electrodes in specific deposit occurred with the 40 wt-% magnesium flux type electrode with 2.7 g/kW, a 35% increase. The highest specific deposit for the aluminum flux type group occurred at the 20 wt-% level with a 2.6 g/kW value, a 30% increase from the baseline value. None of the Part 2 electrodes underperformed the baseline in specific weld deposit results. A 50% increase in specific deposit with only a 10 wt-% modification to a commercial self-shielded FCA welding flux formula using "canned" welding parameters and achieving a sound weld is rather remarkable. One could conceivably save half in electrical energy or weld 50% more with the same electricity. Further gains are likely feasible with parametric electrode optimization studies.

Conclusions

Based on the experimental results obtained in this study, the following conclusions were summarized:

1. The highest increase in normalized measured heat input for this Part 2 study over the new baseline electrode occurs with the magnesium-type flux at a 40 wt-% flux concentration of 14% over the baseline.
2. The aluminum-type flux posted a maximum measured heat input at the 50 wt-% level of about 8% over the baseline.
3. The calorimetrically measured heat input from the baseline value for the Al/Mg (50/50) type flux shows a maximum of slightly more than 11% at the 30 wt-% concentration level.
4. The maximum net composite gain value occurs between the 10 and 20 wt-% electrodes of the wt-% Al/Mg (50/50) type flux. These electrodes used much less electrical power than the baseline comparative while posting positive gains in relative measured heat input values.
5. All of the aluminum-type electrodes have longer normalized electrode extension lengths than the baseline electrode while all of the magnesium and Al/Mg (50/50) electrodes have shorter lengths.
6. All of the electrodes recorded deposit masses greater than the baseline electrode. The highest deposit values were recorded with the 10 and 20 wt-% Al/Mg flux type electrodes.

Acknowledgments

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Appendix: Maximum Electrical Power Transfer* or One Reason Why Arc Welding Processes Show Variance

BY S. H. MALENE

Enough is presently known about the gas tungsten arc welding (GTAW) process to be able to calculate the energy needed to obtain a desired depth of penetration in a given type of metal. However, the arc process efficiency values can range from 0 to 95% efficient for the process in general, and can easily run to ±10% within a "qualified" welding process. Therefore, there is as yet no substitute for running qualification welding runs. The electronic controls are very precise but the nature of the arc plasma itself is the primary cause of much of the imprecision. The interrelationships of the primary process variables can act to exacerbate this imprecision, or with proper development and statistically derived nominal settings, much of the vagary can be effectively damped out. This later situation leads to a "robust" welding process that is generally very repeatable. However, on occasion even a well-developed arc welding process can "go away" and may need to be "redeveloped." Very subtle changes within the arc environment can interact with the welding power supply resulting in unpredicted outcomes of the physical properties of the weld. Not enough is known about the physics of the plasma to be able to control or measure the necessary physical characteristics to effect closer tolerance of the process. Similar conditions exist with resistance welding, only substitute "the volume of metal undergoing joule heating and plastic deformation" for the arc plasma and "resistance welding" for GTAW in the following descriptions. The following discussion utilizes Ohm's law to elucidate one probable

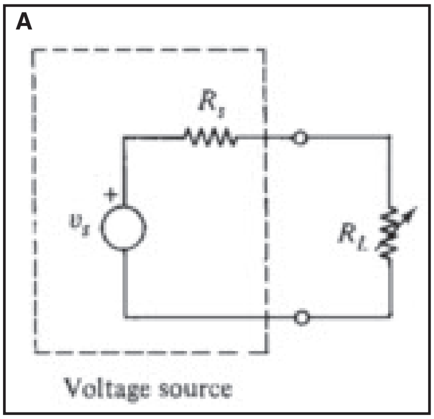

Fig. A — Simple circuit. R_L = variable load resistor; R_S = "fixed" welding system resistance between the arc anode and cathode; and V_S = the welding supply voltage.

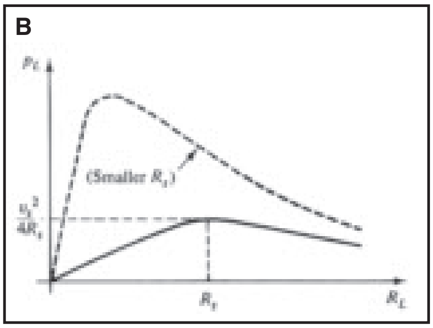

Fig. B — Graphical representation of P_L, the power dissipated in the arc, as a function of R_L, the variable arc load resistance.

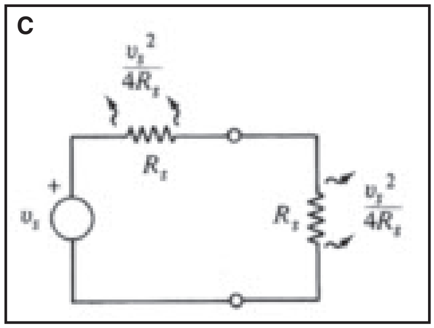

Fig. C — Simple circuit schematic representation of the maximum power dissipation condition. R_L = R_S = one-quarter of the square of the supply voltage divided by this resistance.

cause for GTAW weld variability. The outcome of the discussion is meant to show that at least one source of this variability, a change in the internal power supply resistance, can be minimized by using identical welding machine equipment and ancillary process setup items for both development and production.

Consider the welding arc as the variable load resistor R_L in the simple circuit of Fig. A. R_S is the "fixed" welding system resistance between the arc anode and cathode, V_S is the welding supply voltage. For a resistor, the terminal variables are related through Ohms' law, $V = IR$, so that the power delivered into the load resistor is as follows: $P = VI = I^2R = V^2/R$.

Since either the voltage V or the current I is squarred in the power relationship, the power delivered into a resistor R cannot be negative. A resistor always resists current flow and therefore will always absorb power. The energy absorbed by the load resistor is the power (as a function of time) integrated over time, given in watts (as a function of time), $W(t)$:

$$W(t) = \int_0^t P(t')dt' = R\int_0^t I^2(t')dt'$$
$$= \frac{1}{R}\int_0^t V^2(t')dt'$$

All of the energy absorbed by the load resistor R_L is dissipated physically by the resistor in the form of heat. All of the power (P_S of the R_S, V_S combination in the dashed box of Fig. A) supplied by the voltage V_S goes into the load resistor R_L. Therefore, the power P_L, dissipated in the welding arc is the power received by the arc in load resistance R_L:

$$P_L = I^2R_L = \left(\frac{V_S}{R_S + R_L}\right)^2 R_L$$

When the arc resistance is zero, representing an electrode stub-out condition, or infinite, representing the open circuit condition, no power is delivered by the supply and no heat is generated. Stated succinctly, a short or open circuit cannot transfer any power.

Obviously from the latest equation for the power absorbed by the load, P_L above, for some value of R_L between infinity and zero the power absorbed will peak. To find the value of R_L that will maximize the load power, P_L is differentiated with respect to R_L, the result is then set to zero and solved for R_L:

$$\frac{dP_L}{dR_L} = \frac{V_S^2\left[(R_S + R_L)^2 - 2R_L(R_S + R_L)\right]}{(R_S + R_L)^4}$$
$$= V_S^2\frac{(R_S + R_L)}{(R_S + R_L)^3} = 0$$

This is true whenever $R_L = R_S$. Thus, when the arc resistance precisely matches the resistance of the voltage source (the resistance of the combined welding power supply, workpiece, electrode, and leads), the maximum power available is supplied to the arc. By substituting the now equivalent resistance values into the expression for the power of the arc (load), the maximum power dissipated by the arc becomes:

$$(P_L)_{MAX} = \left(\frac{V_S}{R_S + R_L}\right)^2 R_L\Big|_{R_L = R_S} = \frac{V_S^2}{4R_S}$$

To control the performance of a welding power supply, the operator sets the voltage value or the current level, and the supply manufacturer minimizes the internal resistance. Interestingly, the power being dissipated in the arc, P_L, during welding is also being matched and dissipated by that of the power supply, P_S. The same quantity of heat energy being used to weld from the arc is being dissipated by the power supply. A welding power supply of finite size must therefore periodically be allowed to idle a certain percentage of the time used for welding to avoid a meltdown of the internals. Manufacturers express this in terms of a machine duty cycle for a given power setting. Duty cycle is the amount of idle time to welding arc-on time in a 10-min interval for a given power setting in percent. In general, of course, the load resistance is semifixed in the steady-state welding condition while the power supply and the weld fixturing fix the source (internal) resistance. The power supply usually gives less power than it is capable of, the maximum allowed by the machine settings, except whenever the arc resistance happens to match the supply resistance.

Figure B is a graphical representation of the power dissipated in the arc, P_L, as a function of the variable arc load resistance R_L. Minimization of the internal power supply resistance by using massive copper windings provides for the highest available power and allows for good heat dissipation and higher duty cycles, but at higher material costs.

The dashed line represents a smaller internal supply resistance, by a factor of three, from the solid line resistance, and can therefore result in three times the maximum available power.

Figure C is a simple circuit schematic representation of the maximum power dissipation condition, when $R_L = R_S$ = one-quarter of the square of the supply voltage divided by this resistance. The power that must be physically dissipated in the form of heat for both resistors, the arc and the power supply, is the same maximum value. Of course the welding arc is not just a simple variable load resistor but has capacitance and inductance properties as well, and the heat dissipated (produced for welding) is not all due to joule (I^2R) heating.

The gas tungsten arc welding process utilizes a constant-current type of power supply. For a given cover gas the voltage is a direct linear function of the physical arc gap dimension, the distance from the work surface to the tungsten electrode surface (the distance between the anode and cathode terminal ends defining the arc length) barring surface charge effects. Any physical change in this dimension during welding changes the voltage and therefore, for a given current setting, the arc resistance. If this change is toward the "peak" value, coming from either side, the actual power delivered into the work will change to a higher value. Likewise, if the arc resistance changes away from the peak value a lesser amount of power will be supplied. Anything that affects the instantaneous resistance value of the arc column will have an effect on power consumption.

Commercial power supplies are made to operate in the most efficient region — that necessarily being close to that yielding maximum power for a given operating range. Therefore, small perturbations from either within the arc environment or changes to the internal resistance of the machine and ancillary components can easily result in measurable variations in heat input that will physically relate to weld geometry variations. Usually the depth of penetration is the primary response variable to changes in heat input. Clearly, small variations in welding machine and ancillary equipment internal resistance values can have a significant effect on the outcome of a welding operation. Differences between machine manufacture brands and models are expected.

Also of note is that Ohm's law cannot hold within the arc when the charge carrier species are physically changing in type and amount as might be expected to result from nonsteady-state transient power consumption variations. The maximum power transferred from a welding machine through the arc will occur whenever the arc load resistance matches the system hardware internal resistance in a resonant (value over time) manner. This phenomenon is offered here as a partial explanation for the apparent dependence of arc welding processes on the operator and development engineer skill level and expertise. A simple technique to minimize this dependence is to use identical welding equipment through development and into production.

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The Discontinuous Weld Bead Defect in High-Speed Gas Metal Arc Welds

A new type of high-speed gas metal arc weld bead defect was observed and characterized

BY T. C. NGUYEN, D. C. WECKMAN, AND D. A. JOHNSON

ABSTRACT. A common weld bead defect that occurs at high fusion welding speeds is the periodic undulation of the weld bead profile, also known as humping. In the present study, when using argon shielding gas, 0.9-mm-diameter ER70S-6 and ER70S-3 electrode wires, and welding powers between 9 and 12 kW during high-speed gas metal arc welding of SAE-AISI 1018 cold rolled steel plate, swinging spray metal transfer was observed and the welding speed was found to be limited to 15 mm/s by the onset of the periodic humping phenomenon. However, rotational metal transfer was observed when using reactive shielding gases at these powers and the welding speed was limited to 22 mm/s by the onset of a new, as yet unreported, weld defect that was distinctly different from humping. This new high-speed defect is referred to as the discontinuous weld bead defect, since the defective weld bead is broken up into several good bead segments by aperiodic or irregularly spaced valleys or depressions where melting of the base metal occurred but no filler metal was deposited. The results also indicated that nominal electrode wire composition did not appear to play a significant role in the formation of the humping or the discontinuous weld bead defects.

A LaserStrobe™ video imaging system was used to obtain video images of typical sequences of events during the formation of the humping and discontinuous weld bead defects. From these images, the discontinuous weld bead defect was found to be caused by the inconsistent, aperiodic deposition of molten filler metal during rotational filler metal transfer mode when using reactive shielding gases. The long molten filler metal string on the end of the electrode wire was erratically fragmented and required time to re-form prior to the resumption of the transfer of filler metal. The temporary disruption of filler metal deposition created a filler-metal-free depression that broke up the otherwise good weld bead, thereby forming the discontinuous weld bead defect. The irregular fragmentation of the molten filler metal string during rotational transfer and subsequent formation of the aperiodic discontinuous weld bead defect are phenomena that have not previously been observed or reported in the open literature.

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KEYWORDS

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Humping
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Discontinuous Weld Beads
Carbon Steel

Introduction

Welding is a ubiquitous process and an integral part of most manufacturing industries such as the construction, shipbuilding, aerospace, automotive, petrochemical, and electronics industries. To remain competitive in today's manufacturing environment, companies must continuously improve their productivity without sacrificing the quality of their products. Increases in productivity will reduce overall production costs, thereby maintaining and strengthening the company's competitiveness. Overall production costs can usually be reduced by evaluating the productivity of the welding processes used. For many welded products, an increase in productivity often requires use of higher welding speeds. Frequently, this can be achieved through optimizing or automating existing welding processes. In certain cases, switching to newer high-energy-density welding processes will also result in higher welding speeds and increases in productivity.

In order to weld at higher welding speeds, the heat input of all fusion welding processes must be increased to maintain the same amount of energy input per unit length of weld required for melting of filler and base metals (Refs. 1–3), otherwise, the weld cross section will decrease and eventually no melting of the base metal will occur. While increasing welding speed and heat input will provide the desired productivity increase, continued increases of the welding speed is in practice limited by the deterioration of the quality of weld bead profile. One of the most commonly occurring geometric defects that has been observed at high welding speeds is the humping phenomenon (Refs. 4–6). An example of a humped gas metal arc (GMA) weld bead is shown in Fig. 1. Humping can be described as a periodic undulation of the weld bead with regularly spaced humps and valleys. Figure 2 shows transverse sections at a valley and a hump, respectively, of the humped GMA weld bead in Fig. 1. Although the depth of penetration is the same for both transverse sections, there is more weld metal accumulation at the hump. The humping defect compromises the mechanical integrity of the weld joint, thereby limiting the welding speed and thus overall production rates.

Nguyen et al. (Ref. 5) and Soderstrom and Mendez (Ref. 6) have recently reviewed the literature related to high-speed fusion weld bead defects, their causes, and techniques that have been used to increase welding speed. Humping of the weld bead has been the most commonly observed high-speed weld defect. It has been reported to occur in both nonautogenous welding processes, such as GMA welding (Refs. 7–9) and autogenous processes such as gas tungsten arc (GTA) welding (Refs. 10, 11), laser beam welding (LBW) (Refs. 12, 13), and electron beam welding (EBW) (Refs. 14–16).

Bradstreet (Ref. 7) was the first to report the formation of humped welds during GMA welding of plain carbon steel using spray transfer mode. He found that the humping phenomenon is periodic and influenced by the welding speed, the welding voltage, the angle of the electrode with respect to the workpiece, and other parameters. He also observed that reactive shielding gases such as Ar-CO_2 and Ar-O_2 mixes significantly increased the limiting welding speed before humping occurred and argued that this was a result of the lower surface tension and improved wetting that occurred when the reactive gases were used. In later studies, Nishiguchi et al. (Refs. 8, 9) developed a parametric map of arc voltage vs. welding speed for GMA welding of mild steel using short circuit metal transfer mode while Nguyen et al. (Ref. 17) used Ar and two reactive shielding gases and spray transfer mode to create a map of GMA welding power versus welding speed. These parametric maps showed regions of process parameters that produced good weld beads and regions that resulted in humping and other weld bead defects. In both cases, they found that humping occurred as the welding speed was increased above a certain critical welding speed and that there was an inverse relationship between this critical welding speed and the welding voltage or power used, i.e., as the welding voltage or power was increased, humping occurred at lower welding speeds.

In autogenous welding processes, humping has been found to be periodic and influenced by welding process parameters such as welding speed, welding power, type of shielding gas, ambient pressure, electrode geometry, travel angle, and energy density at the workpiece, etc. (Refs. 10–16). Several attempts have been made to express the relationship between these process variables and the onset of humping (Refs. 7–21). Typically, these included process maps that show the onset of humping with respect to welding speed and welding current or welding power. On each of these process maps, welding process parameters such as the shielding gas composition, the torch angle, or the GTA electrode geometry are normally kept constant.

Several models of the periodic humping phenomenon have been proposed. These include the Rayleigh Jet Instability model first proposed by Bradstreet (Ref. 7) and its modifications by Gratzke et al. (Ref. 22), the Arc Pressure model by Paton et al. (Ref. 23), and the Supercritical Flow model by Yamamoto and Shimada (Ref. 10). In a subsequent study of humping during GTA welding of stainless steel, Mendez and Eagar (Refs. 19–21) argued that humping was caused by periodic premature solidification of the thin liquid film at the bottom of the arc gouged region of the weld pool. This choked off flow of molten metal to the back of the weld

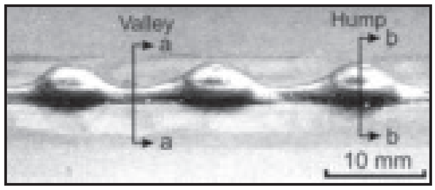

Fig. 1 — A bead-on-plate GMA weld in plain carbon steel exhibiting the humping weld bead defect.

pool and resulted in the initiation of a new hump further along the weld bead. These models suggest that fluid flow, arc pressure, metallostatic pressure, capillary force, and lateral instability of a cylindrical jet of molten weld metal and premature solidification of the thin film of molten metal in the arc gouged region of the weld pool are all possible factors responsible for the periodic humping phenomenon.

Based on video imaging of GMA welds made on mild steel plates and corroborating experiments, Nguyen et al. (Refs. 5, 17) have recently proposed a curved wall jet model of humping in nonautogenous welding processes such as GMA welding. Figure 3 shows a schematic diagram of this model of humping in high-speed GMA welding. As the welding speed increases, the weld pool becomes elongated, shallow, and narrow. Also, the electrode, the welding arc, and the metal droplet stream move forward and closer to the leading edge of the weld pool, i.e., the longitudinal distance from the leading edge of the weld pool to the location where the filler metal droplet impinges the top surface of the weld pool, d, decreases. The combined actions of the arc force and the droplet momentum create a depression or gouged region at the front of the weld pool that contains a thin layer of liquid metal underneath the welding arc. In addition, the filler metal droplets hit the sloping leading edge of the weld pool and this molten filler metal is then redirected toward the tail of the weld pool at high velocity through a semicircular curved wall jet similar in shape to the valley portion of the humped weld bead shown in Figs. 1 and 2A, dragging with it any liquid metal in the front of the weld pool from the melting base metal. At the tail of the weld pool in Fig. 3, the molten weld metal accumulates to form a swelling that is drawn into a spherical bead shape by surface tension (see humps in Figs. 1 and 2B) as molten metal is fed into the swelling from the front of the weld pool through the wall jet. As the welding arc continues to move to the left along the weld joint, the wall jet shown in Fig. 3 becomes increasingly elongated and the thermal mass of molten metal inside the wall jet becomes distributed over a longer distance until continued solidification of

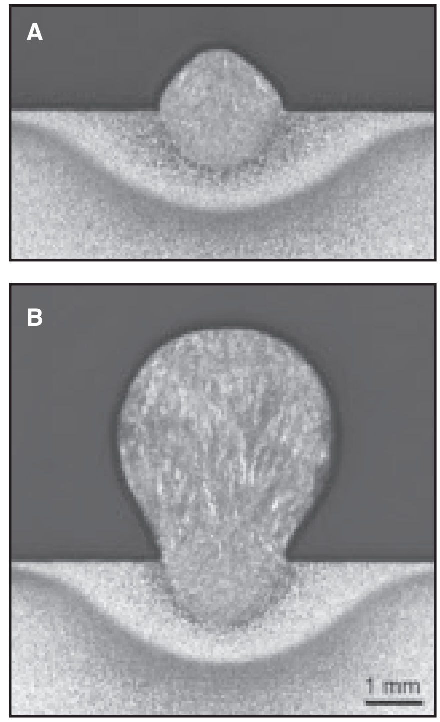

Fig. 2 — Transverse sections of the GMA weld shown in Fig. 1 at the following: A — A valley, and B — a hump.

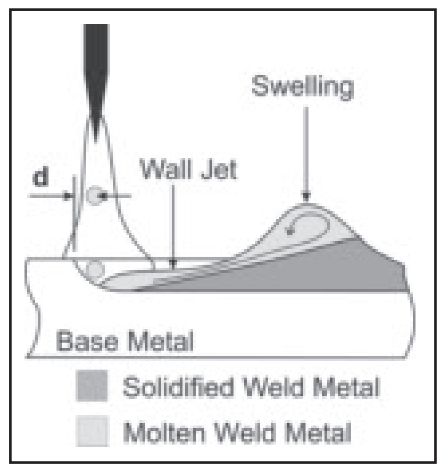

Fig. 3 — The curved wall jet model for the periodic humping phenomenon during high-speed GMAW (after Nguyen et al. (Refs. 5, 17)).

the weld and the molten metal in the elongated wall jet chokes off the flow of molten metal to the swelling. Solidification of the wall jet illustrated in Fig. 3 forms the valley typically observed between swellings in a humped GMA weld bead such as those shown in Figs. 1 and 2A. Initiation and growth of a new swelling closer to the arc and further along the weld bead occurs very soon after fluid flow in the wall jet is choked off. This sequential formation of a swelling or hump at the tail of the weld pool and solidification of the wall jet is a periodic phenomenon where the humping

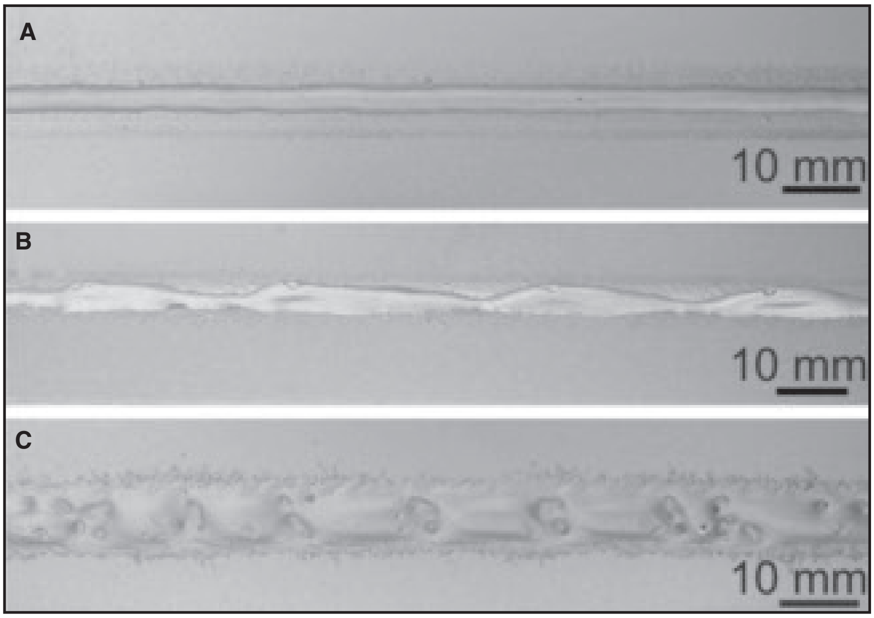

Fig. 4 — Top view of GMA welds produced using a reactive shielding gas, 40 mm/s welding speed. A — 6 kW; B — 8 kW; and C — 11 kW welding power.

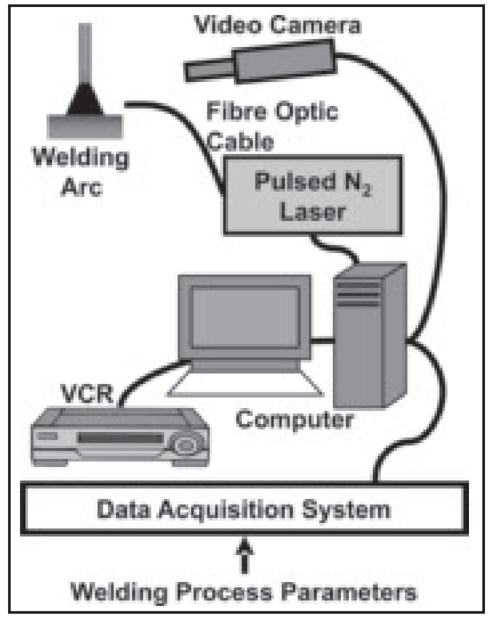

Fig. 5 — A schematic diagram showing various components of the LaserStrobe™ video imaging system.

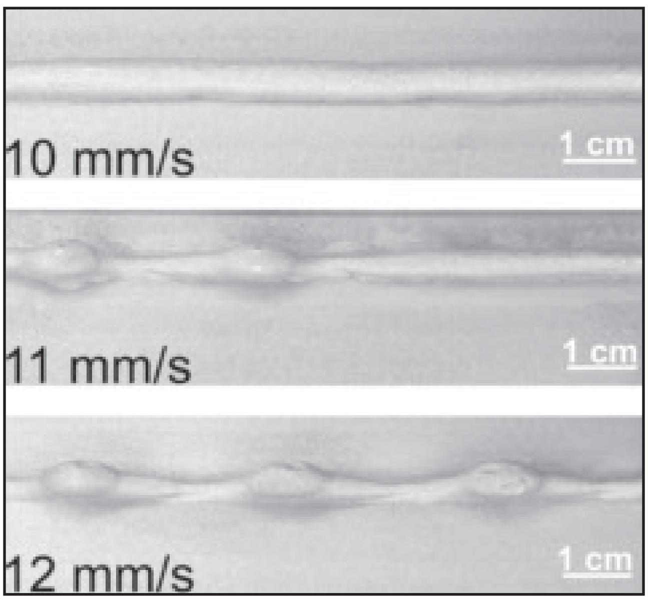

Fig. 6 — Top view of GMA welds produced using 6.3 kW welding power, argon shielding gas, and at various welding speeds.

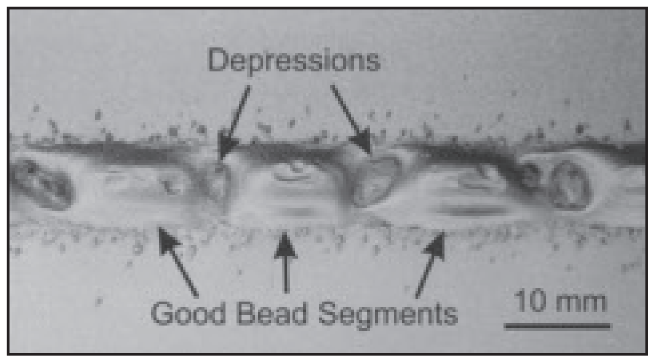

Fig. 7 — A close-up top view of a bead-on-plate GMA weld showing the aperiodic discontinuous weld bead defect.

frequency has been shown to increase with increasing welding speed or decreasing welding power (Ref. 24).

During their study of the humping phenomena in high-speed GMA welding of plain carbon steel, Nguyen et al. (Refs. 5, 17, 24) observed a change in the humped weld bead morphology when welds were performed using reactive shielding gases and welding powers greater than 9 kW. Figure 4 shows three GMA welds that were produced at 40 mm/s welding speed using a reactive shielding gas and increasing welding powers of 6, 8, and 11 kW. These welds have been cleaned by sandblasting to clearly reveal the different geometric features of the bead. As shown in Fig. 4A, a good GMA weld was produced when using 6 kW welding power and humping was observed when the welding power was increased to 8 kW — Fig. 4B. However, as shown in Fig. 4C, when the welding power was further increased to 11 kW, the GMA weld produced showed a distinctly different type of geometric weld defect that is clearly not humping. The regular, periodic behavior of humping was no longer evident and the curved wall jet in the valleys of the high-speed weld bead defect was no longer present. This new high-speed defect is referred to here as the discontinuous weld bead defect, because the defective weld bead as shown in Fig. 4C is broken up into several good bead segments by aperiodic or irregularly spaced valleys or depressions where melting of the base metal occurred but no filler metal was deposited. In addition, while the normally observed decrease in critical welding speed with increasing welding power was evident at the lower powers when humping occurred, the critical welding speed was not affected by the welding power when this new weld bead defect was observed. This particular aperiodic high-speed GMA weld bead defect has not been previously identified or reported in the literature (Refs. 1–5, 17, 24). The objectives of the present study (Ref. 24), therefore, were to observe, identify, experimentally validate, and understand the physical mechanisms responsible for this new discontinuous weld bead defect that occurred during high-speed GMA welding of plain carbon steel.

Experimental Apparatus and Procedures

In the present study, bead-on-plate GMA welds were made using a Fanuc ARC Mate 120i 6-axis welding robot and a Lincoln PowerWave™ 455 power supply operating in constant voltage mode with an integrated Power Feed 10 wire feeder over a wide range of preset welding speeds and welding powers. A PC-microcomputer was used with *Labview*™ software and National Instruments™-based data-acquisition system to record the welding voltage and current. Voltage between the contact tip and the workpiece was measured at the rate of 1000 samples/s using a LEM™ LV100 voltage transducer and the welding current was measured using a LEM™ LT505-S current transducer. The measured voltages, V (V), and currents, I (A), were then postprocessed to calculate the time averaged welding power, P (W), using $P = V \times I$.

A LaserStrobe™ video system (Ref. 25) was used to observe and to record images of the humping phenomenon during bead-on-plate GMA welding of plain carbon steel plate. As shown schematically in Fig. 5, the LaserStrobe™ video imaging system consisted of a video camera, a video recorder (VCR), a pulsed nitrogen (N_2) laser strobe with fiber-optic beam delivery, a data-acquisition system, and a personal computer that acted as a system controller. The pulsed N_2 laser strobe was used to overwhelm the intense radiation of the GMA welding arc since the laser light was much brighter than the light coming from the welding arc at the N_2 laser wavelength (Ref. 25). The laser-illuminated scene was viewed by a video camera equipped with a CCD video sensor, a narrow band-pass filter centered on the 337.1-nm wavelength of the N_2 laser, and an image intensifier that was also used as a high-speed electronic shutter. The image intensifier limits the resolution of the LaserStrobe™ image to about 420 line pairs in the horizontal direction (Ref. 25). The computer synchronized the camera's electronic shutter with the laser pulses. The combination of temporal filtering provided by the electronic shutter, N_2 laser pulse synchronization, and spectral filtering from the narrow band-pass filter allowed unobstructed viewing of the events taking place during the formation of humped GMA welds without the intense light from the welding arc. During filming, the video camera was mounted on a fixture that moved along with the GMA welding torch.

All bead-on-plate GMA welds were made in the flat position on degreased 6.5-mm- (¼-in.-) thick cold-rolled SAE-AISI 1018 plain carbon steel plates using

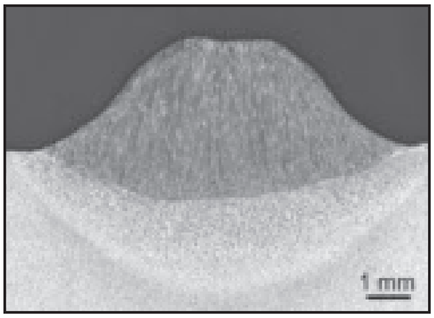

Fig. 8 — A photomicrograph showing the transverse section of a good bead segment of a GMA weld with discontinuous defect. The weld was produced using TIME™ shielding gas, 10 kW welding power, and 30 mm/s welding speed.

0.9-mm- (0.035-in.-) diameter ER70S-3 and ER70S-6 electrode wires and a 22-mm contact tip-to-workpiece distance. The majority of GMA welding experiments were performed using ER70S-6 electrode wire. However, ER70S-3 electrode was also employed to determine the effects of the differences in chemical composition of the filler metal on the formation of high-speed weld defects. The nominal chemical compositions of these GMAW electrode wires are as listed in Table 1 (Ref. 3). Both of these electrodes have relatively high levels of the deoxidizing elements, Mg and Si. The ER70S-6 electrode wire has the highest concentrations of Mg and Si and is often recommended for applications that use high welding current or GMAW over steel plates that are covered with light rust, whereas the ER70S-3 electrode is recommended when welding clean steel with argon-based shielding gases (Ref. 3). In all cases, the working angle of the GMAW gun was 90 deg and the travel angle was 0 deg.

Three different welding-grade shielding gases were used: argon, Mig Mix Gold™ (MMG™[1]) and TIME™[2]. The composition of each shielding gas is listed in Table 2. In this study, argon was an inert shielding gas while MMG™ and TIME™ were reactive shielding gases due to their oxygen (O_2) and carbon dioxide (CO_2) contents.

To determine the usable welding speeds at each power level, the weld bead profiles were examined and the maximum welding speed that produced a non-humped or acceptable weld bead was recorded. For example, Fig. 6 contains photographs showing the top view of GMA welds produced using 6.3 kW welding power, argon shielding gas, and 10, 11, and 12 mm/s welding speeds, respectively. In Fig. 6, the welds produced at 10 mm/s welding speeds or slower were classified as good welds, since the weld beads show no significant variation in weld dimensions or shape along the length of the weld. However, at 11 mm/s welding speed, the weld bead begins to exhibit intermittent swellings that are separated by valleys. The occurrence of the humps and valleys becomes consistently periodic at 12 mm/s welding speed. Thus, the difference between good weld beads and a humped weld can be clearly identified by the significant variations in weld bead dimensions and shape that occur along the length of the humped weld bead and the occurrence of regularly spaced humps and valleys. Based on the weld beads shown in Fig. 6, the limiting welding speed for production of good argon-shielded GMA welds using 6.3-kW welding power was 10 mm/s. This procedure was also used to determine the critical or maximum welding speed that could be used before the newly identified discontinuous weld bead defect became evident.

Table 1 — The Nominal Chemical Compositions of ER70S-3 and ER70S-6 Electrode Wires in wt-% (Ref. 3)

	Carbon	Manganese	Silicon
ER70S-3	0.06–0.15	0.90–1.40	0.45–0.70
ER70S-6	0.07–0.15	1.40–1.85	0.80–1.15

Note: Phosphorus 0.025 max. and Sulfur 0.035 max.

Table 2 — Compositions of the GMAW Shielding Gases Used

Shielding Gas	Composition
Argon	100% Ar (ultrahigh purity grade)
MMG™	92% Ar, 8% CO_2
TIME™	65% Ar, 8% CO_2, 26.5% He, 0.5% O_2

Results and Discussion

Geometric Features of the Discontinuous Weld Bead Defect

As the welding power was increased from 5 to 9 kW, the onset of high-speed weld defects in GMA welds produced using the reactive shielding gases occurred at lower welding speeds. The high-speed weld defect observed was primarily humping. The results of these experiments and an explanation of the periodic humping phenomenon in high-speed GMA welding are reported in detail in a previous article by Nguyen et al. (Ref. 17). However, at welding powers greater than 9 kW, the filler metal transfer mode in the GMAW process was observed to change from

1. MMG™, Praxair Distribution, Inc., Kitchener, Ont., Canada.

2. TIME™, BOC Gases Canada Ltd., Waterloo, Ont., Canada.

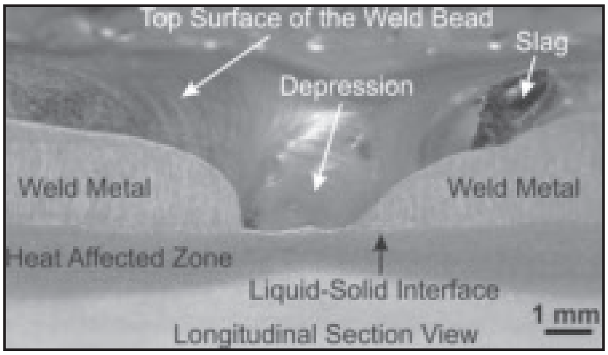

Fig. 9 — Top and longitudinal section views at the depression of a GMA weld with a discontinuous weld bead defect. The weld was produced right to left using 10 kW welding power, TIME™ shielding gas, and 30 mm/s welding speed.

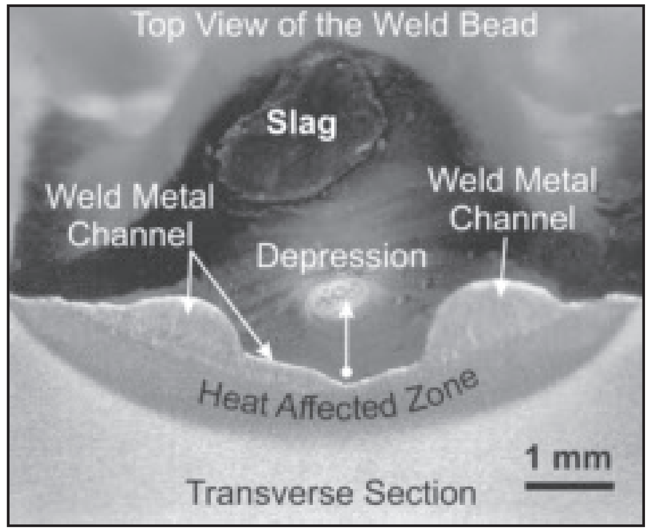

Fig. 10 — The transverse section and the top view at the depression of a GMA weld with discontinuous weld bead defect. The weld was made using 10 kW welding power, TIME™ shielding gas, and 30 mm/s welding speed.

spray to rotational transfer and there was a distinct change in the weld bead morphology as shown in Fig. 4C.

Figure 7 shows a close-up top view of the aperiodic discontinuous weld bead defect. This particular weld was produced using 10 kW welding power, 30 mm/s welding speed, and TIME™ shielding gas. Again, the top surface of the weld has been cleaned by sandblasting to reveal all features of the weld. The weld bead is not continuous but is broken up into segments of good weld bead by irregularly spaced depressions. As may be seen in Fig. 7, the adjacent good weld bead segments are connected by small metal channels on the outer edge of the depression. In addition, the discontinuous weld bead exhibits a significant amount of weld spatter immediately adjacent to the weld bead.

A transverse section across a good bead segment of a discontinuous weld bead defect is shown in Fig. 8. This weld segment has a bead profile that shows good penetration, wide width, and excellent wetting with the original surface of the workpiece. At the deepest point, the depth of penetration is approximately 1 mm. There is no evidence of the characteristic finger penetration or nail-head weld profile that was typical of the welds produced using spray transfer at welding powers less than about 9 kW (Ref. 17).

Figure 9 shows the top and the longitudinal section views of a GMA weld with the discontinuous weld bead defect from the end of one good weld segment across the depression to the beginning of another good weld segment. The welding direction was from the right to left. The depression shown in Fig. 9 can be described as a cavity or a sunken valley between two good weld segments following closely the shape of the fusion boundary. The fusion boundary of the depression has the same depth of penetration as the good weld bead segments. However, unlike the good segments of the weld bead, the depression has a shallower heat-affected zone (HAZ), which is delineated by the dark band immediately located below the fusion boundary — Fig. 9. In this photomicrograph, the HAZ of the weld was revealed by etching the polished longitudinal section with a 5% Nital solution (Ref. 26). The shallower HAZ is an indication that the total amount of heat input was less at the depression compared to that along the good segments of the defective weld. This would suggest that the lack of the weld metal at the depression reduced the amount of sensible heat input into the base metal, thereby decreasing the size of the HAZ.

The good weld bead segment on the right side of Fig. 9 has a gradual forward-sloping profile in the direction of welding. As indicated, there is a slag particle on the top surface of the weld bead prior to the depression. Based on energy dispersive X-ray (EDX) analysis, this was a $(Mn,Si)_xO_y$ glassy slag with about 7 at.-% Mn, 17 at.-% Si, and 74 at.-% O with trace amounts of Fe and Al. These features were typically seen at the end of GMA welds produced using the reactive shielding gases. Meanwhile, beyond the depression, the start of the next weld bead segment did not have good wetting with the bottom surface of the weld pool, since its contact angle is very close to 90 deg ($\pi/2$ radians). These geometric features suggest that a momentary stoppage in the transfer of filler metal had occurred during welding, since these two adjacent weld bead segments appear to be the end of one and the beginning of another GMA weld bead.

To further examine the features of the depression, Fig. 10 shows a transverse section of a discontinuous GMA weld made using 10 kW welding power, TIME™ shielding gas, and 30 mm/s welding speed. The transverse section was etched with 5% Nital solution. In this photograph, the specimen was tilted forward to reveal the transverse section as well as the top view of the depression and the view is toward the tail of the weld. As indicated in Fig. 10, there is a patch of $(Mn,Si)_xO_y$ slag on the top surface of the previous good weld segment. Also, inside the cavity of the depression, there appears to be a very thin layer of solidified weld metal. This is consistent with observations made by Yamamoto and Shimada (Ref. 10) and later by Mendez et al. (Refs. 19–21) of gouged weld pools during high-speed autogenous GTA welding of stainless steel.

From the transverse section of the weld shown in Fig. 10, the HAZ is uniform in thickness at the depression. In addition, there are two solidified channels or wall jets on both sides of the depression near the upper rim. These weld metal wall jets connect the adjacent good segments of the discontinuous weld bead defect. These solidified weld metal channels or wall jets are similar to those observed by Mendez et al. (Refs. 19–21) in their GTA welds. Since the molten weld metal flows around the rim of the depression and there is a thin layer of molten weld metal within the depression, high arc pressure must have been present inside the depression during welding. This geometric feature is very similar to that produced during the high-power autogenous GTAW process, especially at high welding speeds. These observations suggest that during the time when the depression is created in the discontinuous weld bead, the GMA welding process behaves like an autogenous welding process with little or no filler metal transferred from the electrode to the workpiece.

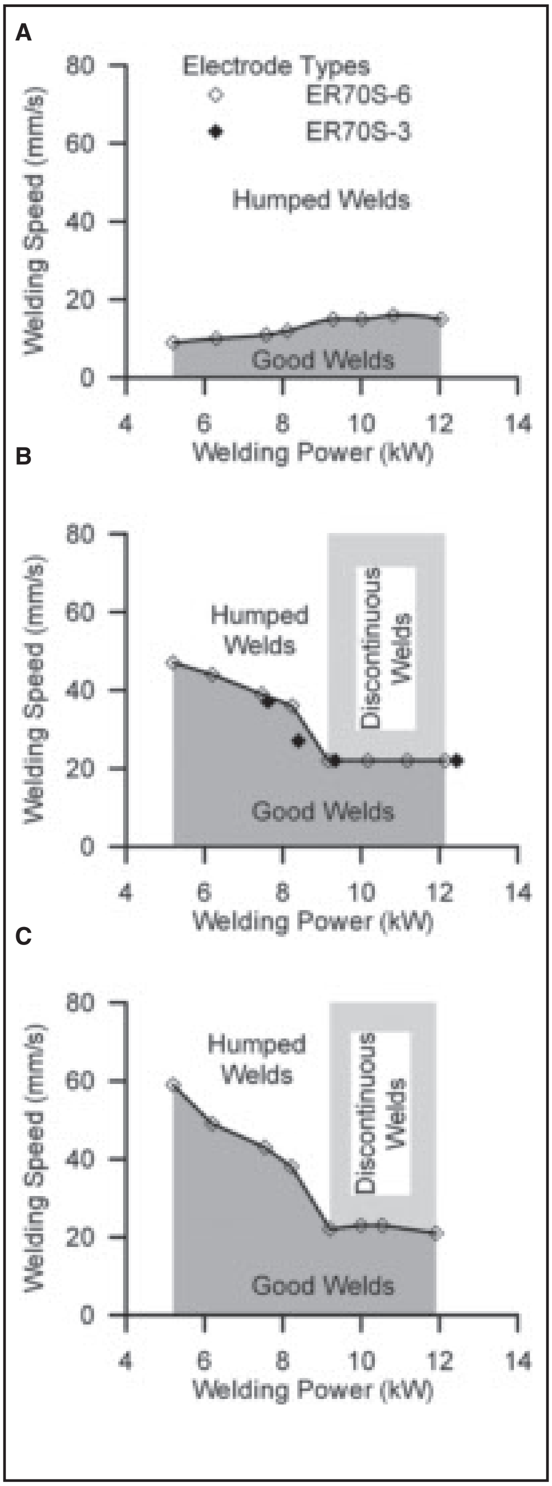

Fig. 11 — Regions of good and defective weld beads on welding speed vs. welding power plot for — A — Argon, B — MMG™, and C — TIME™ shielding gases.

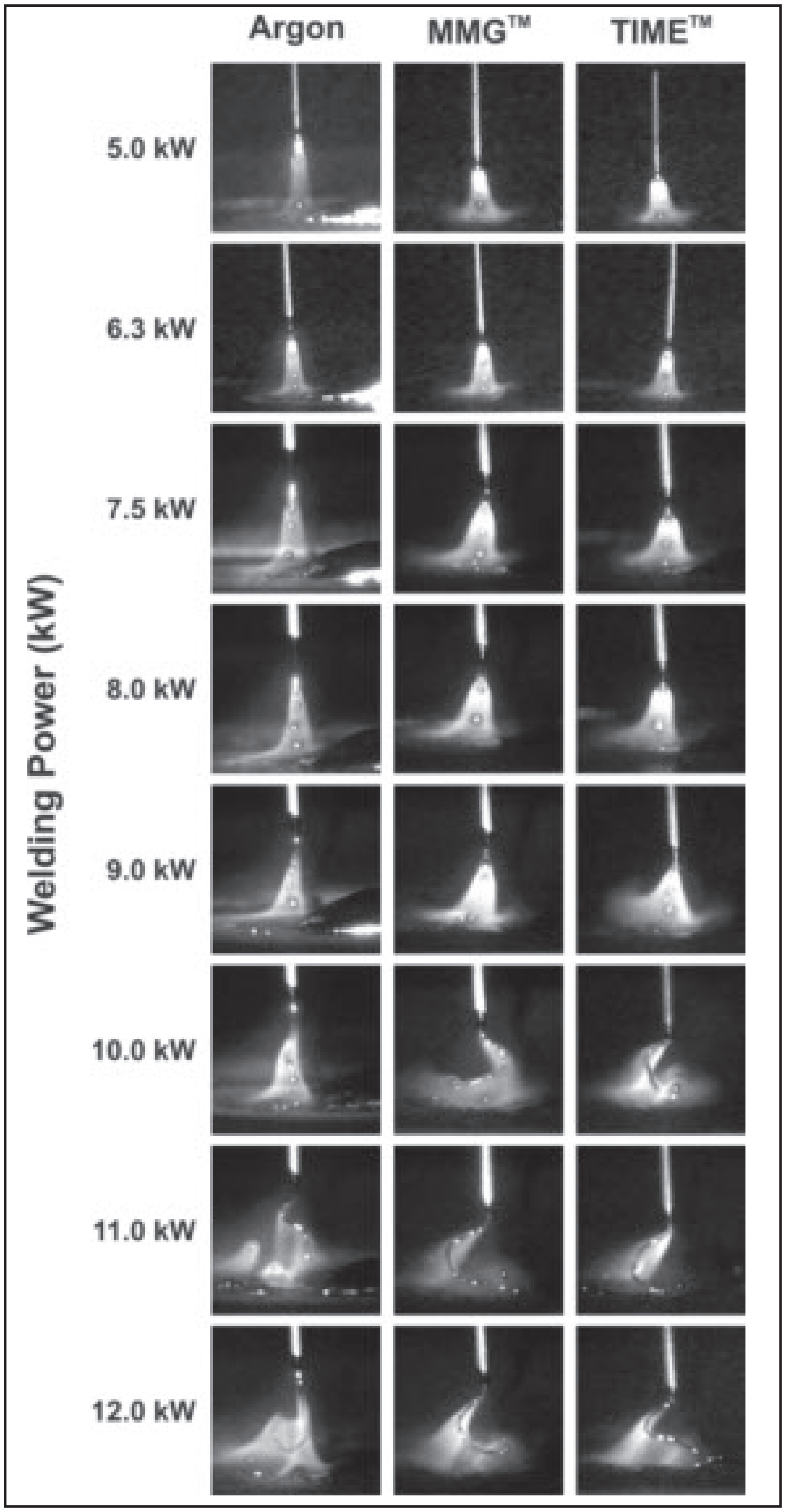

Fig. 12 — The filler metal transfer modes as a function of the welding powers and shielding gases. In these images, the diameter of the filler metal electrode wire is 0.9 mm.

Effects of Welding Power and Welding Speed

In a previous study of the humping phenomenon in GMA welding, the total welding power used was varied from 5 to 9 kW (Ref. 17). In the present study of the discontinuous weld bead defect, however, the total welding power was increased further to 10, 11, and 12 kW. For each different combination of welding power and shielding gas, the previously described experimental procedure for determining the limiting welding speed was performed. The new limiting welding speeds generated from these experiments were then combined with previous data and plotted.

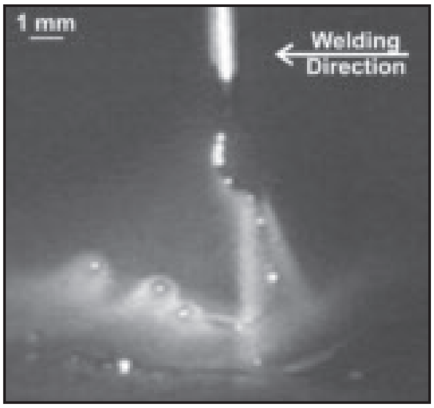

Fig. 13 — The flight path of molten filler metal droplets in rotational transfer mode at 11 kW using argon shielding gas.

Fig. 14 — An image of rotational transfer mode produced using argon shielding gas and 12 kW welding power showing the detachment of a long string fragment from the molten filler metal string.

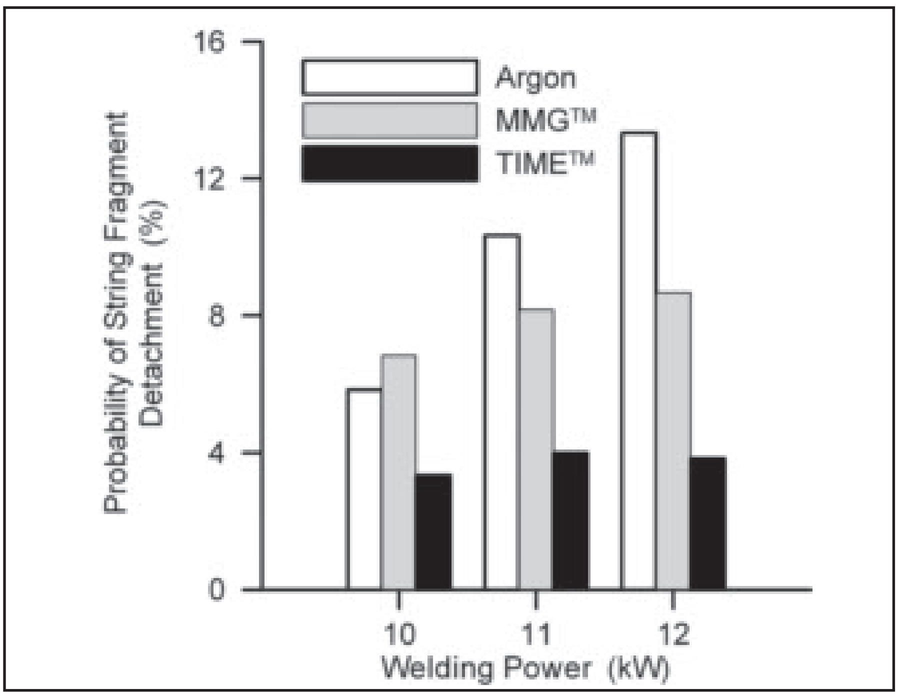

Fig. 15 — The relative frequency of the breakup of the molten filler metal string at three different welding power levels and three different shielding gases.

The three graphs displayed in Fig. 11 are process maps showing regions or ranges of welding power and welding speed that resulted in good and defective weld beads when using the three different shielding gases: argon, MMG™, and TIME™. On these plots, the connecting line segments represent the maximum or limiting welding speeds that could be used to produce a GMA weld without a defective weld bead profile. The area located directly underneath the limiting welding speeds represents various combinations of welding speed and welding power that produced good or acceptable GMA weld beads. For convenience, these areas are labeled as good weld regions on the plots. As the speed is increased beyond the limiting welding speeds, a geometrically defective or unacceptable weld bead was observed. Note that the limiting welding speeds and the types of high-speed weld defect for GMA welds produced using MMG™ shielding gas and ER70S-3 electrode wire are also plotted in Fig. 11B. As may be seen in Fig. 11, there were two types of geometric weld bead defects observed at higher welding speeds: humped and discontinuous weld beads as shown in Fig. 6B and C, respectively. The type of high-speed weld defect observed was a function of the shielding gas and the welding power used to make the weld. In addition, there is no significant difference between the results when ER70S-3 or ER70S-6 electrode wires were used with MMG™ shielding gas.

When using both the MMG™ and TIME™ shielding gases and less than 9 kW welding power, the usable welding speed was limited by the occurrence of humping. In this range of welding power, as the welding power was increased, humping occurred at lower welding speeds — Fig. 11B, C. When using lower welding powers and TIME™ shielding gas, defect-free welds were produced at slightly higher welding speeds than those made using MMG™ shielding gas. However, this advantage diminished with increasing welding power. On the other hand, when using argon shielding gas, there was a small increase in limiting welding speeds with higher welding powers. This limiting welding speed increase when using Ar shielding gas was thought to be due to the effects of the transition from streaming to swinging spray transfer modes of the filler metal on the humping phenomenon (Ref. 17).

When the welding power was increased beyond 9 kW, the limiting welding speed for welds produced using the argon shielding gases leveled out at approximately 15 mm/s and became independent of the welding power — Fig. 11A. The same trend was also observed for GMA welds produced using the reactive shielding gases, MMG™ and TIME™; however, the limiting welding speeds were greater at approximately 22 mm/s — Fig. 11B, C. As indicated in Fig. 11A–C, as the welding power was increased beyond 9 kW when using argon shielding gas, the observed high-speed weld defect was still humping, whereas when using the reactive shielding gases, the usable welding speed was limited by the onset of the discontinuous weld bead defect. In addition, there was a distinct point of inflection between the limiting welding speed lines for humping versus the discontinuous weld bead defect. This point of inflection and change in behavior at welding powers greater than 9 kW is indicative that a transition has taken place in the physical phenomena taking place during GMA welding such as a change in the filler metal transfer mechanism. The filler metal transfer mode in the GMA welding process is known to change from globular to spray and finally to rotational transfer with increasing welding power (Ref. 4). In the following, therefore, the relationship between the filler metal transfer modes and the welding power levels is explored.

The Filler Metal Transfer Modes

Individual LaserStrobe™ video frames showing the typical filler metal transfer modes observed when using the different shielding gases and welding powers are shown in Fig. 12. The welds produced using argon shielding gas had the longest arc length of about 9 mm whereas the welds produced using MMG™ and TIME™ shielding gases were typically about 50% shorter. Between welding powers of 5 and 7.5 kW, the spray transfer mode is evident for all shielding gases. At these welding power levels, the molten filler metal droplets detached from the end of the electrode wire and were propelled straight down through the welding arc to the weld pool. The molten filler metal droplets for the argon shielding gas was found to have a more constricted flight path resulting in a smaller impingement area on the top surface of the weld pool (Ref. 17). Meanwhile, the molten filler metal droplets for welds produced using reactive shielding gases are spread out and this resulted in larger impingement areas and weld widths (Ref. 17).

Between welding powers of 7.5 and 9 kW, the filler metal transfer mode for all shielding gases was predominantly spray transfer. However, as shown in Fig. 12, the individual filler metal droplets were swung around in a helical path as they detached from the tip of the electrode wire and propelled across the welding arc to the weld pool. This is identified as swinging spray transfer mode, which is considered to be a transitional stage between spray and rotational transfer modes (Ref. 27). For the GMA welds produced using argon shielding gas, the swinging spray transfer mode can facilitate higher welding speeds since it reduces the vertical velocity component of the molten filler metal droplets to lessen their ability to gouge the weld pool enlarges the impingement area on the top surface of the weld pool, and prevents the molten filler metal droplets from always hitting the leading edge of the gouged weld pool. This reduces the momentum of the molten weld metal toward the rear of the weld pool, thereby suppressing the tendency for humping to occur until high welding speeds are used (Ref. 17).

As shown in Fig. 12, above 9 kW welding power, the welding wire melts and forms a long liquid string that is still attached to the solid tip of the electrode. This molten filler metal string is indiscriminately coiled and violently swung around inside the shroud of the welding arc. This is identified as the rotational transfer mode, which typically occurs at power levels higher than those obtained for spray transfer (Refs. 28, 29). The direction of rotation of the molten filler metal string is random even when identical welding parameters are used (Ref. 30). In general, the rotational transfer mode produces the highest level of filler metal deposition rates when compared to other transfer modes (Refs. 1–4, 28, 29).

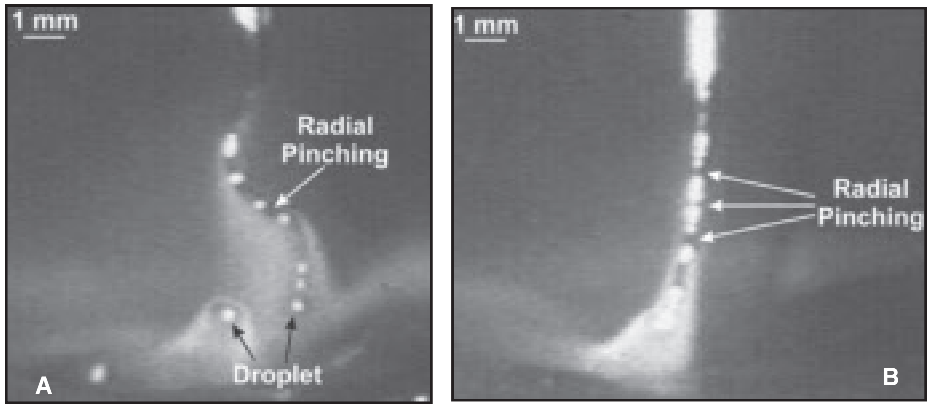

Fig. 16 — The LaserStrobe™ video images showing the effect of radial pinch instability on the molten filler metal string during GMA welding of steel using argon shielding gas and 11 kW welding power. Depending on the orientation, the molten filler metal string can be viewed as dark field in A or a bright field in B.

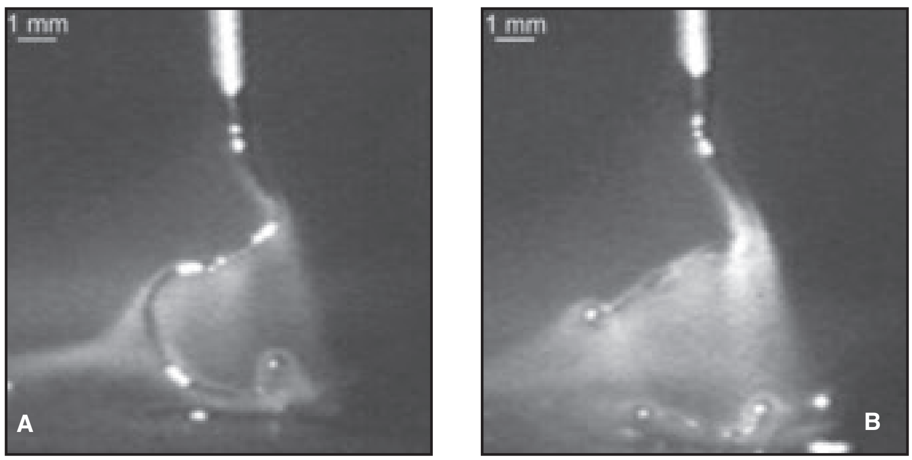

Fig. 17 — The breakup of the long filler metal string as a result of short circuiting with the surface of the workpiece.

From the results shown in Figs. 11 and 12, the occurrence of the humping weld defect coincides with the spray transfer mode. When using the reactive shielding gases, however, the transition to rotational transfer mode coincided with the appearance of the discontinuous weld bead defect. Thus, for reactive shielding gases, the type of high-speed weld bead defect observed appears to be related to the filler metal transfer modes. To further understand the formation of the discontinuous weld bead defect, a more detailed examination of the rotational transfer mode was undertaken.

Rotational Transfer Mode during GMA Welding

From the images in Fig. 12, rotational metal transfer mode occurred when the welding power was greater than 9 kW. The filler metal droplets can be seen to detach from the tip of the molten string similar to that previously reported for rotational transfer mode in GMA welding (Refs. 27–30). The flight path of the detached droplets was typically along the same line as the molten string. However, since the string rotated in a random manner, the droplets were erratically deposited over the surface of the weld pool. For instance, the image of an argon-shielded GMA weld at 11 kW welding power in Fig. 13 shows that some of the molten filler metal droplets were detached in the welding direction and transferred to the front portion of the weld pool. In addition, the swinging action of the molten filler metal string resulted in some of the droplets having an upward flight path prior to falling back down to the weld pool. The swinging action of the molten filler metal string and the erratic deposition of the molten filler metal droplets generated spatter on the surface of the workpiece adjacent to the weld bead — Fig. 7. Also visible in this and other images is a halo of glowing gas around each metal droplet and a glowing comet tail trailing behind the droplets. This may be evidence of interactions between vaporizing elements from the metal droplets such as Mn and the ionized high-

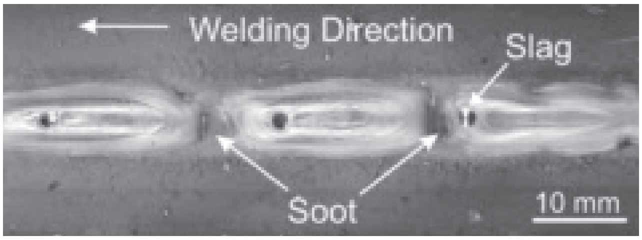

Fig. 18 — The top surface of a GMA weld with discontinuous weld bead defect immediately after welding.

Fig. 20 — LaserStrobe™ video image that shows the length of the depression formed.

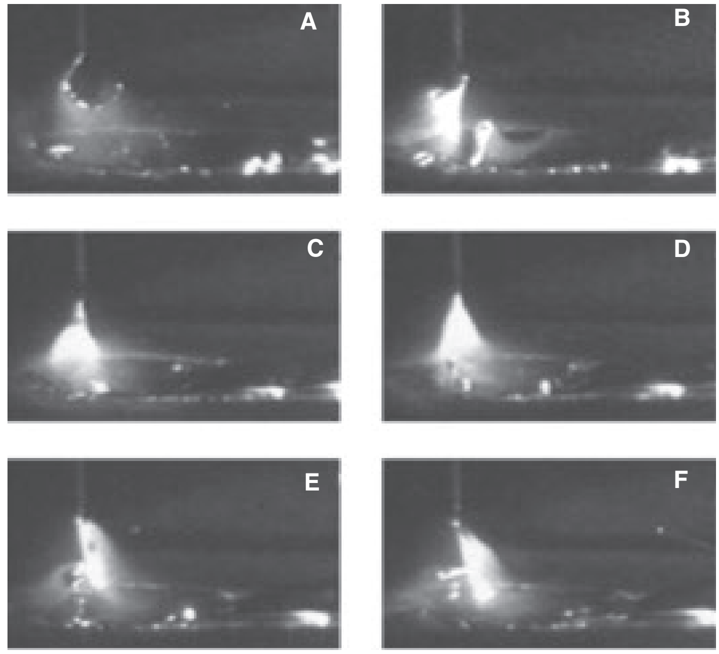

Fig. 19 — A sequence of six LaserStrobe™ video images showing the formation of a discontinuous weld bead defect.

velocity plasma stream in the arc.

In addition to the droplets detaching from the tip of the filler metal string, the molten filler metal string was also seen to be broken up into longer fragments that fell directly into the weld pool. While metal transfer by droplet detachment has been observed and reported in previous publications of rotational transfer mode in GMAW (Refs. 27–30), this is the first time that metal transfer by fragmentation or complete detachment of the long molten metal string on the end of the electrode has been observed. An image of the fragmented molten filler metal string is shown in Fig. 14. Detachment of the long string fragment shortened the molten filler metal string considerably. In this case, the original molten string was cut in half as a result of the breakup. At the new tip of the string, a new molten filler metal droplet was forming and would be detached very shortly.

Fragmentation of the molten filler metal string was not restricted to argon-shielded welds. Similar LaserStrobe™ video images showing the breakup of a long molten filler metal string were also found for welds produced using the reactive shielding gases. For each shielding gas and welding power combination, 600 LaserStrobe™ video images were examined to determine the number of frames that clearly showed the fragment of the molten filler metal string. The results were then divided by 600 and converted to a percentage to represent the probability of having the long molten filler metal string breaking up into fragments. The probability of having a fragmented string when using each shielding gas at 10, 11, and 12 kW welding power are plotted in Fig. 15. From these results, the molten filler metal string that exists during rotational transfer mode occasionally broke up into long fragments rather than droplets. The probability of breaking up into string fragments was highest for argon followed by MMG™ and TIME™ shielding gases, respectively. For GMA welds produced using TIME™ shielding gas, the breakup of the molten filler metal string is constant at about 4% and relatively independent of the welding power. Meanwhile, for welds produced using MMG™ shielding gas, there is a slight reduction in the frequency of breakup of the long molten filler metal string into fragments at lower welding powers. Lastly, the welding power had the most influence when using argon shielding gas; the higher the welding power, the more frequent was the breakup of the long molten filler metal string. In fact, on increasing the welding power from 10 to 12 kW (20% increase), the frequency of string fragmentation more than doubled; i.e., it increased from 6 to 13%.

If it is assumed that the molten filler metal string can be approximated as a fluid cylinder, then the GMAW filler metal transfer modes can be attributed to influences of either the radial pinch or kink instabilities (Ref. 27). The radial pinch instability of the fluid cylinder is responsible for the formation and the detachment of molten filler metal droplets in the globular and spray transfer modes during GMA welding. Meanwhile, the swinging action of the molten filler metal string observed in rotational filler metal transfer mode is caused by the effect of the kink instability on the fluid cylinder. This particular instability can be described geometrically as the collapse of a straight fluid cylinder into a spiral shape (Ref. 27). During rotational transfer mode, however, the radial pinch instability is also present and is responsible for the detachment of droplets from the tip of the molten string in rotational transfer mode as shown in the LaserStrobe™ video image of Fig. 13. Thus, in rotational transfer mode, the effects of radial pinch instabilities on the fluid cylinder are still present, but not dominant.

Figure 16 shows two LaserStrobe™ video images of the molten filler metal string at different times during GMA welding of steel using argon shielding gas and 11 kW welding power. In Fig. 16A, the molten filler metal string is at an orientation such that the specular reflection of the N_2 laser light toward the CCD camera does not occur. As a result, the string in this image appears mostly as a dark field. Meanwhile, in Fig. 16B, the molten filler metal string is a bright field since its orientation allows the N_2 laser to be reflected back to the CCD camera of the LaserStrobe™ video imaging system.

In Fig. 16A, the formation and detachment of molten filler metal droplets from the tip of the filler metal string are clearly observed. The spherical-shaped droplets reflect the N_2 laser light back to the CCD camera. As a result, a bright spot on the surface of each droplet is clearly observed in the image. Although the string is seen as a dark field because the curved surface of the string does not allow the reflection of the N_2 laser back to the CCD camera, there are a few visible bright spots in Fig. 16A. The bright spots are simply an indication that the N_2 laser light is being reflected back to the CCD camera at these locations by specular reflections off a spherical shape similar to the molten filler metal droplets. In other words, these bright spots represent the swellings that occur along the length of the molten filler metal string. Similar to the formation of the droplets, the swellings are formed by radial pinching of the molten filler metal string into thinner necking regions. The thinning of these necking regions will ultimately result in breakup of the long molten filler metal string into fragments as seen in Fig. 14.

In Fig. 16B, a major portion of the molten filler metal string is seen as a bright field. At this instant in time, the molten filler metal string had an orientation that allowed specular reflection of the N_2 laser light back to the CCD camera. However, there are several dark segments along the bright length of the molten filler metal string. The surface profile at the dark segments must be different than the rest of the molten filler metal string in order to cut off the specular reflection of the N_2 laser light back to the CCD camera. If these dark segments have a swelling or a spherical surface profile, then a bright spot similar to that observed for a droplet would be visible. However, this is not the case. As indicated in Fig. 16B, these dark segments occur in between the bright segments of the molten filler metal string. From these observations, the dark portions must have pinched or necking surface profiles, a direct result of a radial pinch instability.

From the images in Fig. 16A, B, although it is not dominant, the radial pinch instability is present during rotational transfer mode. In addition to producing and detaching the droplets at the tip, the radial pinch instability also causes necking to form along the length of the molten filler metal string. The thinning of these necking regions will eventually break up the molten filler metal string into fragments as seen in Fig. 14. The fragment of the molten filler metal string shortens the molten metal string considerably. In addition to necking, the long molten filler metal string can also be broken up into fragments as the string momentarily touches the surface of the workpiece. This phenomenon is illustrated by the images in Fig. 17.

Table 3 — The Voltage and the Measured Welding Current at 10, 11, and 12 kW for Argon, MMG™, and TIME™ Shielding Gases

	Argon		MMG™		TIME™	
	Voltage (V)	Avg. Current (A)	Voltage (V)	Avg. Current (A)	Voltage (V)	Avg. Current (A)
10 kW	32.5	306.5	34.5	288.0	35.5	278.4
11 kW	33.0	326.1	35.0	315.0	36.0	306.7
12 kW	36.0	333.7	37.3	326.9	38.5	311.5

The LaserStrobe™ video images shown in Fig. 17A and B were taken approximately 33 ms apart. In Fig. 17A, a long molten filler metal string was violently swung around with the end portion of the string about to touch the surface of the workpiece. In Fig. 17B, the molten filler metal string was broken up into two segments. During the 33-ms time interval between the first and the second images, the long molten filler metal string apparently touched the leading edge of the weld pool. This contact momentarily created a short circuit, which resulted in a surge of welding current. Since the molten filler metal string was in liquid form, a small current surge was needed to eliminate the short circuiting. In the process of eliminating the short circuiting, the molten filler metal string was shattered into fragments as shown in Fig. 17B.

The Soot Layer

A layer of rust-colored soot was observed covering the bottom surface of many of the depressions of the discontinuous weld bead defect. The presence of a contaminant layer can prevent molten weld metal from refilling the gouged region of the weld pool by preventing contact and wetting at the fusion boundary. As this could also contribute to the formation of the depressions that break up the weld bead into segments, further examination of the soot layer at the bottom of the depression and its effects on the formation of the discontinuous weld bead defect was undertaken.

Figure 18 shows the as-welded top surface of a GMA weld with the discontinuous weld bead defect. The surface of the workpiece adjacent to the weld bead is covered with a thick layer of rust-colored soot, while the good weld bead segments are relatively clean. As noted in Fig. 18, the dark spots formed on the top surface at the end of each good weld bead segment were found to be a $(Mn,Si)_xO_y$ glassy slag. In addition, there was a thin layer of soot completely covering the bottom surface of the depressions of the discontinuous weld bead. The chemical composition of the soot on the top surface of the adjacent workpiece and the soot covering the bottom surface of the depression were analyzed using a LEO FESEM 1530 field emission scanning electron microscope equipped with an EDX analysis system. Since the soot just covered the top surface of the workpiece, the scanning electron microscope was set at 15 keV to minimize the interaction volume between the electrons and the analyzed material (Ref. 31). The small interaction volume ensured that the elements detected during the chemical analysis belonged to the soot. The elemental constituents of the soot covering the top surface of the workpiece adjacent to the weld bead were identified as Fe, Mn, Si, Zn, and oxygen. Since the ER70S-6 electrode wire has a high content of deoxidizers such as Mn and Si (Table 1), it is not unexpected to find these elements in the chemical composition of the soot. During welding, it is thought that the Mn and Si from the electrode wire were vaporized inside the welding arc. As the welding gun moved forward, the Mn and Si metal vapors oxidized and condensed on the surface of the workpiece adjacent to the weld bead. Meanwhile, as shown in Fig. 18, the good weld segments were clear of any soot since the weld bead was at higher temperatures during the time period when the metal vapors condensed.

An EDX analysis was also performed on the soot layer covering the bottom surface of the depression — Fig. 18. Using the same setup on the scanning electron microscope, the elements detected by this EDX analysis were Fe, Mn, Si, and oxygen, which are similar to those elements found in the rust-colored soot formed on the surface of the workpiece adjacent to the weld bead. From the results of the chemical analysis, the soot, which covers the bottom surface of the depressions of a discontinuous weld bead defect, was chemically similar to the common welding soot that typically forms on the cooler metal surface adjacent to the weld bead. As previously discussed, the shallow HAZ suggests that there was less sensible heat input at the depression — Fig. 9. As a result, the surface of the depression was cooler than the adjacent good segments of the weld bead. The Mn and Si metal vapors condensed over the bottom surface of the depression just as they condensed on the surface of the workpiece adjacent to the weld bead. Since the soot layer was produced from the metal vapors that oxidized and condensed at some distance behind the welding arc, it was not present inside the weld pool to prevent the molten weld metal from refilling the gouged region. Thus, the observed layer of soot is not responsible for the formation of the depressions in the discontinuous weld bead defect.

The Role of Rotational Transfer Mode in Forming the Discontinuous Weld Bead Defect

The LaserStrobe™ video imaging system was used to observe the formation of a discontinuous weld bead defect made at 40 mm/s welding speed when using MMG™ shielding gas, ER70S-6 electrode wire, and 10 kW welding power. Figure 19 contains a sequence of six video images each 33 ms apart detailing the events that took place during the formation of a discontinuous weld bead defect. In Fig. 19A, a long molten filler metal string is clearly visible with the molten filler metal droplets that are being formed, detached, and transferred to the weld pool from the tip of the string. As previously mentioned, in the rotational transfer mode regime, the radial pinch instability that acts on the molten filler metal string is responsible for the formation and detachment of the droplets (Ref. 27). This particular instability is also capable of producing necking at various places along the length of the molten filler metal string. In Fig. 19A, the necking regions are seen as the dark rings along the length of the molten filler metal string. The thinning of these necking regions will eventually break up the long molten filler metal string into fragments as shown in Fig. 19B. With the breakup, the original molten filler metal string and the arc length are shortened as compared to those in Fig. 19A.

In Fig. 19B, the end of the detached fragment is clearly visible above the surface of the weld pool while the remaining portion of the original molten filler metal string is still attached to the solid electrode wire. However, in the 33-ms time period between Fig. 19B and C, the remaining portion of the original string has broken off from the tip of the solid electrode wire and transferred to the weld pool. As is clearly evident in Fig. 19C, during this time period, transfer of molten filler metal to the weld pool does not occur. In fact, a new molten filler metal droplet is beginning to form at the tip of the electrode in Fig. 19C. With the formation of a new molten filler metal droplet at the tip of the solid electrode wire, the arc length is apparently the longest in the sequence as compared to the arc lengths of Fig. 19B and C, respectively.

In Fig. 19C, the welding arc behaves as if it is an autogenous welding process. As may be seen in Fig. 19A–D, the width of the weld pool remains consistently the same. This suggests that the heat input from the welding arc has not been influenced by the breakup and the detachment of the long molten filler metal string. As a result, the heat generated by the welding arc continues to melt and to penetrate the original surface of the workpiece although the transfer of molten filler metal does not occur.

In Fig. 19D, one molten filler metal droplet is seen momentarily before touching the top surface of the weld pool. This may be the molten filler metal droplet, which is noted in the previous image of Fig. 19C. In the 33-ms time period between Fig. 19B and C, there is a large addition of molten filler metal to the weld pool due to the detachment of a long molten filler metal string. Meanwhile, for the same time period between Fig. 19C and D, there is approximately one filler metal droplet transferred to the weld pool. This is a considerable reduction in the amount of filler metal transferred. The reduced transfer of molten filler metal may also extend from the Fig. 19D to Fig. 19E time period. After the detachment of a long molten filler metal string, the GMA welding process temporarily switches back to the early stage of spray transfer mode as evidenced by the formation and the detachment of a molten filler metal droplet. Eventually, a new molten filler metal string begins to form again in Fig. 19E and rotational transfer mode is resumed with the long molten filler metal string as illustrated in Fig. 19F. For the 67-ms time period starting from Fig. 19C and ending at Fig. 19E, there is a large reduction in the amount of filler metal transferred into the weld pool. During this time period, the welding arc continued to melt and to penetrate the workpiece similar to an autogenous welding process. As a result, the depression of a discontinuous weld bead defect should have the same penetration depth as the good weld segments. As previously discussed, this was one of the observed geometric features of the depression region of a discontinuous weld bead defect. However, because of the reduced amount of the filler metal transferred, the HAZ at the depression is smaller compared to the HAZ under the good weld bead segments — Fig. 9.

At 40 mm/s welding speed and 67-ms time period, the linear distance traveled by the welding arc along the weld joint is approximately 2.7 mm. Over this distance, the amount of filler metal transferred to the weld pool has been drastically reduced. There will not be enough molten weld metal to form a proper weld bead profile. As a result, a depression separating the good weld bead segments will form. Theoretically, the length of the depression as measured in the welding direction should be approximately 2.7 mm. Figure 20 is a LaserStrobe™ video image showing the length of the depression that was formed during the sequence of images in Fig. 19. As indicated, the length of the depression is approximately 2.7 mm, which is equal to the linear distance over which the amount of filler metal transferred to the weld pool was drastically reduced. These images suggest that inconsistent filler metal transfer rate during rotational transfer mode causes the formation of the depression in discontinuous weld bead defect.

For GMA welds produced using argon shielding gas, the discontinuous weld bead defect did not occur at higher welding powers although the filler metal transfer mode was rotational. One possible explanation is the frequent fragment detachments from the long molten filler metal string with argon shielding gas as shown in Fig. 15. The arc lengths of argon-shielded GMA welds were about twice the arc lengths of welds produced using the reactive shielding gas (Ref. 17). In addition, the surface tension of molten steel in argon shielding gas will be higher than that in reactive shielding gases (Ref. 32). Because of the long arc length and the high surface tension, the length of the molten filler metal string will also be longer compared to those present when using reactive shielding gases.

For each GMA weld, the voltage and the wire feed speed were normally set prior to welding. In the present study, during welding, the current was measured using the previously described data-acquisition system. The voltage and the average welding current for different welding powers and shielding gas combinations are shown in Table 3. In general, the welds produced using argon shielding gas had lower voltage settings, but larger welding currents, than those produced using the reactive shielding gases. With high welding currents, the radial pinch force would be stronger since the electromagnetic force that generated the pinch force is a function of the welding current (Refs. 2, 29). As a result, the detachments of molten filler metal droplets and more importantly, the fragments, occurred more frequently for argon shielding gas — Fig. 15. With the long molten filler metal string and the more frequent fragment detachments, the filler metal deposition rate will be more consistent. In other words, the time period in which the molten filler metal is not transferred to the weld pool is relatively short or nonexistent. As a result, the discontinuous weld bead defect does not occur at higher welding powers. Instead, the humping phenomenon is the limiting factor that prevents achievement of higher welding speeds.

With the higher welding powers and rotational filler metal transfer, the welding speeds for GMA welds produced using reactive shielding gases are limited by the formation of the discontinuous weld bead defect. From experimental observations, the inconsistent amount of molten filler metal deposited during rotational transfer mode is the cause of the discontinuous weld bead defect. This inconsistent filler metal transfer rate is caused by the erratic breakup of the long molten filler metal string that typically exists in rotational transfer. After the detachment of the fragment, time is required for the string to reestablish. Meanwhile, at high welding speeds, the welding arc proceeds along the weld joint as if it is an autogenous welding process. The heat generated by the autogenous welding arc consistently maintains the weld width and the penetration depth. However, the lack of filler metal transfer during this time period creates a depression that breaks up the otherwise good weld bead. Consequently, the discontinuous weld bead defect is formed.

Conclusions

Detailed observations of the sequence of events taking place during the formation of weld bead defects during high-speed bead-on-plate gas metal arc welding of plain carbon steel using ER70S-3 and ER70S-6 electrode wires, and Ar and two different reactive shielding gases have been made. At welding powers between 5 and 9 kW, spray metal transfer occurred and the welding speed was limited by the onset of the periodic humping weld bead defect.

For GMA welds produced with argon shielding gas, there was a small increase in the critical welding speed at which humping began as the welding power was increased from 5 to 9 kW. When the welding power was further increased from 9 to 12 kW, however, the filler metal transfer mode was observed to go from streaming to swinging spray transfer and the critical welding speed at which humping was observed remained constant at about 15 mm/s.

When using the reactive shielding gases, MMG™ and TIME™, the filler metal transfer mode changed from spray to rotational transfer when the welding power was increased above 9 kW. In this case, the critical welding speed of the GMA welds produced using rotational transfer mode and reactive shielding gases was defined by the onset of a new aperiodic high-speed weld bead defect that was identified and defined as a discontinuous weld bead defect. Above 9 kW welding power, the discontinuous weld bead defect always occurred at welding speeds greater than 22 mm/s independent of the welding power. The results indicated that nominal wire composition did not appear to play a significant role in the formation of periodic humping or the aperiodic discontinuous weld bead defects.

The aperiodic discontinuous weld bead defect is distinctly different from the periodic humping weld bead defect and has never before been reported in the open literature. This weld bead defect can be described as the breakup of a good GMA weld bead by the aperiodic or intermittent formation of valleys or depressions where melting of the base metal occurred but no filler metal was deposited. The good weld bead segments of discontinuous weld beads had well-rounded fusion boundaries without the finger penetration weld pool profile characteristic of GMA welds made using spray transfer mode. This good weld bead was broken up into segments by the aperiodic occurrence of filler-metal-free depressions that were very similar to a severely gouged autogenous weld bead produced using high welding power but no filler metal.

The formation of the discontinuous weld bead defect has been explained as the consequence of the inconsistent transfer of the molten filler metal from the electrode wire to the weld pool when welding with reactive shielding gases in rotational transfer mode. LaserStrobe™ video images of the rotational transfer mode showed the filler metal detaching from a long molten metal string on the end of the electrode that was violently swung around inside the shroud of the welding arc. Due to the radial pinching or necking that occurred along the length of the molten string, the filler metal was transferred either as droplets or as long fragments into the weld pool. On occasion, the long molten filler metal string momentarily touched the weld pool and broke up into fragments. Fragmentation or complete detachment of the molten filler metal string during rotational transfer mode has not been observed or previously reported in the open literature. This fragmentation of the long molten metal string on the end of the electrode wire temporarily disrupts the transfer of the molten filler metal into the weld joint. Since the welding arc is moving forward at high welding speed, the disruption in filler metal transfer creates a depression, a region of the weld bead where no filler metal has been deposited, and breaks up the normally good GMA weld bead to form the aperiodic discontinuous weld bead defect. The random fragmentation of the molten metal string on the end of the electrode during rotational metal transfer has not been previously observed or reported.

For the GMAW process, the periodic humping weld defect and the aperiodic discontinuous weld bead defect limit the usable welding speed in spray and rotational transfer modes, respectively. The discontinuous weld bead defect is distinctly different from humping and is the direct result of inconsistent filler metal deposition during rotational transfer. For the first time, the manner in which the molten filler metal is transferred from the electrode across the welding arc to the weld pool during the GMAW process has been shown to be very influential in the formation of high-speed defects such as humping and discontinuous weld beads.

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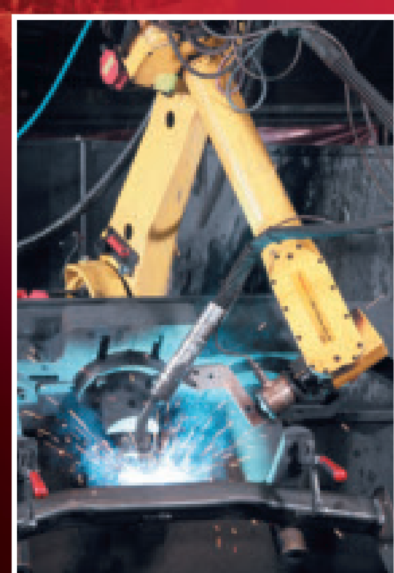

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