WELDING *Journal*

September 2008

- **FABTECH International & AWS Welding Show Preview**
- **New Method of Cleaning Welding Wire**
- **A Look at D1.1 Changes**
- **Solid-State Welding**
- **Laser Cladding in a Marine Application**

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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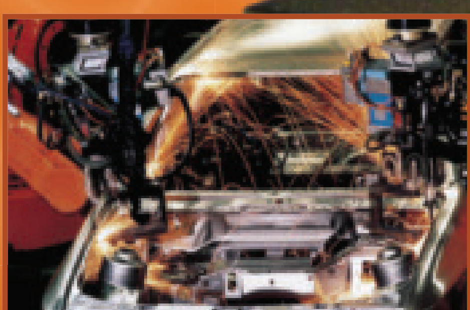

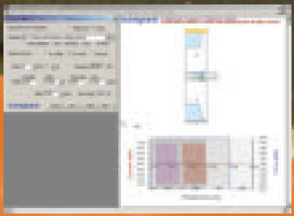

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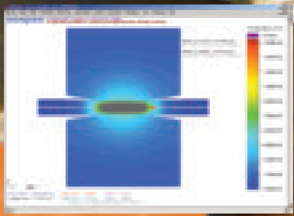

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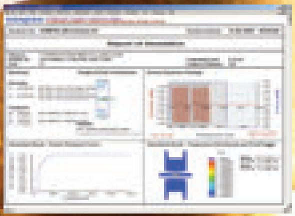

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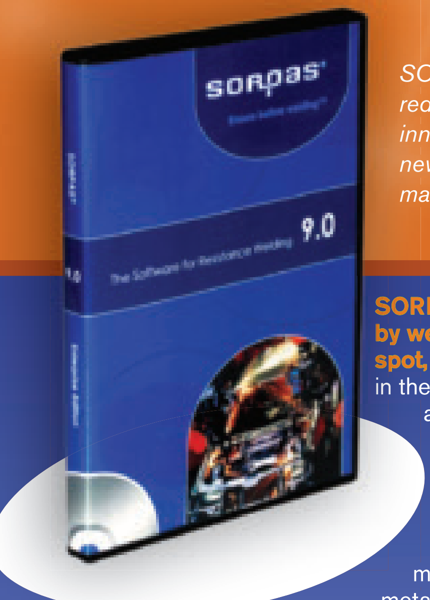

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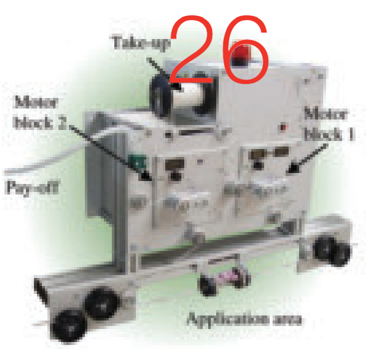

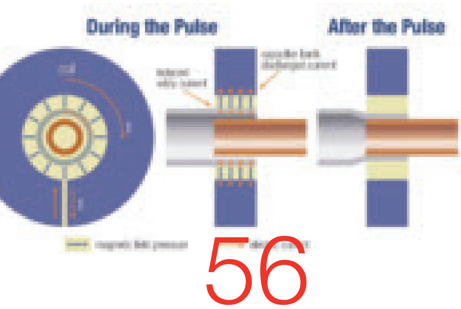

Features

Welding Research Supplement

Cover: The site of this year's FABTECH International & AWS Welding Show, the 3.2 million-sq-ft Las Vegas Convention Center is located a short distance from the Las Vegas Strip. It is operated by the Las Vegas Convention and Visitors Authority. (Photo credit: Las Vegas News Bureau).

AWS Web site *www.aws.org*

Departments

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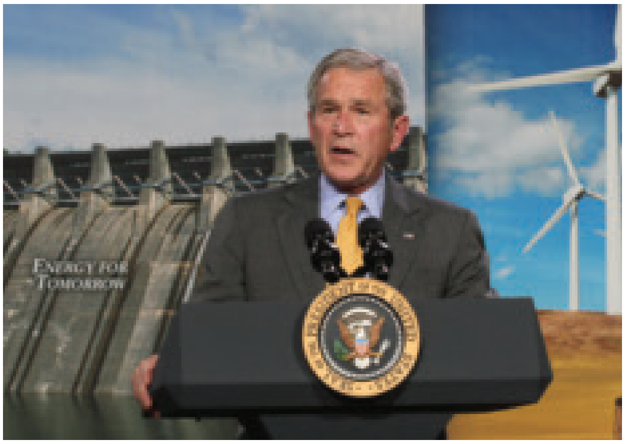
PRESS TIME NEWS

President Bush Discusses U.S. Economy, Energy during Trip to Lincoln Electric Co.



During President Bush's visit at Lincoln Electric, he discussed the economy and the importance of developing domestic energy sources. He also toured the company's plant. (Photo by Jeff Weber.)

President George W. Bush visited Lincoln Electric Co., Euclid, Ohio, on July 29. George Blankenship, president of Cleveland Lincoln Electric, escorted Bush to the podium where he proceeded to discuss American competitiveness, the economy, and energy. "I'm proud to be here with 'the welding experts,'" Bush said.

He spoke of the economic uncertainty U.S. citizens are facing, including paying high prices at the gas pump and the housing crisis, but said we should play to our strengths along with implementing good common-sense policy.

Also, he referred to Lincoln seeking new business in Columbia. "I don't know if you know this or not, but most of the goods produced in Colombia come to our country duty free. The United States Congress, as a result of what is called the Andean Trade Preference Act has passed law that said they can sell into our markets, which frankly is good for our consumers. The more product you get to choose from, the better off you are. On the other hand, products going into Colombia from the United States face a duty, a tariff, a tax," Bush said.

He went on to remark, "I think it makes sense for the United States Congress to level the playing field, to say, 'We treat you one way, you treat us another way.' So we've negotiated a treaty that said with Colombia, all we want to do is be treated fairly in the United States of America...we want our products, like those manufactured right here in Euclid, Ohio, going into that Colombian market without a special tax on it. And Congress needs to pass that trade bill."

Moving on to the energy situation, Bush noted there is no such thing as a quick fix, but conservation can make a difference as well as the government helping to work on higher fuel efficiency standards for automobiles.

"The reason why your gasoline prices are high is because the demand for oil is greater than the supply of oil," Bush said. One reason for this is new emerging economies. He suggested learning how to find more oil in the United States, and noted that with technology advances, oil and gas can be found in environmentally friendly ways. He called on Congress to support offshore drilling and exploration. "The more active we are here in the United States to find our own oil reserves, the more business companies like yours will get," Bush said.

A new era is ahead. "The United States of America needs to understand that if we truly are concerned about the environment and want to make sure we continue to grow our economy, we've got to expand nuclear power...so when you hear me talking about making sure that we have electricity at reasonable price, just keep in mind that there are technologies available that make it easy for me to say I am confident nuclear power is safe, because I understand that the products that go into a nuclear power plant are made by some of the finest welders in the United States of America," Bush said. Solar and wind power need to be part of the mix, too.

"It's a huge honor to be here with you today," he concluded.

Among the attendees at this event from the American Welding Society (AWS) were Executive Director Ray Shook, CFO/Deputy Executive Director Frank Tarafa, Deputy Executive Director Cassie Burrell, and Associate Executive Director Jeff Weber. Also present were City of Euclid Mayor Bill Cervenik and two members of the United States Congress, Steve LaTourette and Pat Teeberry, from the state of Ohio.

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Today's Word...Growth

We are once again approaching the annual FABTECH International & AWS Welding Show. Each year, AWS attempts to bring its members and customers a better show. I look forward to having a record-breaking show and program. The Society is constantly growing. Yes, it is quite apparent that the American Welding Society is growing. We are seeing our membership increase to more than 53,000, and the number of services we provide is increasing. The entire infrastructure of the Society is expanding, with a lot more to come as we face the welder shortage challenge.

The AWS has partnered with companies such as ITW, OKI Bering, and Lincoln Electric, and individuals such as AWS Foundation Chair Ron Pierce — with more signing on all the time — to bring about the Work Force Development program. This is not "a let's talk about it" activity, but an actual hands on doing something about it effort. The AWS Foundation has implemented the SOS (Solutions Opportunity Squad). They are special AWS Foundation employees located throughout the country, who will work to bring about the joining of corporate America, education and training, and state and federal government entities to create a team effort on the skilled labor shortage problem. The future is in our hands and we have the ability to be not only a part of the growth but be able to cultivate the level and direction for the future of our great profession. After all, we all know that "Welding Holds the World Together!" I am proud to say I am a welder. While I don't weld every day as part of my job, I do depend on the knowledge and experience I have in welding to perform my duties as a global customer service specialist. I must be able to understand my customers' issues in order to provide solutions.

While conducting the meeting in Graz, Austria, for Commission 14 of the International Institute of Welding (IIW), it was interesting to discover that all the countries in attendance are experiencing the same issue of skilled labor shortages. Many countries have been trying to solve the problems by getting their governments to lead the way. They have been only marginally successful. They all are looking at the model that AWS is doing with a great interest. It made me proud to be a member of the AWS.

The American Welding Society is really on the move, and we will see new programs and member benefits evolve in 2009. We'll see increased conference and seminar programming, new certification programs, and new and updated standards and specifications. We have about 70 standards in the works at present and I want to tell all our members that the volunteers who serve on committees and the AWS staff who work with the volunteers are really doing an excellent job. Thank you. We truly have a great team.

In closing, I would pose a challenge for all who read this. Bring a new person into the profession. Mentor, guide, advise a neighbor, relative, or friend regarding the great opportunity that awaits him or her in the welding profession. The job offerings are varied in range and scope.

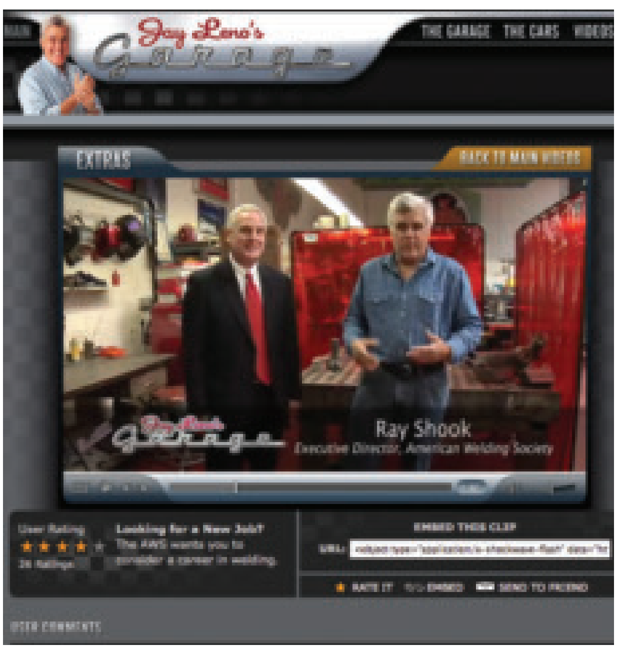
When you come into Lincoln Electric, there is an inscription over the front hall that states, "The Actual Is Limited, but the Possible Is Immense." Think about it — it is possible to make a difference.

I look forward to seeing you at the Show. Bring a new prospect for the profession along with you.

Victor Y. Matthews
AWS Vice President

Jay Leno Endorses the American Welding Society's Mission

On YouTube, there is a video with Jay Leno speaking about the importance of welders. "They're skilled technicians. They can do the work that most people cannot do," he said. On the left is an EcoJet car being worked on, and there is a welded chassis on the table to the right.



Here's a shot of the Web site featuring a video with Jay Leno promoting welding. AWS Executive Director Ray Shook made an appearance in this one to talk about the Society, the present need for welders, and benefits of a career in welding.

American Welding Society (AWS) Executive Director Ray Shook met Jay Leno at his Big Dog Garage in Los Angeles, Calif., on July 1 with the help of Lincoln Electric Co., Cleveland, Ohio.

Leno made a video strongly endorsing welding as a career and recommending that his fans contact AWS. On YouTube, it can be viewed at *www.youtube.com/watch?v=PASEG5xLlRo*. The video starts with Leno at his garage showing an EcoJet car that uses an LT-101 jet engine and runs on biodiesel. "I'm into this car for probably well over a million bucks. If you're wondering where all that money went — welders," he said jokingly.

He went on to mention, "It's interesting this country was built by welders, and somewhere along the line, we kind of lost our focus...you could actually do something that actually helps the country fix our infrastructure, build bridges."

Leno further stated welders now have mostly all gray hair. "What we need are young people that want to do this job. And you can make a lot of money doing this job. I know how much welders charge me," he said.

He pointed out the welding that has been done on a chassis for the EcoJet. "It's a skill as much as anything else in this country, but for some reason, I don't know where working with our hands suddenly became a detriment. We didn't win World War II only because we had the best soldiers, we won also because we could turn out a plane, a Liberator, a B-17, every 55 minutes. We could actually make airplanes quicker than they could shoot them down. And that's one of the reasons — cause we had skilled people, young people, 18, 19, 20 years old that were making airplanes. Now those same guys are still making airplanes, except they're 80 to 90 years old. But we need to have them pass it on down to you guys. This is a skill — it's a skill that will become even more and more needed as we go along."

Leno ended by stating he tells people to check out the American Welding Society and go to its Web site (*www.aws.org*). "You can make a good living and you can become a rich person and you can bleed people like me dry because I need you," he said.

Additionally, Leno conducted an interview with Shook and posted it on his "Jay Leno's Garage" Web site at *www.jaylenosgarage.com/video/video_player.shtml?vid=276886*. In this video, filmed in the garage's welding section, Leno brought up some of the same points he made in the YouTube clip.

After being introduced, Shook spoke about AWS. "AWS is the professional society for welding. We're the premier society in the world, and our objective is to promote welding as a career," he said.

Shook also talked about the current high demand for welders. "We estimate that the average age of a welder is 54 years old. There's a shortage now, and by the year 2010, it's projected they'll be a shortage of 200,000 welders," he said.

"I like the fact that you can actually make and fix something that will last literally a lifetime," Leno said of welding.

Leno cited the importance of obtaining a certificate/degree stating you are a welder, too. Shook encouraged people wanting to get involved in welding careers to contact AWS. "We'd be glad to have you visit our Web site to see what the opportunities are," Shook said.

Province Invests $15.4 Million in Skilled Trades Training at Niagara College

Ontario Premier Dalton McGuinty recently announced $15.4 million in provincial funding to expand Niagara College's capacity for skilled trades training. This will support a 70,000-sq-ft expansion of skills training spaces at the college and will create 730 new spaces for apprenticeships and skills training. Among the trades to be supported are welding and metal fabrication.

The funding is part of the Provincial Government's Skills to Jobs Action Plan, which supports new skills for new careers, expanded postsecondary student aid and programs, and the construction of new places to learn.

Currently, almost all Niagara College skilled trades programs have a waiting list and, on average, there are more than four applicants for every spot available. Due to this high demand, the

In July, Ontario Premier Dalton McGuinty (standing behind the podium) declared provincial funding for skilled trades at Niagara College. This announcement took place in the Technology Skills Centre at the college's Welland Campus.

college is constructing a new addition to the Technology Skills Centre to accommodate a new welding lab and new classroom space for skilled trades programs.

The expansion project consists of constructing the first phase, which will start this summer, including the welding and construction trades facilities at the Welland Campus; these facilities will be ready for occupancy by January 2009. Construction on the balance of the program will commence this fall with completion by the fall of 2010. Also, this project will be funded through a combination of provincial government capital funding ($15.4 million) and internal reserves (college funding of $2.9 million) for a total of $18.3 million designated to support it.

Hypertherm Enjoys 40 Years of Plasma Cutting, Introduces Mobile Centers

Dick Couch, Hypertherm's founder and president, talks about the company's early years to the hundreds of associates gathered for the company's 40th anniversary celebration.

Hypertherm, a provider of plasma arc metal cutting technology, recently celebrated 40 years of plasma cutting innovation with many worldwide events during the month of June. Its founder and president, Dick Couch, along with vice president of human resources, Barbara Couch, visited associates and customers in Mexico City; São Paulo, Brazil; and other South American cities. Also, at the company's headquarters in Hanover, N.H., more than 800 associates gathered with guests under a giant tent on June 18. This event featured several presentations, in addition to a formal commendation from the State of New Hampshire, and a sit down lunch.

In other news, the company is taking its plasma technology on the road with two new mobile cutting centers that are traveling throughout North America showing the benefits of plasma arc cutting. For the latest schedule, visit *www.hypertherm.com*.

KUKA Robotics Corp. Celebrates '35 Years of Working Ideas'

KUKA Robotics Corp., Clinton Township, Mich., held a "35 Years of Working Ideas" technology open house at its headquarters on June 5. At this event, more than 15 operating robotic demonstration cells were shown for various applications.

Highlights included the company's KR 1000 Titan on display. This robot, featuring heavyweight capabilities that earned an entry in the *Guinness Book of Records*, can lift a payload of 1000 kg with a reach of 4000 mm; handle a Chrysler Jeep body frame; and is suited to handle heavy, large, or bulky workpieces. Also exhibited was the Ingress Protection (IP) 67 rating for its foundry robots. Attendees were able to spray water within this robotic cell, and the robot continued to run because its seals would not allow water to penetrate the joints.

Participants toured KUKA's Accuracy & Sound Calibration Room, an Absolute Accuracy Testing Lab, and Sound Level Validation Testing Lab as well.

The company recently hosted an open house in honor of its many years in the robotics industry. Shown above is the new KR 1000 Titan. This product can lift a payload of 1000 kg, has a reach of 4000 mm, and is capable of moving whole car bodies, heavy metal castings, and more. (Photo courtesy of KUKA Robotics.)

SME and EMCI Establish Unifying Industry Standard for Engineering Management

The Society of Manufacturing Engineers (SME), Dearborn, Mich., has signed an agreement to establish a partnership with Engineering Management Certification International (EMCI), a certification program that facilitates and maintains competence in engineering management among qualified engineers, scientists, and technologists.

SME will close its Certified Engineering Manager (CEM) certification effective July 15 and merge it with the EMCI program. All previously CEMs will become certified through the Engineering Management Certification Fundamentals or Engineering Management Certification Professional designation.◆

German Shipbuilder to Use Disk Laser for Hybrid Welding of Thick Sheet Steel

Meyer Werft, the shipbuilder based in Papenburg, Germany, recently added two TRUMPF TruDisk 10003 and one TruFlow 12000 laser systems to its lineup of laser beam welding equipment. The shipyard has been using CO_2 lasers from the company to weld metal plates for many years.

The two disk lasers will be used to weld I joints and, for the first time, for laser hybrid welding of thick sheet metal. An important factor in selecting the 10-kW disk laser was absolute control over output power. "Reproducible process results that do not depend on ambient conditions are crucial to us for subsequent production," said Herman Lembeck, director of steel production at Meyer Werft. Another benefit of the system is beam guidance via a laser light cable because the disk laser's setup does not depend on location of the processing site, an aid to production versatility.

Linde Begins Construction on Australian Helium Plant

The Linde Group, through its Australian subsidiary, BOC, recently began construction on the first helium plant in Australia. The plant, located in Darwin, Northern Territory, will be the first helium plant in the southern hemisphere and will supply all of Australia's domestic helium needs as well as provide capacity for export to New Zealand and Asia. The plant, which is expected to begin operation in July 2009, will produce approximately 150 million cubic feet of helium per year.

"Helium is produced at a small number of sources around the world and is shipped globally," said Steve Penn, head of global helium, Linde. "Helium demand has increased most in Asia, with steady demand growth forecasted for at least the next five years. With global supply expected to remain tight for the foreseeable future, having a new Asia-Pacific helium source is good news not only for this region but for the entire world."

Helium gas is used in welding, leak detection, manufacture of semiconductors, liquid crystal displays, and fiber-optic cable, as well as for lighter-than-air applications such as blimps and balloons. A nonrenewable resource, helium is extracted from natural gas. Linde has a long-term contract with the Darwin liquefied natural gas plant to extract, purify, and liquefy the helium for shipment to customers.

Applied Manufacturing Technologies Opens Office in India

Applied Manufacturing Technologies (AMT), Orion, Mich., a supplier of factory automation design, engineering, and process consulting services, recently opened an office in Bangalore, India. The office will support the growing Asia-Pacific market as well as AMT's key U.S. customers.

The new office includes all areas of automation engineering, training, field support, and development functions. For more information, visit the company's Web site at *www.appliedmfg.com.*

Training Center for Plastics Welding Opens in Middle East

SKZ Wuerzburg, the German plastics institute, in partnership with BMC Gulf LLC, a provider of plastics welding technology, recently opened a training center in Dubai, UAE. The center is believed to be the first in the Middle East to offer certified training programs for HDPE plastic pipe welding.

Reda Ashkar (left), general manager of BMC Gulf LLC, and Harald Huberth, managing director, SKZ Wuerzburg, cut the ribbon to open the plastics welding training center in Dubai.

The center is a fully equipped facility and will offer courses covering various topics related to plastics. It includes a state-of-the-art welding workshop that will provide students with hands-on training in welding and testing techniques for pipes and plastic products.

The training program is designed for engineers and consultants involved in the design, specification, and supervision of plastic pipeline projects; site supervisors responsible for monitoring on-site welding activities; and welding technicians performing on-site welding and installation of pipe networks. SKZ certifies more than 3000 plastic welding professionals yearly.

"As we witness a rapid growth in the construction of piping networks to cope with the ever-increasing demand for gas and water in the region, we realized that the major failures to pipelines are mainly the result of bad installation practice or insufficient know-how in welding and installation techniques," said Reda Ashkar, general manager, BMC Gulf. "Quality control and monitoring are crucial to assure the longevity and service life of water and gas pipelines in the region, and our training center will help contribute to achieve this goal."

Adept Technology Expands into Indian Market, Signs Distributor

Adept Technology, Inc., Livermore, Calif., a provider of intelligent vision-guided robotics and global robotics services, recently announced its expansion in India for its products and the signing of Menzel Vision and Robotics Pvt. Ltd. of India as an exclusive distributor in western and northern India. India is one of the fastest growing robot markets in Asia.

Menzel Vision and Robotics will be the exclusive distributor in 14 states in western and northern India for Adept's complete line of robotics, controls, vision, and software products. Menzel Vision and Robotics, headquartered in Mumbai, India, has more than ten years' experience in imaging solutions.

Linde Canada Acquires Ontario-Based Distributor

Linde Canada, a member of The Linde Group, recently acquired P&B Industrial Sales, Inc., a Sudbury, Ontario-based distributor of welding gases and equipment. P&B is a privately owned company in business since 1992, serving customers in Sudbury and the surrounding areas.

P&B's employees will become part of Linde Canada's team in that region.

BY DAMIAN J. KOTECKI

Q: Is it acceptable to use air carbon arc gouging to produce a weld joint preparation or to remove defects found in 308L or 316L stainless steel weld metal — either joints or cladding? Concerns have been expressed about carbon pickup from the carbon electrode causing damage to corrosion resistance of the stainless steel weld metal.

A: This question has been around for more than 50 years, and recent discussions can still be found on the AWS Web site forum. It was considered by Hard (Ref. 1) already in 1954, although he did not look at low-carbon stainless steel. The concern usually expressed is that carbon contamination in the metal surface will lead to chromium carbide precipitation with resulting sensitization of the weld metal and/or heat-affected zone.

Actually, there is a second concern that no one seems to mention. This concern is the dross and molten metal that is not blown away by the air stream will also experience nitrogen pickup from the air. If welding is done on the dross and thin film of metal melted by the air carbon arc but not blown away, this nitrogen will enter the weld metal. Since nitrogen is an austenite-promoting element, ferrite content will be reduced and could potentially be reduced to a level low enough that solidification cracking could occur in weld metals like 308L and 316L, which are designed to contain some ferrite.

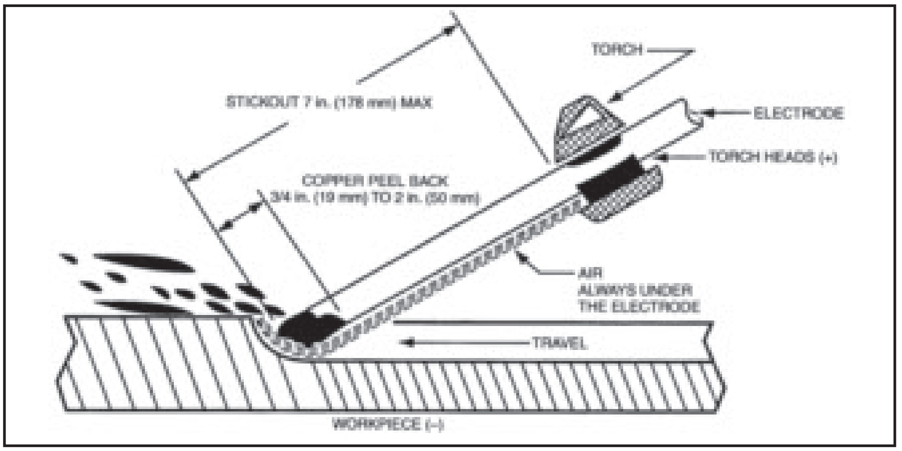


Fig. 1 — Proper air carbon arc gouging technique.

The manufacturers of air carbon arc gouging equipment provide lots of information on how to correctly apply the method to carbon steels, low-alloy steels, stainless steels, aluminum, etc. AWS C5.3:2000, *Recommended Practices for Air Carbon Arc Gouging and Cutting,* is an excellent resource for noncommercial information. The correct technique generally involves a pushing inclination to the carbon electrode, with the air stream directed behind the advancing electrode. Then there are very specific recommendations concerning the correct current range for a given carbon electrode, the correct electrode extension, and the correct air pressure. Figure 1, reproduced from AWS C5.3:2000, shows the correct technique.

Along with correct gouging technique, correct cleanup after gouging is essential. For stainless steels, this means grinding away all traces of dross and oxidized surfaces from the gouge area. Only a bright metallic surface should remain before welding is initiated. If this is done, with proper technique in the application of air carbon arc gouging, all traces of nitrogen pickup and carbon pickup will be removed and the ground surface will be quite suitable for subsequent welding.

Low air pressure in air carbon arc gouging is a particular concern because it can permit greater depth of carburized and nitrided metal than normal grinding would remove. Christensen (Ref. 2) deliberately used low air pressure for air carbon arc gouging 304L stainless cladding as compared to a gouge done with proper air pressure and to a machined groove. Chips were removed by a superficial cut from each of the three surfaces then analyzed for carbon content. The surface prepared entirely by machining was found to contain 0.03% C. The surface gouged with proper air pressure was found to contain 0.04% C, and that gouged with low air pressure was found to contain 0.10% C. Next, each prepared groove was welded with low-carbon stainless steel (grade not specified), and the weld deposit was analyzed for carbon content. The deposited weld metal in all three cases was found to contain 0.03% C. Christensen further noted that nitric acid corrosion tests according to ASTM A262, on backgouged and welded root pass surfaces, showed no adverse corrosion results.

Christensen does not state whether or not the gouged surfaces were subsequently ground to bright metal before the chips were taken for chemical analysis or before welding. From the overall tone of the paper, I believe that no grinding was done. Christensen also did not consider nitrogen pickup or ferrite loss. Even if Christensen's results are based upon not grinding, I would not advocate welding over the as-gouged surface without grinding to bright metal. It is not good practice, from the viewpoint of producing sound, defect-free welds, to weld over heavily oxidized surfaces. And nitrogen contamination of the oxidized surface can result in lower than expected ferrite content and a possibility for cracking. A competent inspector can easily determine visually whether grinding to bright metal has been properly done before welding begins.

As long as grinding to bright metal follows air carbon arc gouging, I see no reason that air carbon arc gouging cannot be an acceptable method for joint preparation of stainless steel or removal of defects from stainless steel welds before repair welding. ♦

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2. Christensen, L. J. 1973. Air carbon-arc gouging. *Welding Journal* 52(12): 782–791.

DAMIAN J. KOTECKI is president, Damian Kotecki Welding Consultants, Inc. He is a past president of the American Welding Society, currently treasurer and a past vice president of the International Institute of Welding, and a member of the AWS A5D Subcommittee on Stainless Steel Filler Metals, and the AWS D1K Subcommittee on Stainless Steel Structural Welding. He is a member and past chair of the Welding Research Council Subcommittee on Welding Stainless Steels and Nickel-Base Alloys. Send your questions to Dr. Kotecki at damian@damian kotecki.com, or to Damian Kotecki, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.

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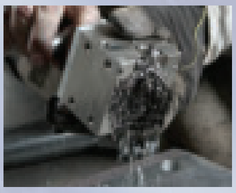
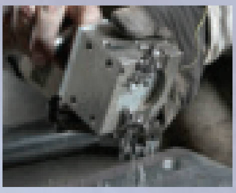
Saving time = saving money

Magswitch tools are lighter and stronger pound for pound than any other switchable magnet system. Unlike competitive products, when the Magswitch is off, it allows debris to fall away.

On



Off

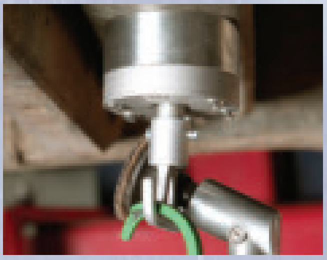


Welding Clamps

- Saves time and money.
- No more searching for or creating a ground location.
- Grounds instantly, turn on Magswitch and start welding.
- Attaches to flat or pipe.
- No more tacking on tabs in large sheet jobs.
- Stays clean.
- Available in three sizes:
  - 600-amp
  - 300-amp
  - 200-amp

MagSquares

- Simple and fast workholding.
- No need for tedious clamping.
- Grips on three sides.
- Precise positioning, holds on flat or round surfaces.
- Use MagSquares to mount workholding jigs.
- Stays clean.
- Available in three sizes, with breakaway force up to:
  - 150-lbs (30MM)
  - 550-lbs (50MM)
  - 1000-lbs (70MM)



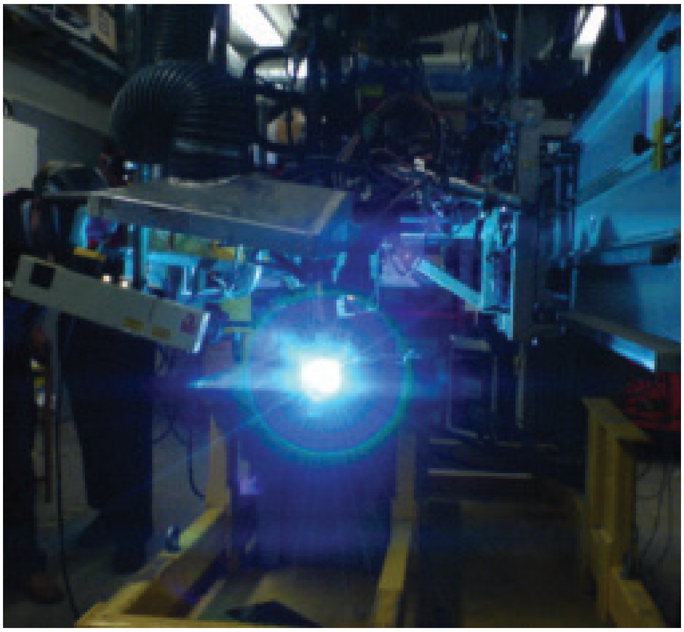
Hanging Hooks

- Perfect for temporary holding of lines, hoses, tools or loose nuts and bolts.
- Perfect for use around the job site or shop.
- It's like having an extra hand.
- Precise positioning, attaches to flat or round surfaces.
- Quickly secure and hold just about anything, anywhere.
- Available in two sizes, with working loads up to:
  - 25-lbs (30MM)
  - 40-lbs (50MM)

Boomerangles

- Adjustable magnetic angle featuring two Magswitches.
- Fast and easy on/off control.
- Versatile rotating Magswitches for virtually any angle.
- Precise positioning.
- Preset positions for 90-degree inside and out.
- Non-marring hold.
- Stays clean.
- Available in two sizes:
  - 10-inch (50MM)
  - 8-inch (30MM)

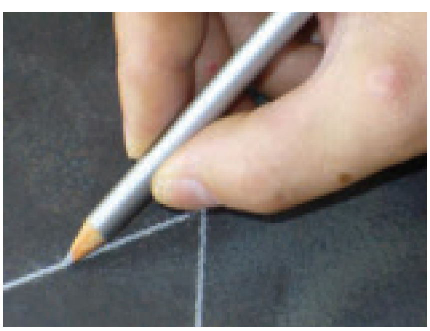
Weld Imaging System for Field and Lab Use



VisiWeld, an imaging system, looks deep into the heart of a welding process to allow engineers to 'see' through the fireball. The photo shows this system set up on an application site; the long white "shoe box" on the left is the laser, and the camera is just behind the laser. It can also record close-up images of the weld process with a field of view as small as 10 × 10 mm; capture transient effects or events that may last as little as 1 ms; and allow users to work in safety by watching a monitor screen. It is so compact that the air-cooled system can be used in the field and laboratory. First, the fireball is illuminated using a laser, and the camera is fitted with a filter that allows only laser light to pass. Second, the lasers can be configured to deliver short pulses of light, while the fireball emits light continuously. Combining these two techniques can reduce the effective brightness of the fireball by a factor of more than 10,000 so that welding processes can be imaged with clarity and without motion blur. Additionally, the systems are available for general-purpose weld viewing with good quality images at standard frame rates, or for time-resolved studies and research, a high-performance system is available.

Oxford Lasers, Inc.
www.oxfordlasers.com
(800) 222-3632

Layout Pencil Marks Visible during Welding

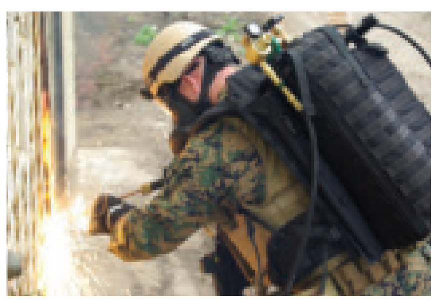


The Silver Welder's Pencil is designed for fine line layout work on all metals. Its marks will illuminate during cutting or welding. In addition, the marks will not burn or rub off. The product can be sharpened in an ordinary pencil sharpener.

J.P. Nissen Co.
www.nissenmarkers.com
(215) 886-2025

Respiration/Cutting System Designed for Smoky Jobs

The Breachers' A.R.C. — Advanced Respiration and Cutting system provides Broco's exothermic torch combined with respiratory protection for serious breach-



ing operations. It features a backpack Molle platform with cylinder support enclosures, battery bag, rod extender and cutting rod holders, pouches for mask, hoses, cable, and keeper clips. Plus, users can customize the configuration of the system to their requirements, including adaptation to a full-size torch with a self-contained breathing apparatus (SCBA) or mini-torch and SCBA among other solutions.

Broco, Inc.
www.brocoinc.com
(909) 483-3222

Hammer Features 900 Strokes per Minute

The Dake Power Hammer can stretch, shrink, dome, jog, bead, and shape sheet metal using standard dies. Capacity is up to 16-gauge steel and 11-gauge aluminum

(annealed 3003H14). Its speed is 900 strokes/min. The throat is 18 in., and the maximum vertical opening is 7 in. Also, this hammer is single phase and mounted on a base with wheels.

Dake Corp.
www.dakecorp.com
(800) 937-3253

Quenchants Offer Slow Cooling Rates

Aqua-Quench 4000 quenchants are

useful for low- and high-hardenability steel products. They provide slow cooling rates in the convection phase and flexible quenching speeds. The quenchants do not cause smoke fumes and fire hazards, and because they use diluted solutions, they produce less sludge and varnish buildup. They are available in nitrite or nitrite-free corrosion-inhibition packages that help protect pipe work, quench tanks, fixtures, fittings, and cooling systems. The products are compatible with most other water-based quenchant technologies.

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

Eyewear Incorporates Antiscratch Lenses

The 4x4™ Sport safety eyewear, which blocks 99.9% of UVA and UVB rays, is a frame/lens option in a line that also includes the 4X4™ Standard and 4X4™ Style. The strong, four-sided, wraparound frame weighs 1 oz. The polycarbonate lenses have an antiscratch coating. Additionally, a soft inset nosepiece helps ensure comfort with a snug, secure fit, and flexible temple tips relieve pressure behind the ear. The Sport model features a silver frame and brightly colored mirrored lenses in sunset red, horizon blue, iridescent green, or sterling silver.

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

Drum Carts Provide Safe Delivery of Welding Wire to Robotic Cells

The LoBoy™ drum cart offers 2.3 in. of ground clearance and a low center of gravity for towing drums or boxes of welding wire used in robotic or hard tooled welding applications. The slim, 33-in.-wide cart is designed to fit adjacent to or in the welding cell and can handle up to 1000-lb containers. Wheel systems provide low push/pull forces for manual moving within ergonomic limits. The no bend towing system features a spring-loaded, self-stowing tow bar, frame-recessed autohitch, and auto-release floor lock.

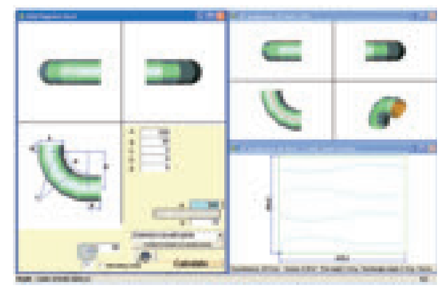
Kinetic Technologies, Inc.
www.ktecinc.com
(440) 943-4111

Welding Cloth Includes Improved Coating

The Bulldog Red™ welding blanket and welding curtain damage-control cloth features a coating that stops hazardous fluids from being absorbed into the cloth. This abrasion- and spark-resistant cloth has a service temperature of up to 1000°F, does not conduct electricity, and is resistant to chemicals and weld spatter. It is available in rolls 38 and 60 in. wide by 50 yards long.

Thermostatic Industries, Inc.
www.thermostatic.com
(800) 345-4217

3D HVAC Software Makes Sheet Metal Cutting Simple



LogiTRACE Unfolding Software makes it easy to cut sheet metal for HVAC piping and ductwork. Users are provided immediate and automatic 3D views, showing how entered data translate into unfolded parts and final products. What's more, unfolded parts are dimensioned immediately and automatically for fast user viewing. If parts are too big for the sheet size, it lets users change the number of welds. The software compensates for sheet thickness and 3D perspectives help eliminate mistakes. There are 128 module templates to draw from and to work with. Features labeled Combi-Contour and Combi-Figure enable users to create their own custom shapes and parts. Additionally, users are able to enter information for order processing. Each part, joint, and fold can be automatically saved in 3D files and 2D DXF formats.

ProMotion Controls, Inc.
www.promotioncontrols.com
(330) 721-1464

High-Nickel Bare Wires Capable of Dissimilar Welding

Arcos 651 (ERNi-CI) is a commercially pure nickel wire designed for making easily machined welds by automatic or semiautomatic methods. This electrode is intended for welding ductile, malleable, and gray cast iron using GMA, GTA, and submerged arc welding processes. It handles dissimilar welding applications that include the welding of cast irons to low-alloy and carbon steels. Arcos 861 provides good corrosion resistance, particularly in alkalis, and is utilized for welding wrought and cast forms of commercially pure nickel ASTM B160, B161, B162, and B163. This wire is suited for joining of Nickel 200 and 201 to stainless steel and joining carbon steels to copper-nickel alloys.

Arcos Industries, LLC
www.arcos.us
(800) 233-8460

Two Hole Pins Presented in Extra Large Size

Extra Large Two Hole Pins (part number 42050-TXL) with hardened double lead fast threads handle big jobs. Made of

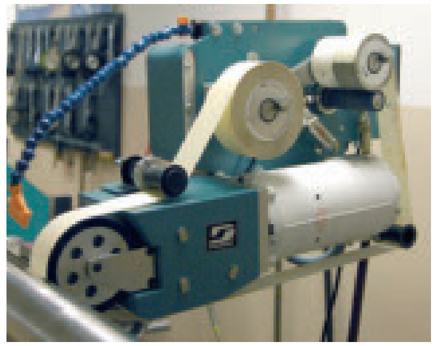
— *continued on page 24*

— continued from page 22

steel, they are designed to be light in weight for easier handling. The threaded extensions are as follows: Double Lead Stud 4½ in. long (part number 0503) and Extension Coupling (part number 0503-EX) comes with each set of pins to accommodate thicker flanges. Also, they will work with flange holes from 5/8 to 3.0 in. in diameter. The product comes in a polypropylene lockable case (part number 8902).

Flange Wizard® Tools
www.flangewizard.com
(800) 222-3789

Finisher Quickly Mounts to a Standard Machine Shop Lathe



The Superfinisher, when used with a shop lathe, ensures a uniform contact force between the workpiece and roller. Useful for wet or dry operation, the tool is ideal for work on tungsten carbide, chilled iron, stainless steel, chrome plating, brass, copper, and a host of other materials. Utilizing abrasive rolls 1–4 in. wide, it constantly advances new abrasive rolls at a speed from 1/16 to 1½ in./min. The oscillation drive features a counterbalance for smooth operation. The product also offers controls that mount on the back, front, or side. Left- or right-hand models are available for mounting in the front or back of the lathe.

Dynabrade, Inc.
www.dynabrade.com
(716) 631-0100

Welding Helmets Offer Three Autodarkening Filter Options

The Python™ welding helmets feature three autodarkening filter options for grinding, sensitivity to 5-A GTA, many delay modes, and three viewing areas — normal, large, and Xtreme™. ComfaGear™ headgear is available with various decals and painted finishes, including green, silver, red, and blue fusion styles along with fighting tiger, silver gray, uptown, and spirit versions.

ArcOne®
www.arc1weldsafe.com/ArcOne%20Home%20Page.html
(800) 223-4685

A Novel Method for Preparing Welding Wire Surfaces

A process is described for cleaning welding wire that can also be used to accurately apply lubricants and other coatings

BY G. BOOCKMANN, K. BOOCKMANN, R. FICHTNER, AND R. SLOVER

Welding, among other wire applications, is developing more stringent requirements for surface preparation. Wire surface properties, such as feedability, slippage on the drive rolls, and electrical conductivity require that contaminants such as flakes, oxides, and liquid or dry drawing lubricants be removed. The technology described can accomplish such stringent cleaning.

Liquid or solid postlubrication, along with the application of enhancement materials, anticorrosive agents, or arc stabilizers, can also be affected with the technology.

Even in this limited field of application, a large variety of surface treatment methods is known. Among these, especially with those using stationary textiles or felts, a lack of process security has been demonstrated. Many methods employing liquids have shown high investment or operating costs, are inefficient, and/or are harmful to the environment.

This article describes a unique method of wire surface preparation by means of wrapping or looping, under high tension, constantly renewed and moving cords that are in 360-deg contact with the wire.

The application principle is the development of a friction force between a relatively fast running wire and a slow moving textile cord. The friction force is a function of cord pretension, the number of loops around the wire, the angle between the wire and the cord, the length of the contact zone, the properties of the cord, and the roughness of the wire surface.

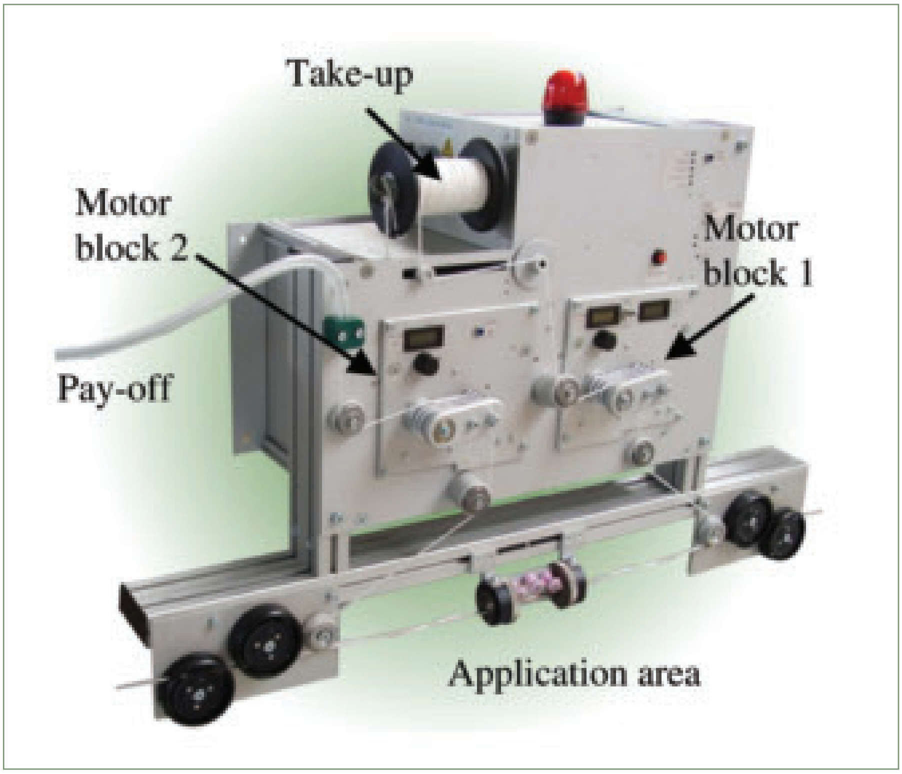


Fig. 1 — The Helicord NB55 unit.

Technology Evolution

Prior to this, for about five decades, attempts to implement similar technologies failed because one could not prevent blocking, and then breaking, of the cord. As examples, we refer to attempts to wipe off excess materials during the coating of wires with liquid zinc (Ref. 1), tin (Ref. 2), or oil (Ref. 3), and/or the application

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of indicating inks (Ref. 4), as well as cleaning (Ref. 5).

However, during the 1990s, it was shown with a simpler machine that magnet wire could be covered, accurately and reliably, with lubricants by using wax-impregnated yarns (Refs. 6–8). This technology, called Helilub, overcame the blocking/breaking problem by mechanically controlling the pre-tension and regulating the speed of the yarn. Because it was used for lubrication of relatively fine magnet wires, this type of equipment was small in scale.

Helicord technology evolved from Helilub through the addition of a motor block for the regulation of the pre-tension of the cord and the development of more powerful, robust equipment and much stronger braided, round and flat, textile cords — Figs. 1, 2. These cords are composed of different materials (e.g., polyamide, cellulose, or aramid) depending on the surface preparation required.

Introduction to Helicord

This technology has the following operating parameters:

- Adjustable cord speed of 4–120 cm/min
- Controlled cord tension with 2–30 N
- Range of friction force from 6 to 100 N.

In both cleaning and coating, the highest friction occurs where the wire enters the contact zone.

Cleaning

The operating conditions for wire cleaning are as follows:

- Wire and wrapped cord run in opposite directions
- Pre-tension regulated cord release from the supply spool
- Collection of the cord under controlled speed.

Thus, where the cleaned wire leaves the application zone, it only comes in contact with fresh, unused cord.

Cleaning is performed by wiping with dry absorptive cord (Fig. 2), or by abrading with grinding or polishing powders absorbed in, or bonded to, appropriate cords.

If required, either can be supported by a pump, which can meter liquid media, with as low as possible surface tension compared to the wire material according to Ref. 9, onto the cord — Fig. 3.

Application of Coatings

For the application of coatings, the operating conditions are as follows:

- Wire and wrapped cord run in the same direction

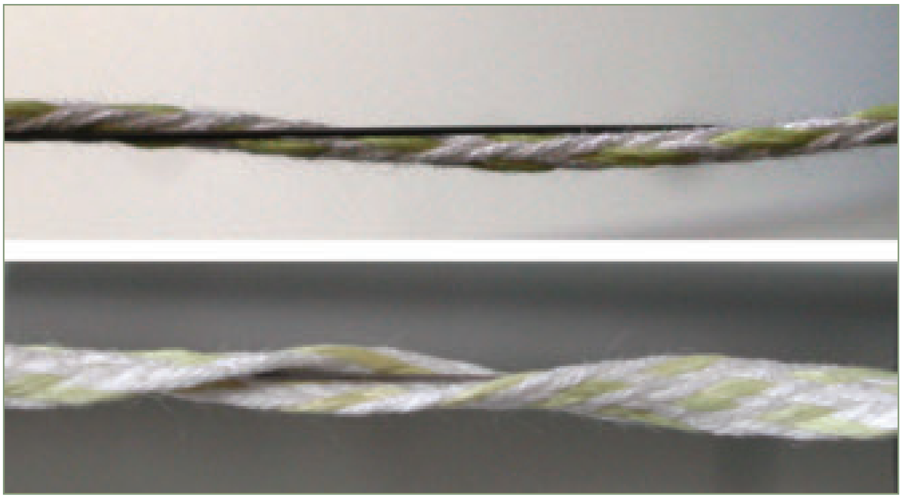

Fig. 2 — Braided round cord (upper) and flat, shoelace-like cord (lower) wrapped around a 1.2-mm-diameter wire.

Fig. 3 — Liquid metering pump NB40B886. It is designed to meter between 0.1 and 20 mL/min of neutral aqueous or specified organic liquids with a viscosity of up to 5000 mPa·s. Liquids can be oily lubricants and sliding agents, metalworking fluids, liquid coatings, cleaning liquids, or nonshear stress-sensitive dispersions.

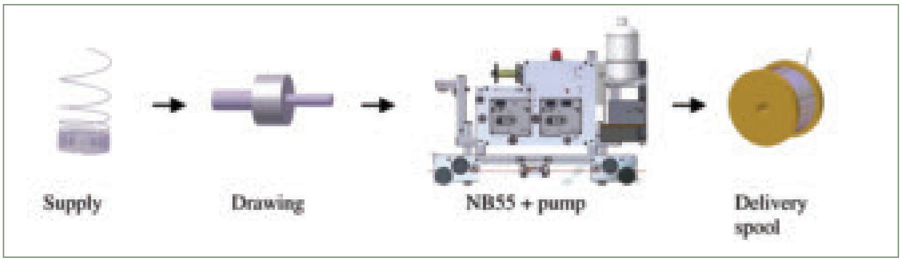

Fig. 4 — The unit with a liquid metering pump dispensing solvent; braided polyamide-polyethylene cord.

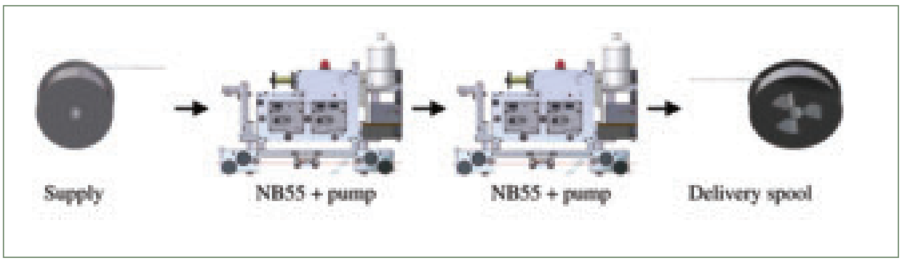

Fig. 5 — Two-step cleaning, with dual units, each with metering pumps dispensing water-based cleaning liquid; abrasive cleaning using braided cord with resin-bonded Al_2O_3 particles of grid mesh 150 µm (left); final cleaning using cotton-aramid cord.

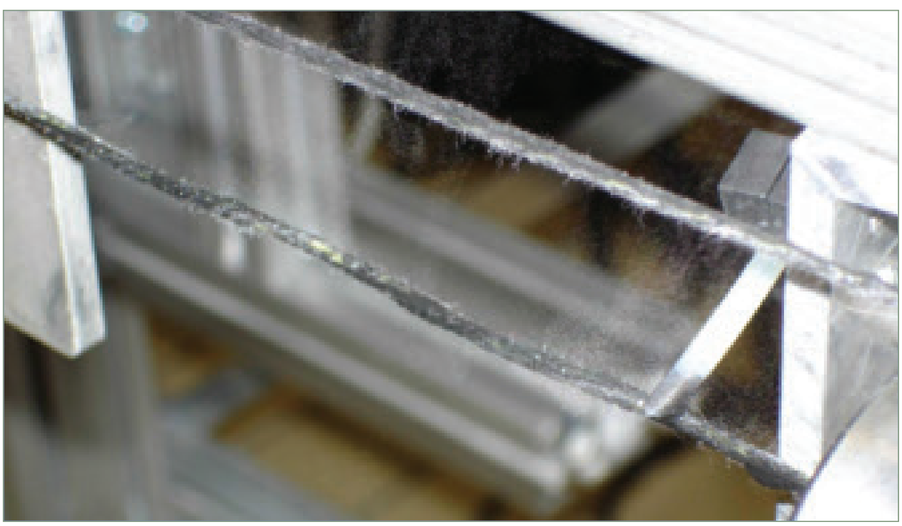

Fig. 6 — Abrasive preparation of a wire surface showing dust clouds of solid drawing lubricants being removed.

- Speed-regulated cord release from the supply spool
- Collection of the cord under controlled tension.

The result is a high extraction of the coating material at the first cord-wire contact and its even distribution where the wire leaves the contact zone.

Wax-like coatings are metered and distributed uniformly on the wire surface by using impregnated cords, supported, if necessary, by a heating device. Liquids or particle-containing dispersions (e.g., graphite or MoS_2 dispersions) are metered by the pump — Fig. 3. Additions of anticorrosives, arc stabilizers, etc., into the wax-like components or liquids to be applied are possible.

The pump is designed to meter between 0.1 and 20 mL/min of neutral aqueous or specified organic liquids with a viscosity of up to 5000 mPa·s. Liquids can be oily lubricants and sliding agents, metalworking fluids, liquid coatings, cleaning liquids, or nonshear stress-sensitive dispersions.

Results and Discussion

Cleaning

In-Line Cleaning of Al Welding Wire from Drawing Oil

Figure 4 shows the setup using one Helicord NB55 unit with a liquid metering pump dispensing a high-boiling solvent. The wire diameter is 1.6 mm and run speed is 180 m/min.

As a result, the oil content on the wire was reduced from 20 to 50 mg/m^2 down to less than 1.3 mg/m^2.

Removing Drawing Lubricants from Solid Steel Welding Wire

The setup for this application is shown in Fig. 5. Two Helicord NB55 units are used, in succession, each with a liquid metering pump. The solid steel welding wire is 1.2 mm in diameter and run speed is 10 m/s.

As a result, calcium-stearates on the wire surface were removed and reduced from about 100 mg/m^2 down to less than 30 mg/m^2 — Fig. 6.

Coating

Paraffin Coating of a Flux Cored Mild Steel Welding Wire

The setup shown in Fig. 7 is one NB56 unit with a heated pulley. Wire diameter is 1.2 mm, speed is 10 m/s, and its temperature below the melting range of the paraffin.

About 80 mg/m^2 of paraffin was applied, resulting in good feedability and increased corrosion resistance.

Due to the latest experiences, the use of the more robust NB55, especially in cases where a reverse movement of the wire cannot be excluded, is preferred. Also, a circulating air heating instead of the heated pulley has proven to be by far more effective for the application of paraffin or wax on cold wires.

Compared to other methods of wax and oil application, e.g., by felts, vapor, or from solutions, the Helicord application has the following advantages:

- Consistency and reliability
- Calculated dosage
- Precision of application and uniformity of distribution
- Possibility for addition of anticorrosive agents, primers, antiadhesives, and flux aids

• Wide range of applicable wire speeds (up to 40 m/s).

The application can be integrated either into the production line or placed directly before the winder for delivery spools — Fig. 8.

Verification of Wire Surfaces

For the repeatable and accurate verification of the results of each wire surface treatment, it is necessary to

• Know the initial state of the wire and to define the desired properties after treatment

• Know which components should be present and in which amounts

• Determine, after treatment, the amount of residues or applied components by suitable analytical methods and/or the surface properties with appropriate testing methods

• Verify the success by operational tests.

Of the different possible verification methods, no standard methods have yet been defined. Candidates include visual methods (e.g., the judgment of color or gloss of a surface, light or electron beam microscopy, judgment of a wiping trace), mechanical methods (e.g., coefficient of friction), gravimetric methods, chromatographic methods (e.g., gas chromatography), or spectroscopic methods (e.g., infrared spectroscopy, mass spectroscopy, or energy-dispersive spectroscopy).

Some methods (e.g., the very commonly used visual judgment of a wiping trace) can lead to false results.

Other methods (as determination of the coefficient of friction or gravimetric methods) turned out to be applicable only under well-defined conditions. Often they are limited to one or just a few classes of materials on the wire surface.

Infrared spectroscopy, for example, was only a short time ago limited on the qualitative and quantitative analysis of only those organic compounds used in wire production, which were soluble in CCl_4. Meanwhile, Ca-stearates with their poor solubility can also be analyzed after transforming the stearates into their related acids by additional chemical pretreatment.

Pyrolytic methods, on the other hand, provide a fast quantitative determination of organic surface contaminants, even of those components that are not soluble. Therefore, these methods are used by some welding wire suppliers in development and production quality control. However, due to potential variations in sample heating, it is obvious to compare the results with a reference sample of known contamination in order to achieve reliable results.

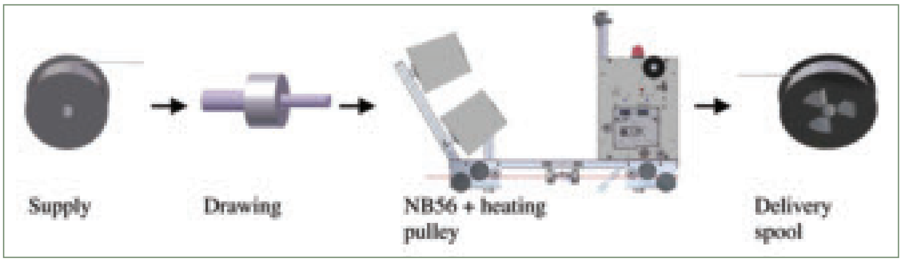

Fig. 7 — An NB56 unit with heating pulley; cord impregnated with low-melting paraffin with sulfonate-based corrosion inhibitor.

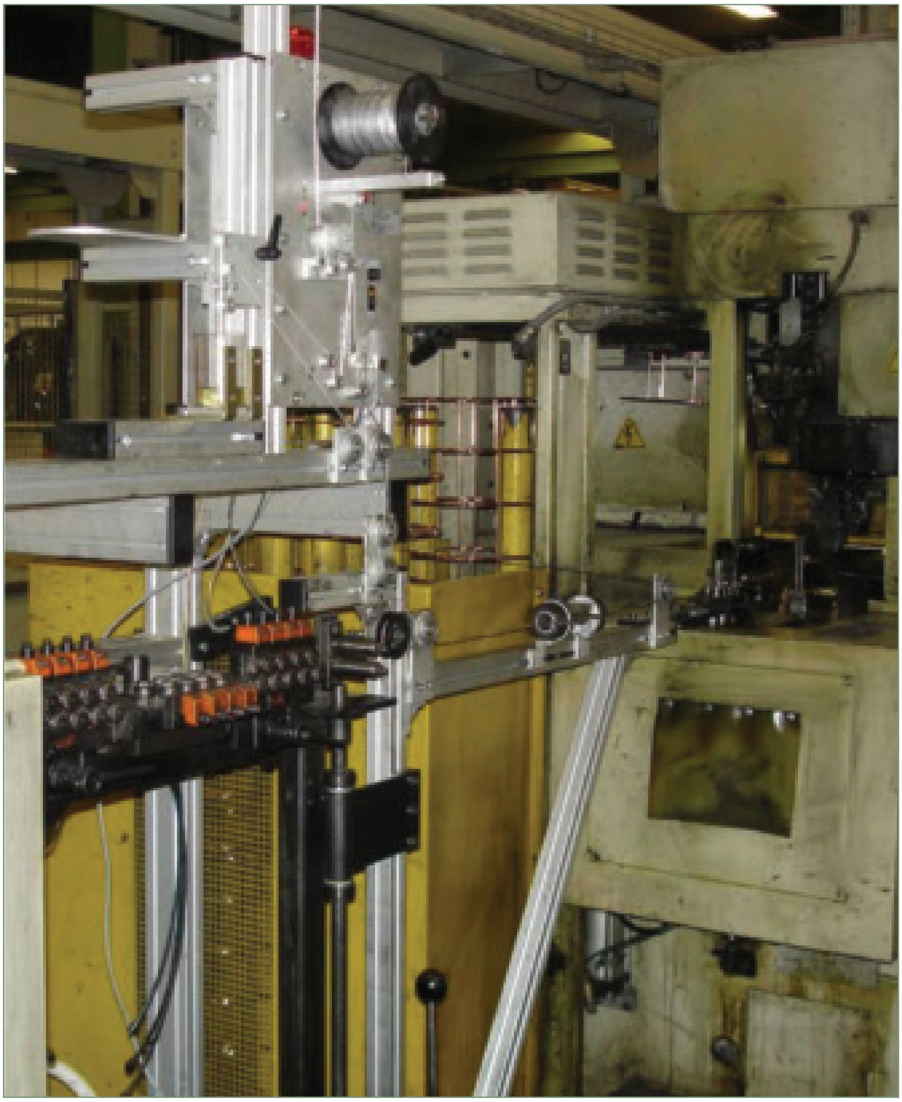

Fig. 8 — Coating with lubricants by means of a swiveling unit before the spooler.

Two methods have been found that are relatively simple and fast: The first is the measurement of the coefficient of friction, which gives an indication on the success of lubricant applications. The second is infrared spectroscopy, as mentioned before and described in more detail below.

Measurement of the Coefficient of Friction

In order to have a first indication of the influence of materials on the feedability of welding wire, the comparative measurement of the coefficient of friction, before and after treatment, has been found to be informative. A simple but effective measurement device has been built up. A description can be found in Ref. 10.

Infrared Spectroscopy

Infrared spectroscopy is a suitable means to analyze qualitatively and quantitatively many organic compounds used in wire production either as coatings or residues. Measuring by reflection directly from the wire surface, one can qualitatively identify materials very quickly.

For quantitative analysis, it is necessary to dissolve the materials from the wire in an appropriate solvent and to compare specific peaks of measured spectra with a calibration curve (Refs. 11, 12).

Conclusions and Prospects

Helicord technology has proven to be a suitable and cost-effective means for both cleaning and coating of all types of welding wires.

The technology is under constant development, especially with respect to enhancement materials. For example, using Helicord it is possible to apply and polish polytetrafluoroethylene (PTFE) onto wire, avoiding the usual breakup of dispersions under shear. On aluminum wire, this has resulted in a reduction of the coefficient of friction from 0.30 to 0.11, and similar results have been noted for other substrates. As an additional benefit on aluminum welding wire, the fluoro-containing compounds act as an arc stabilizer.◆

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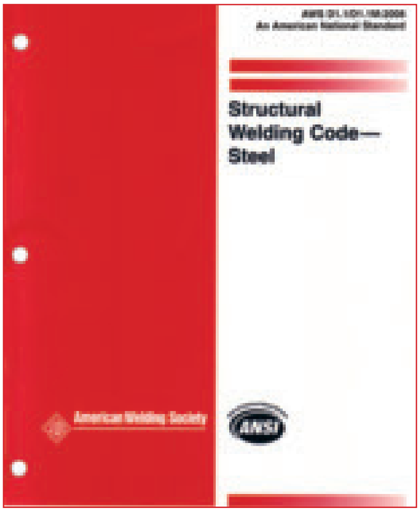
A Preview of the 2008 Changes: D1.1, *Structural Welding Code — Steel*



Tips are presented on what's new in the 2008 D1 code, plus a look behind the scenes at why some of the changes were made

BY JOHN L. GAYLER

Another two years have gone by and its time to readjust your D1.1 acumen. A new edition of D1.1 will be published soon. If you are a true "code pro" then you already know the first place to look when you get a new D1.1 edition is the foreword. The foreword gives a brief list of the changes from the previous edition. The list does not, however, give any explanations nor expound on the reasons for the changes. This article lists the changes found in the 2008 D1.1 and also provides reasons for some of these changes. It is hoped the article will assist code users in coming up to speed on the 2008 code more quickly; however, it provides no code text and it does not specifically state the exact changes made for each revision. Use this article as a check-off list in tandem with the new code in order to get the full picture.

The 2008 publication is the 21st edition of the D1.1, *Structural Welding Code — Steel,* but let us start with a quick history lesson. The earliest AWS standard on this general subject dates all the way back to a 1928 publication titled, *Code for Fusion Welding and Gas Cutting in Building Construction.* The first comprehensive code for welding steel structures was published in 1941 as the D1.0, *Code for Welding in Building Construction.* D1.1 was first published in 1972 and was revised several times in the 1970s. Between 1979 and 1986 the code was published annually. The D1.1 code has been published every other year since 1986.

Why the history lesson? It is to establish that the D1.1 code has been around the block a few times. By now we can call the D1.1 code a mature standard. D1.1 has reached a level of stability in its content and form. Therefore, there are no changes to the base concepts in the code but there are some improvements permitting economy, improving clarity, and enhancing reliability. The code committee reacts to feedback from users on its current code provisions and adjusts the code provisions accordingly.

2008 Revisions of Particular Interest

Design

In the transition of butt joints of unequal thickness, the 2006 code required a chamfering of the butting members to a 2.5 to 1 slope for some static tension load situations. There were instances reported in which users were trying to enforce this clause where, from an engineering perspective, it was an overly conservative approach. In the 2008 edition, this requirement has been removed — see 2.7.1. It was agreed that the joint geometry by itself would not require chamfering of thickness transitions in statically loaded structures; however, in high-stress or severe service locations, a contouring fillet weld should be considered in order to reduce notch effects. The code still establishes transition requirements for cyclic or fatigue applications; this did not change from the 2006 code.

There was some concern that the equation permitting an increase in the basic allowable stress on a fillet weld has been applied to weld groups without accounting for deformation compatibility. Calculation of the capacity of a weld group by summing the capacities of weld elements based on the increased allowable stress would not be a conservative approach. The code committee addressed this concern by adding a provision, 2.5.4.4, on determining the allowable shear stress on concentrically loaded weld groups, and also by clarifying that the equation in 2.5.4.2 is only meant for a single linear fillet weld or fillet weld groups consisting of parallel linear fillet welds all loaded at the same angle and loaded in plane through the centroid of the weld group. The instantaneous center method accounts for deformation compatibility and is still the method of choice for noncolinear weld groups. The weld group load-carrying capacity can still also be conservatively estimated by summing the capacity of the weld elements using the basic allowable stress.

The code contains a provision for cal-

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culating the resistance provided by connections sharing the resistance between welds, bolts, and rivets in 2.6.7. Research conducted by the University of Alberta indicated that some combinations of welds and bolts may not have been designed conservatively using the former provisions. The new provision requires designers to consider the strain compatibility between the fasteners and the welds in the same connection. New commentary cites research that gives some methods for considering that compatibility and better explains the rationale for this change.

Prequalification and Qualification

In previous editions of the code, shielding gases were not mentioned in the prequalified section of D1.1. This led to many questions and some confusion as to whether or not there were any controls or limitations on shielding gases in prequalified procedures. The code committee attempts to address these questions by adding a new prequalified provision on shielding gases, 3.7.4. The first requirement is that all shielding gases used for GMAW and FCAW-G comply with AWS A5.32/A5.32M, *Specification for Welding Shielding Gases.* The second requirement is that gases must meet one of the two following requirements:

1) The shielding gas used must match that used for the electrode classification test as listed in the applicable AWS A5 filler metal specification, or

2) The shielding gas used must be recommended by the filler metal manufacturer for that specific product.

If a contractor chooses to follow No. 2, then there is a requirement to provide documented evidence showing that the filler metal and gas combination can produce sound results.

The current provision, 3.10.1, indicates that the depth of fill for a plug or slot weld may need to be more than the thickness of the thinner member being joined. This was not the intent of the code. This provision has been moved to Section 2, Design, where it is clearly stated that the minimum depth of filling need not be greater than the thinner part being joined.

In order to reduce confusion among code users, essential variable No. 10 in Table 4.6, which concerns changing the number of electrodes in CVN testing applications, was deleted. This variable is already covered in Table 4.5, PQR Essential Variables, and is redundant in Table 4.6. GTAW has been added as an applicable welding process for this essential variable.

Fabrication

In D1.1:2006, Clause 5.18 addresses temporary and tack welds. The code committee determined that the existing language could be restated to better convey its true intent. The most obvious change is the elimination of the term "temporary weld" and the inclusion of a new term "construction aid weld." The division of this subclause's requirements into "tack welds" and "construction aid welds" appears to better relay original intent. There are some additional subtle changes to these requirements so code users should read through this entire revised section carefully in order to correctly apply the requirements.

Inspection

D1.1 has changed the required visual acuity test from the Snellen English test to a Jaeger J-2 test at a distance of 12–17 in. This change syncs D1.1's requirement with that of AWS QC-1, *Standard for AWS Certification of Welding Inspectors.*

The code committee determined that, with the increased reliability of ultrasonic testing (UT) equipment, in particular digital flaw detectors, the current UT calibration frequencies were unnecessarily conservative. The required minimum frequency for horizontal linearity was changed to two-month intervals from the current 40 hours of instrument use in each of the distance ranges that the instrument will be used — see 6.24.1. In addition to this change, the recalibration frequency requirement in 6.25.3 was changed from every 30 minutes to every 2 hours.

The setting of the zero reference level in 6.25.5.2 did not state the required or recommended maximized horizontal trace deflection screen height. After a sampling of industry experts, the code committee agreed that anything between 40 and 60% would be an adequate target range for the maximized horizontal trace deflection screen height. The zero reference level sensitivity used for discontinuity evaluation ("b" on the ultrasonic test report) shall be attained by adjusting the calibrated gain control of the discontinuity detector so that a maximized horizontal trace deflection results on the display. A fixed reference level makes for more consistent testing methodology across the industry.

Stud Welding

The requirement for a quality control test of studs not more than six months prior to delivery of the studs to a customer was deleted from the code — see 7.3.3(2). It is not uncommon for studs to sit in an inventory longer than six months in addition to being shipped to construction sites months before the products are installed. The shelf life of structural bolts is unlimited as long as the structural bolt is sealed in its original container marked with a heat number. There is no significant change in mechanical properties due to any aging phenomena associated with low-carbon steel.

Clarifications on Current Provisions

Clarifications to the code are revisions that do not change the current requirements of the code. Clarifications only restate the current requirements in a manner intended to be better understood by the code user. I provide only a list below because the reason or rationale for each change is the same — to clarify the current code's intention.

- Clause C-1.2 in the commentary was substituted for the code requirement in Clause 1.2.
- Prequalified joint detail B-U7-S now has as-detailed and as-fitup tolerances for groove angle and root opening.
- When performing a fillet weld qualification using Fig. 4.19, Subclause 4.11.2 now clarifies that testing may be for either a single-pass fillet weld, or multipass fillet weld, or both.
- Subclause 4.32.1 on ESW/EGW was reformatted.
- References to shielding gases were deleted in 5.3 and its subclauses since it is already covered in Section 4 (Qualification) and is covered in the 2008 code in Section 3 (Prequalification).
- Small but significant clarification to Subclause 5.22.1 changing "fillet weld leg" to "fillet weld legs."
- Subclause 7.8.5 regarding corrective actions on nonconforming stud material was reworded.
- It was clarified in Annex G that stud bases shall comply not only with ASTM A 108 but also with the mechanical properties in Table 7.1.
- Commentary was added to clarify the meaning of Table 3.7 maximum fill pass and root pass thickness limitations — see C-Table 3.7.
- Extensive commentary was added regarding the code's definition of low hydrogen; anyone confused by the term should make a point to read the new commentary — see C-5.3.2.1.
- Commentary was added to explain why tubular and static radiographic testing (RT) criteria are the same — see C-6.11.1.

There was an extensive effort to reorganize the portion of Section 6 that dealt with RT flaw sizes and Annex C. The illustrations, including Annex C, were all relocated to the Commentary with the text tables defining the flaw sizes remaining in the body of the code. During the editorial process it became evident that there was a lot of redundancy in the stated requirements, which resulted in the merger of several paragraphs. There were no technical changes made to the acceptance criteria, but several new sketches were added to further illustrate those acceptance criteria.

Rationale, Commentary, and Interpretations

Most of the rationale and reasoning stated above are based on the written material submitted with each proposed revision, or it comes from minutes of the meetings where these revisions were approved. I also received some input and comments from select committee members. Although the Structural Welding Committee is not required to publish rationale supporting each and every code provision, it has provided a significant commentary section that quite often does provide either clarification of intent or some degree of rationale for many of its code provisions. When clarification of code intent is needed or rationale sought, the commentary, published in the back of the code, should be the first source consulted. The second source to consult is past official interpretations by the code committee. These are posted on the AWS Web site at *www.aws.org/technical/interps.* There will also be a new D1.1-BI, *Book of Interpretations,* published in 2008.

If an issue of code interpretation is not resolved through a review of the code text, the code commentary, or past official interpretations, it is generally agreed that the most efficient manner of resolving the issue is for the interested parties to come to a mutual agreement. If this is not a possibility, then a request for official interpretation from the code committee can be sought — see Annex O in the code. However, each official interpretation must go through a formal approval process that often takes several months or longer. This delay in receiving an answer is often not helpful in resolving issues with time pressures. In these situations, an experienced, knowledgeable, and impartial arbitrator may be the best option.

In most situations, the code's requirements are clearly stated in the code text. However, the code does not address every conceivable issue that may arise. When the code does not address a particular situation, it is appropriate to say that the code is silent on this issue. If the code user is left to make a decision when the code does not provide parameters or guidance, the code user should use good professional or engineering judgment or best industry practice. It is recommended that code users do not read more into the code than what is clearly stated or addressed.

Wrap up

Several of these 2008 revisions were originally proposed as long ago as 2002; most were submitted in 2004 and 2005. The path that a proposed revision must go through before being included in the D1.1 code is a virtual gauntlet of procedural barriers and obstacles. At each of these obstacles the revisions are intellectually poked and prodded by a broad spectrum of experts whose collective experience spans various industry fields and professions. In total, approximately 100 individuals are involved in the approval of new D1.1 code provisions.

The individuals involved in the revision, review, and approval of D1.1 and other AWS standards are all volunteers. Their time, travel, and effort are either financially supported by their employers or from their own pockets. There is no compensation from AWS for their participation. The volunteers are the life blood of the AWS technical standards program. Without their involvement there is no program, no AWS standards, and no D1.1 code. If you would like to become involved with the code-writing process and join the company of volunteers working on AWS standards, you can find more information online at *www.aws.org/1HPH.* If you would like more information on the D1 Committee specifically, you can find information at *www.aws.org/technical/d1/.*◆

Cladding in Marine Applications Using Direct-Diode Lasers

BY VALDEMAR MALIN AND
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Case study describes the development of a procedure for robotic high-power direct-diode laser cladding of aluminum bronze onto steel-bearing plates

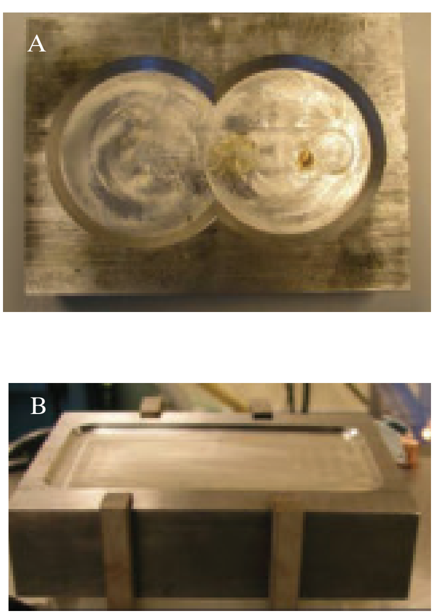

Fig. 1 — Design of steel blank bearing plates. A — Original; B — modified.

Shipboard pumps in naval vessels have bearing plates supporting two shafts that engage rotating gears. To reduce wear of the bearing plate, the surface mating with the gear is made of a copper antifriction alloy. To create a bronze layer on the mating surface, a blank bearing plate (Fig. 1A) is manufactured and machined after brazing. Two shallow (0.280-in.-deep) intersecting 3.75-in.-diameter recesses (pockets) are machined on the surface of the blank forming a figure-eight configuration.

The current brazing process is carried out in a simple heating fixture. The operator heats the blank with rosebud torches until the part becomes red hot. Small chunks of copper alloy are laid into the pockets of the heated blank and covered with special flux. The copper alloy melts and fills the pocket. Then, the part is allowed to cool slowly to room temperature, which may take from 30 to 50 min. It can take from 1 to 1¼ h to complete the entire brazing procedure. Finally, the blank is machined into a bearing plate.

Problems with Brazing

The original brazing process created a number of problems that were of serious concern to the manufacturer, including the following:

1) Extensive porosity in the weld deposit. To cope with porosity, the pockets in the blank are made 0.280 in. deep, much deeper than the required 0.093-in. thickness of the bronze deposit after final machining.

2) Unpredictable quality of the weld deposit. Poor control over the heat source and, thus, part temperature, along with the welder's subjectivity in determining when to end brazing is the main cause for variability in quality.

3) Safety issues. High temperature, noise, and emission of harmful gases jeopardize safety of the welder and pollute the environment.

4) Low productivity (parts/h) and high cost because process is labor intensive.

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Alion Science and Technology's Manufacturing Technology Center received two R&D 100 awards in 2004 and 2005 for developing the cladding system.

Solution

Proposed Approach

To solve the problems associated with the conventional brazing process, Alion Science & Technology's Manufacturing Technology Center (MTC) proposed a feasible alternative to the manufacturer: namely, replace manual brazing with automatic laser cladding. The proposed approach was formulated as follows:

1) Modify the design of the bearing plate blank to make it suitable for automation.

2) Develop a special water-cooled fixture that allows continuous cladding to be carried out without interruption at a high deposition rate and without overheating of the blank and the weld deposit.

3) Replace the existing filler metal (cast slugs made of tin bronze Alloy C905) with filler metal that provides similar or better performance characteristics and allows better control over the composition of the deposit.

4) Build a production setup based on the automated laser cell (ALC) developed at MTC.

5) Develop an efficient and productive one-layer HPDD laser cladding procedure that allows repeatable high-quality weld deposits to be produced with drastically reduced thickness of the deposit (not exceeding 0.125 in.).

6) Confirm high weld quality by conducting a metallurgical study of the deposited metal.

The proposed approach and the results of its implementation are described below.

Modification of Bearing Plate Blank

One of the important rules of automation has always been to modify the object of automation (the part to be welded) to make it suitable for automatic welding (Ref. 1). The original blank of the bearing plate was designed for manual out-of-furnace brazing and was not suitable for automatic laser cladding using the ALC due to several reasons.

- The pocket configuration was not suitable for uninterrupted HPDD laser cladding using the ALC.
- Excessive allowances for machining were made to make up for imperfections in the brazing process.
- The blank did not have any design details that would allow it to be accurately positioned and located in a fixture.

Therefore, the blank design was modified to address those problems, but the original design of the bearing plate was left intact. The new blank design is shown in Fig. 1B. The main changes in the original design were the following:

- The shape of the pockets was changed. As shown in Fig. 1A, the original pockets were shaped as two intersecting circular recesses. The total length of both pockets was 7.06 in. The shape of the pockets follows that of two engaged gears in contact with the bronze deposit. In contrast to manual deposition, such configuration does not lend itself easily to uninterrupted one-layer automatic cladding. Therefore, the two circular pockets were replaced with a rectangular pocket that allows cladding to be run continuously. Also, the start and the end of the cladding cycle (where dilution and iron pickup from the base metal is the highest) are located now in the corners of the rectangle (away from the circular gear-contact area) to be machined after cladding.
- The size of the pocket was increased. The original two 4.06-in.-diameter intersecting pockets in the blank created a pocket 7.06 in. long. The rectangular pocket size was 4.06×7.06 in. In comparison with the original pocket square area (25.9 in.^{2}), the new pocket was larger by 7.5% (28.0 vs. 25.9 in.^{2}). After final machining, the new pocket was ¼-in. larger than the 3.75-in.-diameter gear contact area.
- The thickness of the pocket was significantly reduced. In the current design, the pockets were specified 0.280 in. deep, leaving a relatively large 0.186-in. allowance for final machining that includes not only the bronze deposit, but the steel body of the blank as well. The extra allowance was required to ensure that a porous top layer of the deposit could be removed, while preserving the specified final thickness of the deposit. The proposed new pocket thickness was 0.125 in., leaving only a 0.031-in. allowance. Such close tolerance was realistic due to specific characteristics of the HPDD laser and strict automatic control over the laser cladding process that allows for low dilution, and porosity-free welds of a specified thickness to be deposited in the first layer. As a result, consumption of the expensive bronze was cut in half (2.16 vs. 1.05 lb).
- Two blind holes specified in the original design of the bearing plate on the side opposite to the pockets were opportunistically transferred into the blank with a small allowance for final machining. These holes were used to allow the blank to be seated on a special cooling fixture and used as water-cooled chambers.

Fig. 2 — Automated laser cell (ALC) for cladding and hardfacing.

Cooling Fixture

One of the most important requirements for automatic cladding was the introduction of a continuous, uninterrupted one-layer cladding procedure. However, there was concern regarding overheating of the blank and the deposited copper alloy due to their limited size and prolonged heating by the laser beam. To dissipate the energy accumulated during cladding, a special cooling fixture was designed. This multipurpose fixture is capable of the following:

- allows the blank to be accurately positioned relative to the laser head,
- provides direct water cooling of the blank through two 2-in.-diameter blind holes (chambers) at the bottom in the middle of the blank to prevent overheating of the blank and the deposit,
- enables use of max laser power and wire feed speed to increase deposition rate,
- eliminates lengthy postweld cooling procedure,
- reduces dilution of the weld with steel substrate,

Table 1 — Chemical Composition of Cast Alloy C905

Alloy	Cu	Zn	Sn	Mn	Fe	Si	Ni	P	Al	Pb	Total others
C90	Bal.	2.0–3.0	10.0–11.0	—	0.2	—	1.0	0.05	—	0.3	—

NOTE: For continuous casting, phosphorus is added up to 1.5%.

Table 2 — Composition Requirements of ER CuAl-A2 Filler Metal

Source	Cu	Zn	Sn	Mn	Fe	Si	Ni	P	Al	Pb	Total Others
AWS 5.7 Specification	Bal.	0.02	—	—	1.5	0.1	—	—	8.5–11.0	0.02	0.5

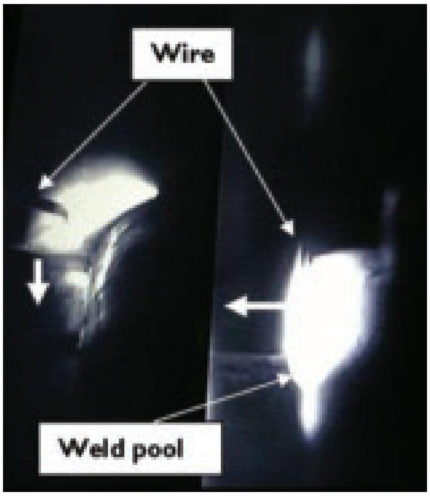


Fig. 3 — A split screen of the monitor displaying the images of the wire and weld pool from two perpendicular views. Thick arrow points in direction of cladding.

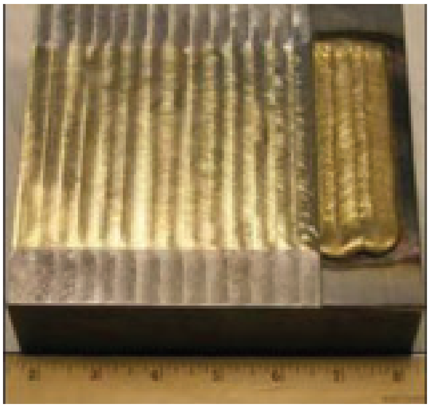


Fig. 4 — Block of the bearing plate after laser cladding with ER CuAl-A2 filler metal. Note: left side is machined off.

• improves microstructure and properties of the deposit, and

• reduces distortion of the blank.

Selection of Filler Metal for Cladding

Alloys C954 and C905 are the filler metals used for brazing by the manufacturer. The filler material most often used for brazing of bearing plates is Alloy C905, formerly known as tin bronze or gun metal 88-10-0-2. The alloy is typically used for casting in many applications such as bearings and bushings, pump impellers, valve components, gears, and others. It is not designed as a filler metal for brazing or welding. The analysis of chemical composition of Alloy C905 that is given in Table 1 shows that it contains a number of elements and in the amounts that may impair weldability. Due to a very high content of tin (Sn), the weld metal has a very wide interval of solidification (liquidus-solidus temperature range) resulting in high susceptibility to solidification cracking. Zinc (Zn) is a volatile element in the weld and may cause porosity. Lead (Pb) is not soluble in copper and remains liquid after weld solidification has been completed, which may cause solidification cracks as well.

Requirements for and Selection of Filler Metal for Laser Cladding

Cladding/welding process may produce detrimental metallurgical reactions in the weld pool. It requires filler metals of special formulation to offset these metallurgical reactions detrimental to weld integrity and properties. Taking into consideration the drawbacks of Alloy C905 composition and the fact that welding wire of proper composition is not readily available, it was evident that a new filler material was needed that is more suitable for cladding, in general, and laser cladding, in particular, and as suitable for the bearing plate application as the original alloy C905. In other words, the material should be corrosion resistant in saltwater vapor as encountered in a marine environment, have good antifriction properties in pair with steel; shows no significant loss of mechanical properties on exposure to high temperatures (as those encountered in welding); and is available in a welding wire form. After evaluation of several candidate filler metals and consultations with the manufacturer, aluminum bronze filler metal ER CuAl-A2 per American Welding Society A5.7 specification was selected. The composition requirements for ER CuAl-A2 filler metal are given in Table 2 (Ref. 2).

ER CuAl-A2 filler metal is an intermediate-strength aluminum bronze, an alloy used for welding aluminum bronze, cladding on cast iron and carbon steel in applications that include worn surface rebuilding, casting repair, and general maintenance. It contains up to 11% aluminum and up to 1.5% iron and is readily available in welding wire and powder forms. Compared with other copper alloys, the higher strength of the aluminum bronzes is combined with excellent corrosion resistance and antifriction properties under a wide range of service conditions. Aluminum bronzes are the most tarnish-resistant copper alloys and show no serious deterioration in appearance and no significant loss of mechanical properties on exposure to most atmospheric conditions, including acids and salt-laden water vapor. It also shows low rates of oxidation at room and high temperatures. The excellent antifriction properties of this alloy are well documented in literature and in cladding practice. These properties make this alloy desirable in marine applications and suitable for welding.

The composition of the selected aluminum bronze filler material ER CuAl-A2 is formulated so that possible metallurgical reactions in a weld pool are suppressed or offset and weld properties are enhanced. For example, aluminum (Al) content (8.5–11%) is sufficient to offset possible losses during welding due to dilution and evaporation. It also allows level of Al above 7% to be maintained to preserve two-phase microstructure. A small amount of silicon (Si) is added to deoxidize the weld metal. Iron (Fe) is present in the amount of 1.5% max to facilitate fine and even grain macrostructure. Lead and zinc are in negligible amounts.

Since aluminum bronze was deposited on mild steel, the main requirements for weld deposit in this study were to prevent excessive iron pickup from the base metal and to avoid excessive loss of aluminum. Excessive iron in the deposit manifests itself in elevated hardness on the surface of the deposit and may wear out a steel counterpart prematurely.

Production Setup

Recently, Alion developed an automated laser cell (ALC) for cladding and hardfacing (Fig. 2). The system is based on the latest advances in robotic, HPDD laser, and sensory technologies. The robot arm carries the laser head surrounded by numerous sensory devices of the laser support system, communication cables, and hoses. The system includes CCD cameras to provide the images of the weld pool zone on a monitor, the wire positioning

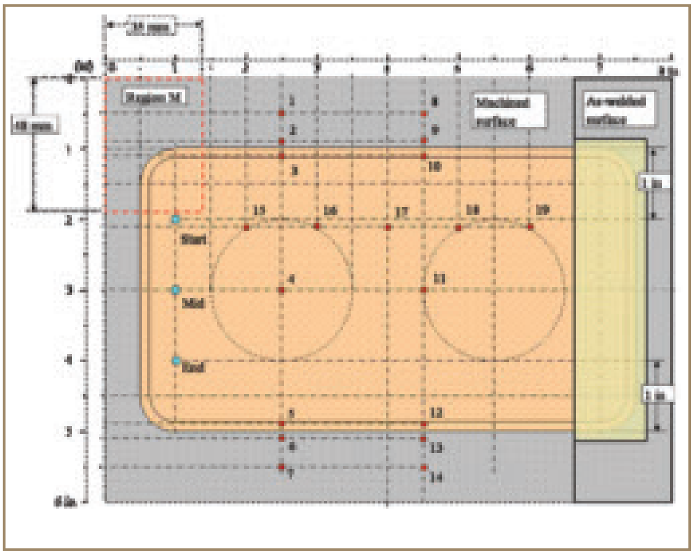


Fig. 5 — Weld blank schematic with two 2-in.-diameter chambers (circles) where water is in direct contact with the steel.

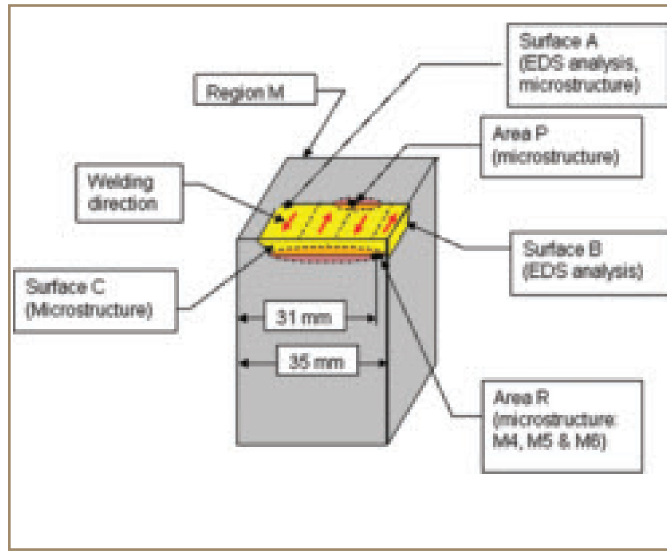


Fig. 6 — Schematic of welding process that shows regions where material was taken for analysis.

system for remote manipulation of the wire relative to the weld pool, an infra-red temperature sensor measuring the temperature of the blank, and other systems. A special robotic program was developed that controlled sequence of operations, laser motion, and welding parameters. The main features of the ALC are described in the literature (Ref. 3). In addition to the ALC, the production setup also includes a water-cooling station and a specially developed fixture described below.

Development of Cladding Procedures

Cladding in Main Area

The main area covers the bottom surface of the pocket (excluding the chamfers and the area above the two 2-in.-diameter cooling chambers in the middle of the blank). The blank is assembled and clamped in the fixture, and the water station is turned on. The robotic program is called in and the cladding cycle starts automatically. The laser head is lowered into welding position and cladding starts. Each weld bead is deposited from one edge of the pocket to another along the shorter side of the pocket. Then it makes a U-turn and runs in the opposite direction overlapping the adjacent bead. Uninterrupted cladding continues until the deposit covers the entire pocket area. The operator is monitoring the cladding process from the safety of the control room adjusting the wire position using a pendant, if necessary. The weld zone is clearly visible on a split screen of a monitor as shown in Fig. 3. The cladding process can be watched through a special protective window also.

Optimal parameters were determined for the laser cladding process by running a number of experiments. Optimal parameters are defined as those that produce weld beads meeting the following weld quality criteria:

- precise thickness (0.125 in. + 0.020/–0.015) and even width ($5/8 \pm 1/32$ in.),
- favorable shape (a smooth transition into the base metal),
- no surface defects (cracks, pores, underfilled spots, excessive ripples, oxidation),
- flat deposit over the pocket (no spots 0.015 in. below the blank surface).

The optimal parameters were determined using the ALC. A 0.035-in.-diameter ER CuAl-A2 wire was used as a filler metal. Argon was used as shielding gas. Two cladding areas of interest were the main and transient areas. The optimal welding parameters that meet the quality criteria specified earlier were determined as follows: laser power, 4 kW; travel speed, 10 cm/min (3.94 in./min); wire feed rate, 550 cm/min (216.5 in./min); argon flow rate, 19 L/min (40 ft^3/h). To produce a flat weld surface within the specified thickness, the adjacent beads were placed with 55% overlap. It takes 22 adjacent beads to cover the pocket. The uninterrupted cladding cycle takes about 20 min to complete. After that, the cooling water continues to run for about 1–2 min to cool the blank to room temperature. The full production cycle, including assembling and disassembling, takes about 25 min. Thus, the original processing time was cut in half, while the amount of energy accumulated in the steel blanks and, thus, distortion level was considerably reduced.

Cladding in Transient Area

A number of experiments were conducted to determine optimal parameters in transient areas of the pocket. The transient areas of the base metal are the areas where specific geometrical details or a method of cooling or thermal conditions are different from those of the main area. The transient areas on the bearing plate blank include weld start/end points; the points where welding direction is reversed; curve at the pocket corner; slope, top, and bottom of the chamfer; and area above the water-cooled chambers. The results of the experiments showed that the beads of favorable shape and good surface quality can be obtained in those special areas as well, provided corresponding adjustments in sequence of operation and weld parameters were made.

Here are examples of such adjustments. At the weld start, the iron pickup in the weld is always the highest due to a thermal shock and due to delays in travel and wire feed intended to preheat cold metal. As the weld progresses and more filler metal is added, iron content is gradually reduced. Although the start area of the base and weld metals is removed at final machining, it is located close to the gear contact area. If iron content there is excessively high, it may not be reduced to an acceptable level over the gear contact area. So, iron content in the start area is reduced by raising the laser power in steps to avoid thermal shock. At the end of the weld cycle, the crater feeling sequence was implemented to avoid cracks. At the points where welding direction is reversed, the travel speed was accelerated to avoid bumps. In the areas above the

Table 3 — Hardness of the Steel Blank and the Aluminum Bronze Deposited Using HPDD Laser Cladding

				Average	Scale	
1	87.9	84.7	88.7	87.1	HRB	Steel
2	97.9	99	99.2	98.7	HRB	Steel
3	88.3	87.5	89	88.3	HRB	Aluminum Bronze
4	89.7	91.9	92	91.2	HRB	Aluminum Bronze
5	87.6	87.8	88.2	87.9	HRB	Aluminum Bronze
6	94.6	96.7	95.4	95.6	HRB	Steel
7	91	83.2	85.3	86.5	HRB	Steel
8	90.7	86.4	88	88.4	HRB	Steel
9	99.7	94.2	98.6	97.5	HRB	Steel
10	88.9	89.8	86.7	88.5	HRB	Aluminum Bronze
11	91.1	90.1	90.5	90.6	HRB	Aluminum Bronze
12	88.2	86.2	88.8	87.7	HRB	Aluminum Bronze
13	97.8	92.9	98	96.2	HRB	Steel
14	92.2	90.1	93.5	91.9	HRB	Steel
15	87.9	87.6	88.7	88.1	HRB	Aluminum Bronze
16	89.4	88.7	88.8	89.0	HRB	Aluminum Bronze
17	89.2	89.9	90	89.7	HRB	Aluminum Bronze
18	88.2	89	89.9	89.0	HRB	Aluminum Bronze
19	89.4	89.8	89.1	89.4	HRB	Aluminum Bronze

water-cooled chambers where cooling was the most intensive, the welds solidified faster and became narrower. To avoid incomplete fusion between passes, weld overlap was increased from 50 to 55%. All these adjustments were programmed in the robot memory to allow one uninterrupted weld cycle to be implemented.

Weld Surface Appearance and Quality

Other blanks were visually inspected at the Alion facilities and later were cut into specimens for metallurgical examination. Visual inspection of the as-welded deposit showed that all the welds performed at optimal parameters have met the weld quality criteria described above. No surface cracks, incomplete fusion between passes, porosity, or other defects were found. The surface of the deposit was fairly even with very small ripples between passes not exceeding 0.015 in. It had a bright golden color with no black marks of oxidation, an indication of adequate shielding of the weld pool. To inspect the quality of the metal surface to be engaged with the gears and to check whether the allowance of 0.031 in. (0.8 mm) was adequate for final machining, the surfaces of the steel blanks (along with the bronze deposits) were machined down by 0.031 in. (0.8 mm). No low areas or weld defects were detected on the surface of the deposit after machining. Figure 4 shows a blank after cladding, the left portion of it being machined off. Some welded blanks were returned to the manufacturer for independent testing. After machining, no cracks, porosity, low spots or other defects were found. The bearing plates successfully passed testing on a testing stand.

Metallurgical Study

A metallurgical study was conducted to determine the suitability of the selected aluminum bronze deposit for the required service conditions. The most important service requirement for the aluminum bronze deposit mating with a steel gear of a pump is its wear resistance, which is largely determined by hardness of the bronze mating surface. In its turn, among the factors that affect hardness, the most important are the contents of iron and aluminum in the deposit. Other factors are microstructure and presence of discontinuities. The scope of this task was to conduct a study to determine hardness of the bronze deposit and steel, to determine the contents of iron and aluminum in the deposit, and to analyze macro and micro structures of the bronze deposit and steel.

Hardness of Bronze Deposit

The objectives of this task were to answer three questions regarding hardness of the deposit made by the HPDD laser using ER CuAl-A2 filler metal. Is hardness within values recommended by practice in similar applications? Is hardness

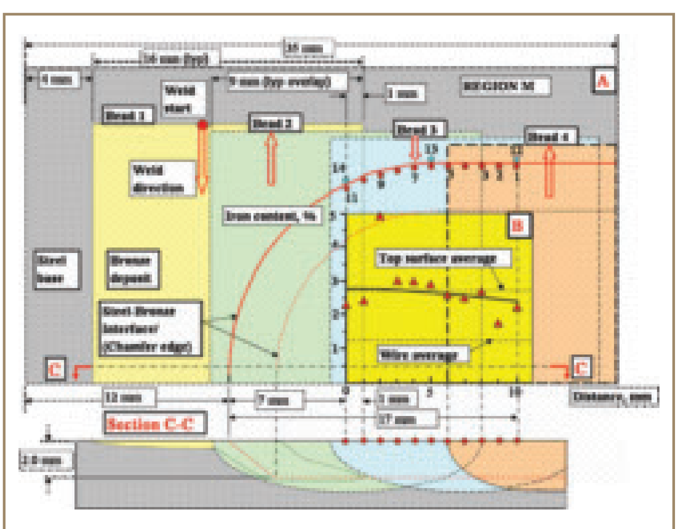


Fig. 7 — A — Schematic of top portion of bearing plate where cladding process begins and shows the directional passes and the corresponding iron (Fe) content along the points; B — results of iron readings superimposed on Fig. 7A.

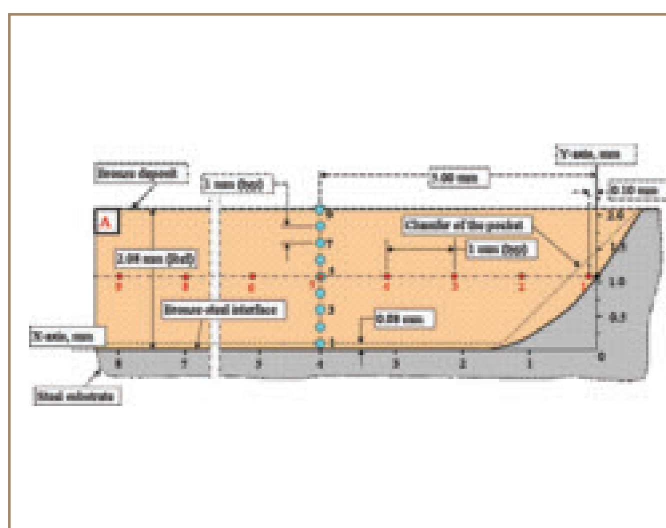


Fig. 8 — Schematic of Section B that has locations of where measurements were taken and represented in Table 7.

within values recommended by the manufacturer? Does nonuniform direct cooling of the blank with running water create hard local areas in the deposit?

Figure 5 shows the welded blank with two 2-in.-diameter chambers (circles) where water is in direct contact with the steel. The left side (noncolored) is machined to leave about 2-mm- (0.080-in.-) thick bronze deposit in the pocket forming a gear-contact surface. The curved line represents an interface between the steel and the aluminum bronze. The layout of points of measurement is shown also. Rockwell B hardness was measured at these points identified by sequential numbers from 1 to 19. Three readings were made at every point and averaged. The data are given in Table 3.

Hardness: HPDD Laser Cladding vs. Brazing

The data received from the manufacturer showed that hardness obtained in brazing using a C95400 copper alloy is the highest. The maximum hardness allowed on a machined gear-contact surface by the manufacturer was 84 HRB average. According to Table 3, in HPDD laser cladding in the main area (outside of the directly cooled areas where cooling was applied indirectly through conduction), hardness values (points 3, 10, 5, and 12) are within 87.6–88.9 HRB (88.25 HRB average). Thus, the deposit made by the HPDD laser is only slightly harder (by about 5% despite of indirect cooling) in comparison with that deposited by brazing. The result was acceptable for the manufacturer.

Hardness: HPDD Laser Cladding vs. Arc Welding

According to Ref. 4, in arc welding, Brinell hardness (3000-kg load) of the weld deposited using the ER CuAl-A2 electrode ranges within 140–160 BHN (150 BHN average). As was discussed above, the hardness readings on the surface of the deposit made by the laser in the main area range within 87.6–88.9 HRB (88.25 HRB average). The equivalent Brinell hardness numbers, according to conversion tables in Ref. 5 are 172–179 BHN (175.5 HRB average). Comparison of the average hardness data shows that hardness produced by the HPDD laser procedure is by 17% higher than that produced by arc welding due to higher cooling rate produced in HPDD laser accelerated by indirect water cooling of the blank.

Effect of Direct Water Cooling on Hardness

The blank was cooled by a direct contact with running water through two 2-in.-diameter blind openings machined in the center of the blank on its opposite side. There was a concern that direct water cooling may produce an excessive hardness of the deposit or create local hard spots. According to Table 3, the hardness on the surface of the deposit inside and on the periphery of the cooled circles (points 4, 11, 15, 16, 18, and 19) range within 87.9–91.1 HRB (89.5 HRB average), being the maximum hardness measured in the deposit as expected. What was surprising is that this hardness is higher than that in the main area (88.25 HRB) just by 1.5%. Such small difference indicates that the developed laser cladding and cooling procedures produce fairly uniform hardness on the surface of the deposit without local hard spots, the maximum hardness being only 6% higher in comparison with brazing (84 HRB). The reason is that water cooling does not increase cooling rates much over those already produced by HPDD laser, while effectively removing excessive heat buildup. The maximum temperature of the blank did not exceed 250°F during cladding.

Table 4 — Results of Chemical Analysis of ER CuAl-A2 Filler Metal

Metallurgical Laboratory	Composition (wt-%)		
	Cu	Fe	Al
#1	Bal.	1.42	8.38
#2	Bal.	1.06	8.9
Average	Bal.	1.24	8.64

Table 5 — Content of Iron and Aluminum in the Deposit of Main Area

Location	Method	Series 1 Fe (wt-%)	Series 2 Fe (wt-%)
start	XRF	1.3	1.36
mid	XRF	1.29	1.48
end	XRF	1.31	1.45
Average		1.3	1.43
	Al (wt-%)		
	EDS	8.08	

Hardness of Base Metal

The range of hardness fluctuations for the steel blank (outside of the deposit) is much higher than in the bronze deposit (86.5–98.7 HRB or about 12%). Lower values 86.5–91.9 HRB were observed in the heat-affected zone (HAZ) (points 2, 9, 6, and 13) next to the deposit. Higher hardness values (95.6–98.7) were obtained in the base metal (points 1, 7, 8, and 14) not significantly affected by heat of welding. This can be explained by the effect of the welding thermal cycle and higher than normal cooling rates produced by water cooling. However, due to low-carbon content in the steel, no detrimental mi-

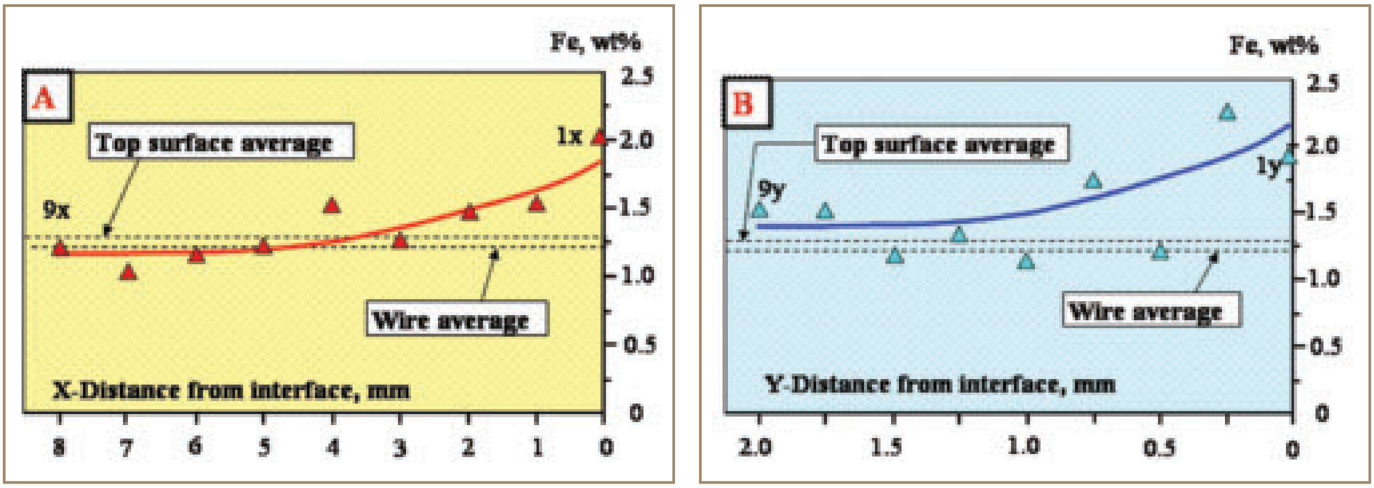


Fig. 9 — Iron distribution along interface. A — Group 1; B — Group 2.

Table 6 — Results of Measurements on Top Surface A

Deposit	Fe (wt-%)	Al (wt-%)	Base Metal	Fe (wt-%)	Al (wt-%)
1	2.22	5.12			
2	1.72	5.48	12	99.66	0.15
3	2.70	6.90			
4	2.58	5.90			
5	2.62	5.04			
6	2.85	5.78	13	99.17	0.07
7	2.97	5.15			
8	2.98	7.03			
9	4.92	7.36	14	99.58	0.00
10	2.42	6.20			
11	2.28	7.14			
Average	2.75	6.10	Average	99.47	0.07
STD	0.81	2.32	STD	1.16	0.30

crostructural changes were detected in the HAZ.

Contents of Iron and Aluminum in the Deposit

Iron and aluminum are two most important alloying elements in the aluminum bronze deposit. If too much iron (Fe) is in the bronze deposit, it will increase hardness and cause excessive wear of the gears. It is desirable that Al content be above 7 wt-% to provide more wear-resistant dual-phase microstructure. The contents of Fe and Al are not uniformly distributed around the bronze deposit. The largest portion of the deposit (77%) is called main area. It is the area where the differences in thermal conditions during cladding, dilution, and variation in composition are relatively small. In contrast, in transient areas, Fe and Al contents may differ significantly. The most unfavorable transient area in terms of iron pickup is the area close to the steel-bronze interface, especially around top edges of the pocket chamfer where melting is more intensive than on the bottom of the pocket.

Iron and Aluminum Contents in Main Area

The main area constitutes about three quarters of the deposited area and is not likely to have considerable differences in Fe and Al contents.

Methods of Measurements

The measurements were made by two methods: energy-dispersive spectrometer (EDS) analysis and X-ray fluorescence (XRF) analysis. The EDS is a localized method compared to XRF. It allows the composition to be scanned with much greater resolution. Iron (Fe) content was determined using both methods, which are in a good agreement. However, measurement of Al using the XRF method was inconclusive. Therefore, all the following measurements of Al in the bronze deposit were conducted using the EDS method, including average content of iron and aluminum in the ER CuAl-A2 filler metal. The results of chemical analysis of this filler metal (iron and aluminum contents) are presented in Table 4.

Iron Content in Main Area

Iron content was measured in the main area of the deposit using the optimal welding conditions as summarized in Table 5. The measurements were made on the machined surface of the bronze deposit in the main area (outside of directly cooled circles and away from the steel-bronze interface). As shown in Fig. 8, three measurements (identified as start, mid, and end) were made on an individual 4-in.-long bead running along the short side of the pocket, two beads away from it. Two series of readings were made on the two deposits using the optimal cladding conditions: Series 1 — at the optimal travel speed, and Series 2 — at higher travel speed.

According to Table 5, iron content in Series 1 turned out to be only slightly higher than in the filler metal (1.31 vs. 1.24 wt-%). It is just about 5% different. This is an indication of a very low dilution of the deposit with the base metal. As a result, a very low iron pickup from the base metal occurs. A 20% increase in travel speed in Series 2, from optimal 10 cm/min (3.94 in./min) to 12 cm/min (4.7 in./min), causes slightly higher iron pickup (1.43 wt-%). This phenomenon can be explained as follows:

At the optimal travel speed, an incident spot of the laser beam is kept in the center of the molten pool, the latter shielding the base metal from direct contact with the laser beam. As the travel

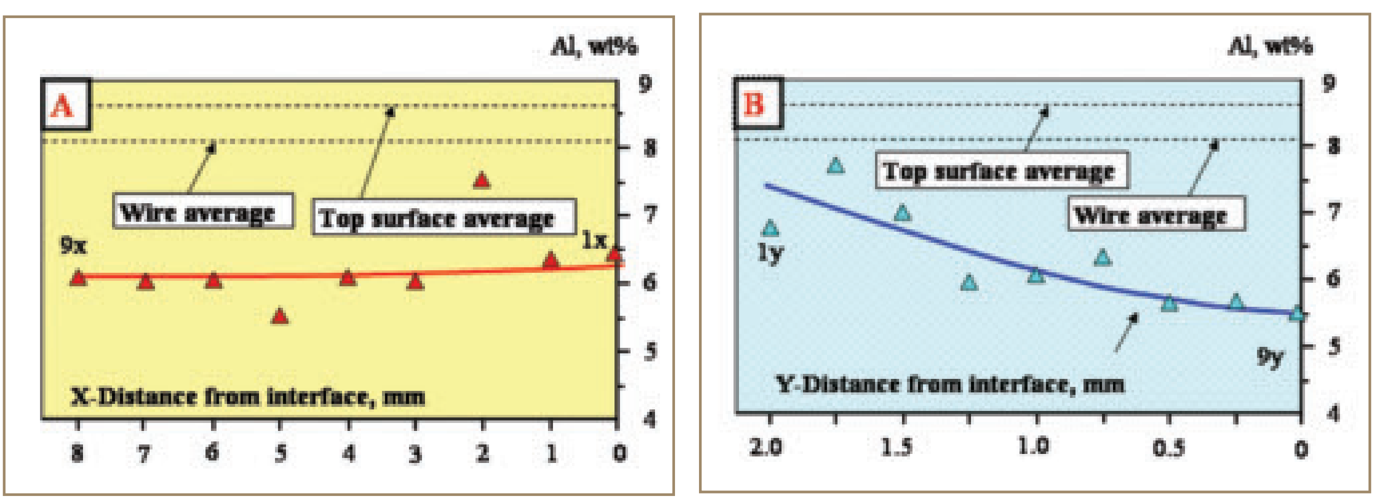


Fig. 10 — Aluminum distribution along interface. A — Group 1; B — Group 2.

Table 7 — Results of Measurements on Side Surface B

Deposit x-axis	Fe (wt-%)	Al (wt-%)	Deposit y-axis	Fe (wt-%)	Al (wt-%)	Base Metal	Fe (wt-%)	Al (wt-%)
p1x	2.00	6.43	p1y	1.87	5.50	p1o	99.55	0.00
p2x	1.55	6.38	p2y	2.25	5.69	p2o	99.38	0.18
p3x	1.41	7.5	p3y	1.22	5.66	p3o	99.87	0.13
p4x	1.25	6.01	p4y	1.73	6.36	p4o	99.76	0.24
p5x	1.53	6.13	p5y	1.12	6.03	p5o	99.98	0.02
p6x	1.20	5.51	p6y	1.35	5.90	p6o	98.96	0.79
p7x	1.14	6.05	p7y	1.20	7.01	p7o	99.92	0.08
p8x	1.04	5.98	p8y	1.51	7.65			
p9x	1.23	6.08	p9y	1.56	6.72			
Average	1.37	6.23	Average	1.53	6.28	Average	99.63	0.21
STD	0.29	1.44	STD	0.37	1.91	STD	0.36	1.69

speed increases, the laser spot shifts closer to the front edge of the molten pool. As a result, more heat is transferred into the substrate.

Aluminum Content in Main Area

According to Table 5, aluminum content in the deposit is slightly lower than in the filler metal (8.08 vs. 8.64 wt-%). It represents a loss of about 6.5% Al contained in the wire. It is likely that the loss of Al occurs largely due to dilution with the base metal, which contains a negligible amount of aluminum. Some loss due to vaporization may also occur.

Thus, the laser cladding procedure developed provides extremely low iron pickup on the surface of the first layer of the bronze deposit at a low loss of aluminum. The reason is that high cooling rates inherent in HPDD laser process are accelerated by direct cooling of the substrate, producing low dilution.

Iron and Aluminum Contents at Bronze-Steel Interface

In contrast to the surface of the deposit, where Fe and Al contents are close to those in the filler metal, the area of the bronze deposit close to the bronze-steel interface was suspected of containing higher local amount of iron and lower amount of Al. To confirm that assumption, a corner section where cladding started (Fig. 5 as Region M) was cut out as a specimen for metallurgical analysis. This section is shown in Fig. 6 where three surfaces (A, B, and C) were metallographically prepared to conduct EDS analysis and SEM microstructure examination.

Iron Content on Top Surface A

Layout of measurements to determine iron content on top surface A is shown in Fig. 7A. The weld deposit in Region M includes three full adjacent beads (Nos. 1, 2, and 3) and the portion of bead No. 4. Contents of iron and aluminum were determined along the steel-bronze interface. After machining, the interface clearly follows the contour of the rectangular pocket with radii at the corners. Eleven measurements (points 1 through 11) were made in the bronze deposit at an increment of 1 mm (0.040 in.). The readings were taken at a distance of 0.050 mm (0.002 in.) from the interface. Also, three measurements (points 12, 13, and 14) were made on the steel side of the interface at 0.002 in. (0.050 mm) from the interface at an increment of 0.197 in. (5 mm) to verify composition of the base metal (1018 steel). The results are presented in Table 6 and plotted in Fig. 7B superimposed on Fig. 7A.

Figure 7B shows that the bronze deposit on the contact surface at 0.050 mm (0.002 in.) from the interface has an elevated iron content, the average along the interface being 2.75 wt-%. It is higher in comparison with that on the surface in the main area (1.31 wt-%) due to a higher level of dilution of weld with the steel. The iron content slightly decreases as the measurements are getting closer to the cooling circles. This elevated amount of iron (2.75 wt-%) at the interface is not likely to affect antifriction properties of the deposit. As reported in Ref. 6, antifriction properties of the deposited aluminum bronze containing 7–9% aluminum are similar to those of cast aluminum bronze if content of iron does not exceed 3%.

Aluminum Content on Top Surface A

Layout of EDS measurements to determine aluminum content on the top surface A is shown in Fig. 7A. The results are given in Table 6. In contrast to iron, aluminum is characterized by a greater range and scatter (5.04–7.36 wt-%, average being 6.10 wt-%). This represents a sizeable loss of aluminum in the deposit at the interface in comparison with the content on the surface (8.08 wt-%). The reason is that the borderline aluminum migrates by diffusion mechanism to the interface from the liquid bronze toward solid steel creating an aluminum-depleted area close to, and a thin hard (so-called diffusion) layer, at the interface. This phenomenon was reported by Ref. 7. Here, a 0.050-mm-(0.002-in.-) wide aluminum-depleted area was found in 9% aluminum bronze at the

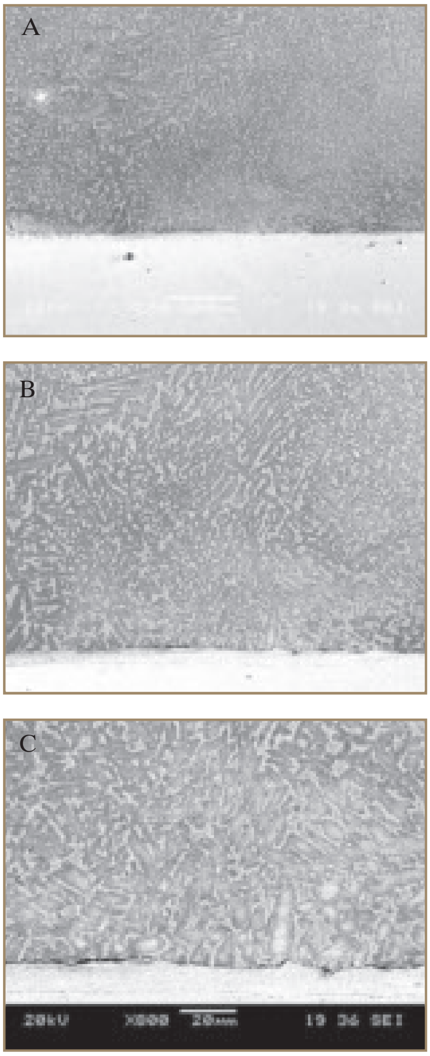
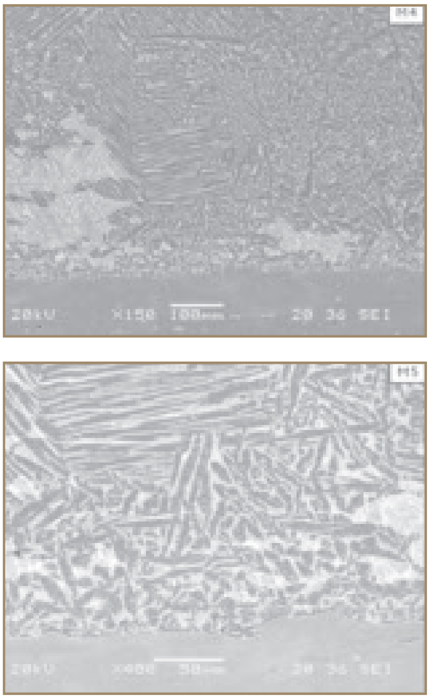


Fig. 11 — Microstructures in area P (for location, see Fig. 6). A — 200 ×; B — 400 ×; C — 800 ×.



12 — Microstructures in area R (for location, see Fig. 6). A — 150 ×; B — 400 ×.

bronze-steel interface, the lowest aluminum content being less than 5 wt-% and the diffusion layer being about 0.012 mm (0.0005 in,). According to Ref. 8, a diffusion layer in 9% aluminum bronze at the bronze-steel interface may contain about 6% Al, 3% Cu, and Fe-balance. A thicker layer may cause greater depletion of the surrounding areas in aluminum.

Iron Distributions on Side Surface B

Layout of EDS measurements to determine iron content on side surface B is shown in Fig. 8. The results are summarized in Table 7 and plotted in Figs. 9A and 9B. Surface B is cut through bead #4. Group 1 of measurements consists of nine points (1x through 9x) that were taken in mid thickness of the deposit in X-direction. Point 1x is located 0.100 mm (0.004 in.) from the interface and the following points (2x through 9x) are away from the interface at an increment of 1 mm (0.039 in.). Group 2 of measurements was taken in a through-thickness (Y) direction, the first one (9y) being taken at the surface of the machined deposit and the following ones — at an increment of 0.25 mm (0.010 in.), except point 1y located at 0.080 mm (0.003 in.) from the interface. A number of measurements was also taken on steel side at 0.10 mm (0.004 in.) from the interface.

Iron distribution for Group 1 is plotted in Fig. 9A. It shows an elevated iron content (around 2 wt-%) close to the interface, but decreases rapidly away from it, yielding 1.37 wt-% average (compare with 1.31 wt-% average on the surface in other experiments). The data for Group 2 (Fig. 9B) show a similar trend: elevated iron content (around 2 wt-%) close to the interface and rapid reduction toward the surface of the machined deposit (1.53 wt-% average, 2 mm (0.080 in.) away from the interface). Such distribution may be contributed to the low-dilution rate and possibly the insufficient speed of the molten pool flow inherent in HPDD laser.

Thus, iron in the aluminum bronze deposited on steel substrate by HPDD laser cladding is characterized by an ideal distribution: elevated iron content at the interface that strengthen a metallurgical bond and low iron pickup at the surface that allow the high antifriction service properties of the deposit to be maintained.

Aluminum Distributions on Side Surface B

Layout of EDS measurements to determine aluminum content on side surface B is shown in Fig. 8. The results are summarized in Table 7 and plotted in Fig. 10A and B. Aluminum distributions for Groups 1 (X-axis) and 2 (Y-axis) are plotted in Fig. 10A and B, respectively. As shown in Fig. 10A, Al distribution in midsection of the deposit is fairly even, but the average content of Al (6.23 wt-%) is below that on the surface (8.08 wt-%) and the wire (8.64 wt-%). Aluminum distribution for Group 2 (Y-axis) is plotted in Fig. 10B. It shows that Al content increases away from the interface toward the surface of the deposit.

Thus, the aluminum content at the interface of the aluminum bronze deposited on the steel substrate by HPDD laser cladding is lower than that on the surface of the deposit. It increases rapidly toward the surface.

Dilution of Bronze Deposit

A metal deposited on a substrate is largely a mixture of a filler and a substrate metal (aluminum bronze ER CuAl-A2 filler metal and 1018 steel in this case). As a result of mixing, the weld deposit will pick up some iron from steel and lose some aluminum contained in the filler metal. This metallurgical phenomenon is called dilution and the composition changes can be quantitatively measured by a criterion called dilution rate. A high degree of dilution may introduce an excessive amount of iron and reduce the amount of aluminum in the deposit, thus, affecting the wear-resistant properties of the deposit. By definition, dilution percentage is determined as follows:

$$D = [1 - (m_b/m_w)] \times 100\ (\%) \qquad (1)$$

where $m_w = m_b + m_f$, D = dilution, m_w = mass of the weld, m_b = mass of the base metal (steel), and m_f = mass of the filler metal (aluminum bronze wire)

If contents (%) of a given element in the weld, base, and filler metals are known and identified as k_w, k_b, and k_f, respectively, and $k_b >> k_f$ then the dilution rate can be calculated by the following formula (Ref. 9):

$$D = [(k_f - k_w)/(k_f - k_b)] \times 100\ (\%) \qquad (2)$$

Dilution at the Surface of Deposit

According to average data in Table 5, ER CuAl-2A aluminum bronze wire contains 1.24% iron (k_f = 1. 24). According to Table 6, 1018 steel contains about 99.47% iron (k_b = 99.47), while the deposit contains 1.31% iron (k_w = 1.31) per Table 6 and 1.53% iron (k_w = 1.53) per Table 7. Dilution for both cases is determined as follows:

$D = [(1.24–1.31)/(1.24–99.47)] \times 100\% = (–0.07/–98.23) \times 100\% = 0.07\%$.

$D = [(1.24-1.53)/(1.24–99.47)] \times 100\% = (–0.29/ –98.23) \times 100\% = 0.3\%$.

Dilution at the Interface

According to average data in Table 5, ER CuAl-2A aluminum bronze wire contains 1.24% iron (k_f = 1. 24). According to Table 6, 1018 steel contains about 99.47% iron (k_b = 99.47) and the deposit contains 2.75% iron (k_w = 2.75). Dilution is determined as follows:

$D = [(1.24–2.75)/(1.24–99.47)] \times 100\% = (–1.51/–98.23) \times 100\% = 1.5\%$. Thus, the HPDD laser cladding provides a very low dilution and iron pickup at the gear-contact surface of the aluminum bronze deposit.

Microstructure Analysis

Under conditions of slow cooling typical for casting, aluminum bronze with an aluminum content below 7% has monophase microstructure that consists largely of α-phase (solid solution of aluminum in copper). Aluminum bronze weld metal with aluminum content within 7–10% at higher cooling rates typical for welding does not have sufficient time to achieve equilibrium and displays dual-phase (α + β) microstructure where β is a high-temperature phase based on Cu_3Al combination (Ref. 10). The selected ER CuAl-2A wire made of an alloy that belongs to the latter category.

According to Ref. 11, high cooling rates associated with welding may facilitate the development of even more complex multiphase microstructures in the deposited 7–10% aluminum bronze when a metastable (martensitic) β′-phase may precipitate from β-phase. The β′-phase typically is not found in as-welded conditions in the bronze deposit, but the β→ β′ transformation may occur at ambient temperature without diffusion under load causing plastic deformation in micro volumes of the deposit during machining of the bronze or during service.

However, according to Ref. 12, high cooling rates above 15°C/s from 900°–1000°C may produce martensitic β′ phase and needle-like α-phase even at aluminum content lower than 10%. Presence of needle-like phases increase strength and hardness of the deposit and improve its wear resistance, at the expense of ductility.

The described HPDD laser cladding procedure is characterized by high cooling rates that may well be above 15°C/s. Therefore, the constituents described above were expected in the bronze microstuctures to be analyzed especially at the bronze-steel interface where temperature gradient and cooling rates are the highest. The areas where SEM micrographs were taken for microstructure examination are shown in Figs. 11 and 12. The images in Fig. 11 were photographed at 200×, 400×, and 800× magnification and include the interface area and aluminum bronze deposit. The analysis of the images shows no cracks, porosity, or other discontinuities. Some very small isolated nonmetallic inclusions are present.

Micrographs taken in Area P (Fig. 6) are located at top surface A and are a few mm from surface B. As expected, the images show dendritic dual-phase (α + β) microstructures with a significant amount of β-phase (Fig. 11A). At higher magnification, the presence of needle-like α and β phases is evident in areas slightly away from the interface — Fig. 11B.

Micrographs taken in Area R (Fig. 6) are located on the front surface C and close to surface B. Since Area R is located closer to the cooling circles than surface P, higher cooling rates are expected in this area. The dual-phase (α +β) microstructure displays even greater amount of β-phase — Fig. 12A. The presence of needle-like α and β phases is even more pronounced — Fig. 12B.

Diffusion layer is relatively thin 0.012–0.018 mm (0.0005–0.0007 in.) as seen in Fig. 11C. According to Ref. 8, the diffusion layer is much harder than low-carbon steel and aluminum bronze and may reach 0.100 mm (0.004 in.) at very low cooling rates. If the layer is thicker than 0.015 mm (0.0006 in.), it may reduce strength of adhesion between these metals.

Copper penetration between grain boundaries of the steel substrate was not found. Copper penetration phenomenon occurs during contact of liquid copper alloy and solid steel substrate (Ref. 13). The developed optimal HPDD laser procedure provides no copper penetration due to high cooling rate, and, thus, a short liquid-solid metals contact time.

Conclusions

Alion's high-power direct-diode (HPDD) laser cladding technology was successful in depositing 8.5–11% aluminum bronze on steel-bearing plates produced by a shipboard pump manufacturer. The laser cladding provided weld quality, cut in half production time and consumption of the copper alloy, reduced machining time, and eliminated safety and pollution concerns.

The 3.2-mm- (⅛-in.-) thick bronze layer can be deposited with extreme accuracy so that an allowance for machining as low as 0.8 mm (0.031 in.) can be specified.

Hardness of the aluminum bronze deposit is higher in comparison with that currently produced by brazing and arc welding (by 6% and 17%, respectively). It is fairly uniform on the machined surface of the deposit and has no local hard spots.

Iron content on the surface of a 2-mm- (0.078-in.-) thick machined bronze deposit is slightly higher (by 0.07–0.3% max) over that (1.24 %) contained in the filler metal.

Iron distribution in the bronze deposit is favorable for antifriction/wear-resistant service as was confirmed by wear testing at the manufacturer's facility. It contains an elevated amount of iron (2.75%) at the bronze-steel interface, which makes the metallurgical bond stronger, while it does not increase iron on the surface in contact with steel much over that contained in the filler metal.

Aluminum loss on the surface of a 2-mm- (0.078-in.-) thick machined bronze deposit is low (0.56% max) relative to that (8.08%) contained in the filler metal. However, it gradually decreases in through-thickness direction down to about 6–7% at the interface.

Dilution of the bronze deposit with steel is extremely low. Based on calculations using iron contents in the weld, steel, and filler metal, it is 0.3% on the surface and 1.5% at the interface.

Microstructure developed in the deposit is typical for a corresponding aluminum bronze metal. However, it contains hard phases due to higher cooling rates.

Acknowledgments

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Nuclear Fuel Plate Fabrication Employing Friction Welding

The friction stir welding process has been modified to enable the fabrication of plate-type nuclear fuels for the conversion of research and test reactors currently operating using highly enriched uranium to low-enriched uranium

BY DOUGLAS E. BURKES, NEIL P. HALLINAN, AND CURTIS R. CLARK

Friction stir welding (FSW) has been in existence since the early 1990s and has routinely been developed for joining applications in the aerospace and automotive industries. These developments have been encouraged because FSW is a nonmelting joining technology that typically produces higher strength and ductility, increased fatigue life and toughness, lower distortion, less residual stress, less sensitivity to corrosion, and essentially discontinuity-free joints when compared to more conventional arc welding techniques (Ref. 1). A sufficient review of the FSW process can be found in Ref. 2.

Friction bonding (FB) — a modified FSW process — allows bonding between two similar AA6061-T6 thin plates. In this regard, the process is not unlike other friction welding techniques, such as explosion welding, ultrasonic welding, roll bonding, or forge welding. In addition, the FB process is similar to friction stir processing (Refs. 3, 4), in that the workpiece microstructure is locally modified. Friction bonding allows the fabrication of nuclear fuel plates for research and test reactors containing thin, monolithic fuel alloys. The FB fabrication concept is of great importance for the U.S. National Nuclear Security Administration-sponsored Global Threat Reduction Initiative. This initiative seeks to enable research and test reactors throughout the world that currently operate with highly enriched uranium (HEU, ≥ 20% ^{235}U) fuel to operate with low-enriched uranium (LEU, <20% ^{235}U) fuel, which is desirable for nuclear nonproliferation reasons (Ref. 5). The new fuels must behave in a manner without significant penalties in reactor or experiment performance, economics, and safety.

Research and Test Reactors

Highly enriched uranium (HEU) fueled research and test reactors have given rise to advanced and novel fuel concepts because the reduction of enrichment in the fuel requires an increase in the overall uranium density. This has currently been accomplished through use of a uranium-molybdenum alloy in a monolithic form (Ref. 6). Monolithic fuel contains a single foil to replace multiple fuel particles comprising a dispersion fuel plate, provides the highest possible uranium loading, and provides a smaller contact surface area with the aluminum cladding to minimize reaction. Cross-sectional metallographs of a typical dispersion fuel and a typical monolithic fuel are provided in Fig. 1.

Monolithic fuel alloys are basically created by casting a uranium-molybdenum coupon comprised of the desired fuel stoichiometry, hot and/or cold rolling the coupon to a desired thickness (typically 250 to 500 μm), and sandwiching the monolith between two cladding plates, of which AA6061-T6 is the most commonly accepted type. An appropriate joining process is applied to seal the monolith in the cladding, in this case FB, although hot isostatic pressing is also under consideration. The FB process is repeated over the entire surface of the sandwich assembly, both on the top and bottom.

Process Details

Friction stir welding and friction stir processing (FSP) tools generally have extended pins, typically threaded, that aid in extrusion and stirring of material across the joint interface. The tool pin is not allowed to penetrate across the joint interface, so that the fuel foil is not disturbed since FB is being utilized to fabricate fuel plates containing nuclear fuel foils. Thus, bonding between the AA6061-T6 cladding plates and between the uranium-molybdenum monolith and AA6061-T6 cladding is accomplished primarily by mechanical adherence and some intermolecular bonding at the interface, both driven mainly by process load and temperature. There is minimal material movement between the pin face and the foil surface, meaning that the stir action used in the conventional sense is not present, nor is it desired.

The FB process produces a surface finish that closely meets most reactor specifications and, therefore, requires minimal postprocessing surface treatment. Most fuel plates are rectangular and are no thicker than 1.4 mm (0.055 in.). Photographs of an assembly using a stainless steel alloy as the mock fuel are provided in Fig. 2.

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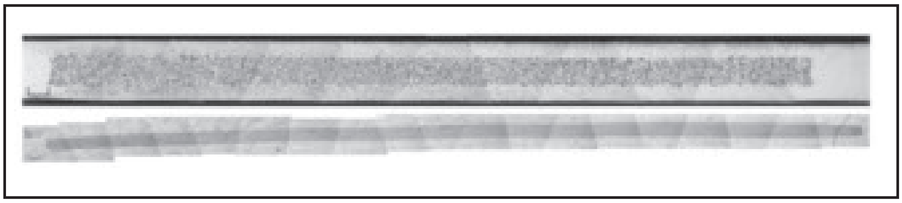


Fig. 1 — Cross-sectional metallographs comparing a dispersion fuel plate (top) with a proposed monolithic fuel plate (bottom). The dispersion fuel plate is fabricated by compacting ground or atomized powders in an aluminum-silicon matrix, and co-rolling the compact with AA6061 cladding. The monolithic fuel plate is fabricated by sandwiching a rolled uranium-molybdenum fuel foil between two pieces of AA6061 cladding that is then bonded by the novel FB process.

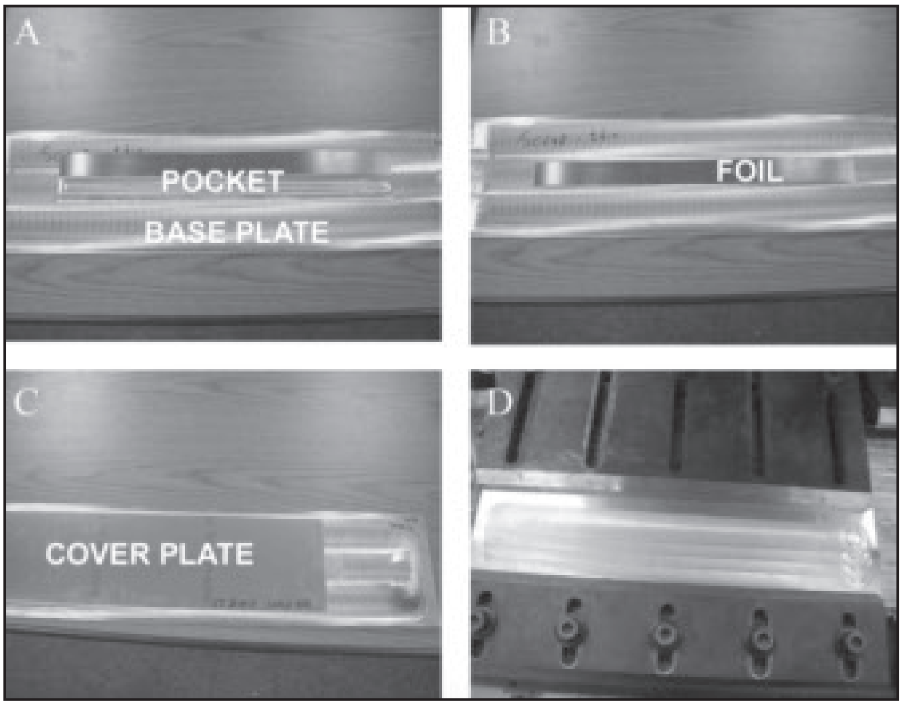


Fig. 2 — Photographs of a mock-fuel assembly for FB. Photographs show the base metal and milled pocket (A), the monolithic foil in the pocket (B), the cover plate completing the fuel assembly (C), and an as-friction-bonded fuel assembly with four passes clearly visible (D).

The aluminum alloy cladding plate surfaces are typically prepped by subjecting them to a rotating stainless steel wire brush in an attempt to remove as much oxide as possible. Even though FSW is often referred to as a "self-cleaning" process, this is not the case for FB due to the lack of material movement across the joint interface and, therefore, minimal mixing action for oxide fragmentation and dispersal. Because the major advantage of FSW is joining materials in the absence of melting, process temperature must be closely controlled while allowing sufficient loads to be applied for mechanical adherence and atomic diffusion, typically 70–90% of the solidus temperature.

This article examines the FB process and its application toward research and test reactor fuel fabrication. It also discusses potential pitfalls of the application and how these were overcome. Though pertinent features of the process are presented and discussed in the context of nuclear fuel plate fabrication, those seeking additional applications for joining laminar structures, particularly for composite structures, will find the current documentation useful.

Development of the Friction Bond Weld Tool

Tool Design

The weld tool is designed so that penetration is limited to the top side of the material to be welded at a discrete distance above both the fuel foil and the interface. If this distance is not maintained, the tool can damage the fuel foil and destroy the resulting plate — Fig. 3. Tool geometry is typically optimized for material flow and governs the tool traverse rate at which the weld can be conducted. Thus, the tool geometry for the current application is optimized such that sufficient forging between the top and bottom AA6061 sheets is accomplished with minimal tool/fuel foil interaction.

Figure 4 provides an example of the weld tool design being employed. The figure shows a short pin extending down from the shoulder with a recessed region between the shoulder and pin. The recessed region was selected in lieu of a concave shoulder to accommodate extruded material from the weld surface and minimize penetration of the shoulder edges into the surface, increasing the stability of the process. The pin is 14.3-mm (0.563-in.) in diameter and extends 0.38-mm (0.015-in.) from the shoulder surface, which is 38.1-mm (1.5-in.) in diameter overall. The relative size of the tool pin and shoulder is the largest contributor to frictional heating. The tool has beveled edges along the outer radius of the shoulder to aide in warp reduction as multiple passes are made across the weld assembly. The tool face is welded to a tool shank containing an annular plenum that allows heat removal from the weld face via an appropriate coolant, e.g., ethylene glycol. A larger tool shoulder diameter will increase the welding torque, but the shorter pin will decrease the longitudinal force exerted on the workpiece (Ref. 8). Photographs of two variations in tool design are shown in Fig. 5.

Backing Anvil Design

A backing anvil is required for this application due to the thin material being joined and because a fixed pin tool design is used. Cooling of the anvil, upon which the assembly rests, during fabrication was also found to be necessary, based on the geometry of the fuel plate assembly being bound. This facilitated rapid heat transfer from the work surface to the bottom of the plate. Without adequate cooling, the heat would residually remain in the workpiece, requiring lower down forces or a change in parameters that would ultimately affect bonding, i.e., a preheating effect. Thus, an appropriate material capable of large applied loads, thermal cycling, effective heat transfer, and high durability is required for the anvil. Initially, heat-treated VEGA steel was used as the anvil material, but this alloy began to crack after only a few plates had been fabricated. In addition, the anvil had a tendency to warp under the temperatures and loads, such that the bottom working surface was no longer uniformly flat. A 4140 alloy steel was selected as a replacement that effectively increased the useful lifetime of the anvil (no cracking was observed) and provided adequate thermal properties that transferred heat from the bottom workpiece surface into the cooled anvil base, in addition to being readily available as an off-the-shelf item. Improvements to this design have incorporated cooling channels directly into the anvil, rather than relying on heat conduction through the anvil into the anvil base.

Challenges of the FB Process

Figure 6 provides examples of some potential pitfalls of the FB process if process parameters and responses are not properly controlled. Figure 6A shows the impact of high surface temperature over an aluminum-aluminum region. The thermal field is established by the shoulder of the tool, and must be maintained in a manner to prevent overheating and surface melting. Attempts were made to increase the downforce of the tool during processing to increase plasticization of the material and, thus, bonding. However, this ultimately had an adverse effect because metallurgical coupling of the tool was relatively poor, which caused surface melting at the tool-workpiece interface and excessive flash — Fig. 6A. This is representative of a hot weld condition where hot spots occur at contact points between the shoulder and workpiece, giving rise to melting. Because coupling of the tool and substrate was not accomplished, the frictional heat generated was not distributed effectively into the top portion of the workpiece. The flash represented in Fig. 6A was caused by increased downforce, although, the same effect could be accomplished by applying a significant increase in the tool rotational rate.

Presence of weld flash is undesirable for five reasons. First, it takes a significant amount of postprocess work to remove the surface irregularity, increasing the time and costs associated with the fabrication process. Second, if the tool insertion depth was increased too much over the fuel region, the tool pin would contact the fuel foil, resulting in undesired damage and significant displacement of material, as shown in Fig. 3. Third, higher process temperatures (of which flash is a process result) were found to significantly increase the amount of buckling in the thin-plated assembly. Fourth, the higher process temperatures also allowed the tool shoulder to sink into the surface deeper than desired. This can have a detrimental impact on bonding, where the bond established by the advancing side of the tool is actually destroyed by the retreating edge (Ref. 9). Fifth, higher process temperatures reduce the friction generating heat, requiring changes in process control, and, ultimately, exacerbate the problem.

The more the material is worked with the tool, the more difficult it is to create a workpiece with an adequate bond and acceptable surface finish. In addition, the potential for creating a running groove along the surface of the bond at the retreating side of the tool pin increases significantly after the temper has been drawn out of the material, i.e., after one bond pass. An example of such a running groove on the surface is provided in Fig. 6B, where the groove tends to appear at the recessed region between the pin and tool shoulder. The aluminum substrate becomes stickier with increasing amounts of work from the tool. As the material cools from the advancing side to the retreating side it has a tendency to stick to the tool rather than the substrate, resulting in the large groove observed in the figure.

Furthermore, the material that sticks to the tool can leave large burrs, i.e., material that sticks up from the surface, in the wake of the bond pass — Fig. 6C. Here, the material sticks to the tool under the retreating edge shoulder and begins to build up at the beveled edge of the tool as it reenters the advancing edge and reheats. As the tool advances to the retreating side, the material at the beveled edge of the tool cools and sticks to the base material on the surface, leaving the burr observed in Fig. 6C.

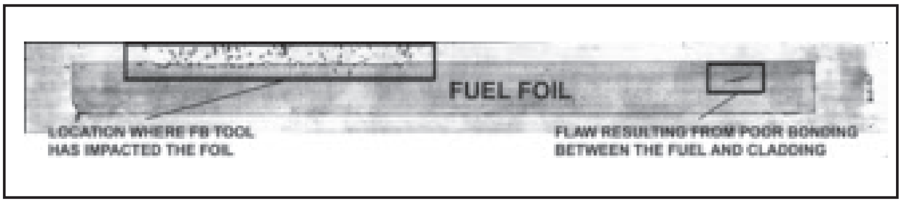


Fig. 3 — An example of the tool pin impacting the monolithic fuel alloy sandwiched between the two pieces of AA6061 cladding as revealed by ultrasonic testing. Material has clearly been removed from the fuel and distributed by the counterclockwise advance of the tool. A flaw resulting from inadequate bonding between the fuel and cladding is also shown in the photograph.

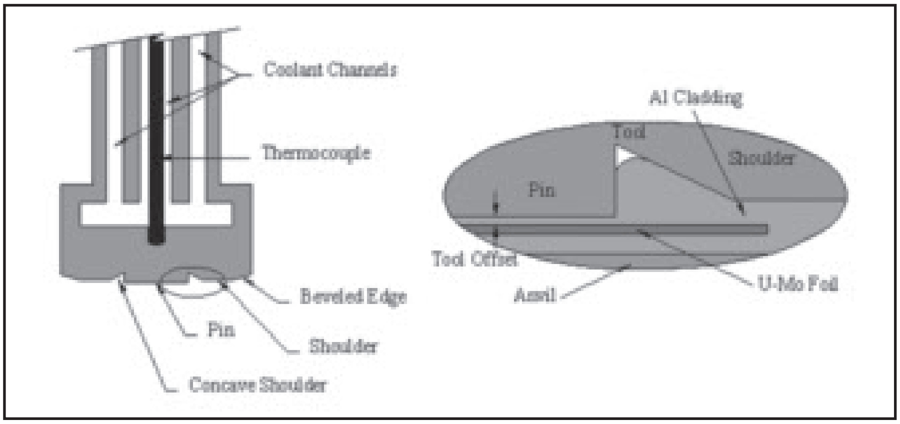


Fig. 4 — An example of a tool design. Note the relatively shallow pin when compared to the overall tool diameter, which is different from designs used in conventional FSW applications (Ref. 7).

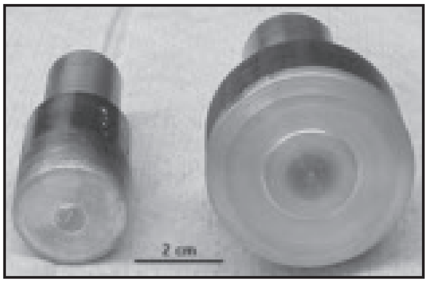
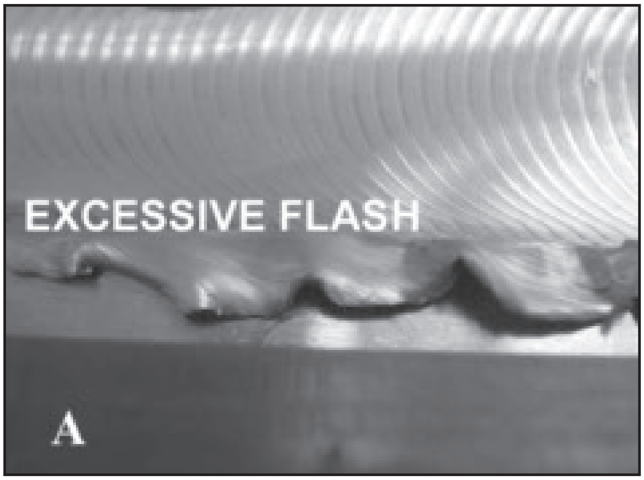


Fig. 5 — Two variations in tool design. The tool on the left had a shoulder diameter of 2.5 cm (1 in.) and a pin diameter of 0.64 cm (0.25 in.), while the tool on the right had a shoulder diameter of 4.7 cm (1.85 in.) and a pin diameter of 2.0 cm (0.79 in.) to effectively increase the weld coverage rate. The tool on the right was further modified to incorporate the design changes discussed in Fig. 4.

Tool Collar Design

The FB process, or the more conventionally employed FSW process, requires



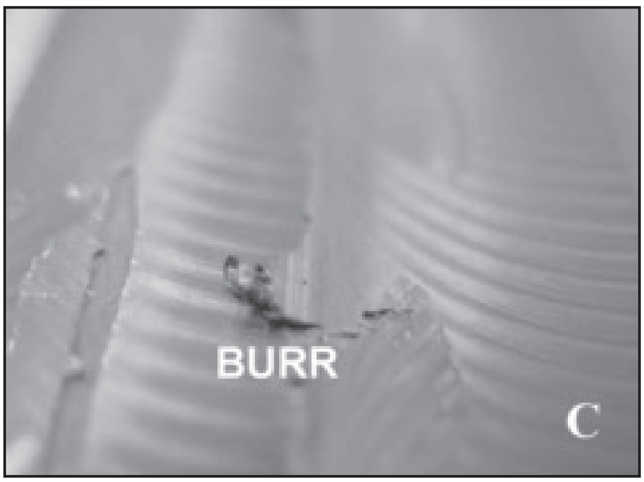


Fig. 6 — Challenges associated with maintaining an adequate balance between tool heat generation and tool heat removal characteristics. A — Excessive flash created by increased downforce; B — a running groove along the surface; C — a large burr such as this is caused by material that sticks up from the surface, in the wake of the bond pass.

rigid clamping to hold the workpiece in place during processing, especially for the current application since two sheets are joined together one on top of the other, where sliding of the sheets must be prevented. Such clamping exerts a high restraint on the assembly during processing and ultimately results in the development of residual stress because the contraction of the weld nugget under the tool pin and the heat-affected zone under the tool shoulder are prohibited during cooling (Ref. 2). Because heat transfer is rapid, i.e., rapid cooling, in the thin assembly geometry for this application, residual stresses in both the longitudinal and traverse directions are significant and are exacerbated by the differences in thermal conductivity of the two materials (aluminum and uranium). Combination of these high stresses results in the buckling of the assembly both before and during the bond pass. If left uncontrolled, the buckle will present an obstacle for the tool to traverse, and because load control is employed for bonding purposes, rather than depth control, the tool has a tendency to punch through or tear the upper workpiece. Initially, the tool load was allowed to drop if the buckling presented too large an obstacle for the tool, but this ultimately resulted in poor and undesirable bonding characteristics. A tool collar was then developed to allow for constant load without increasing buckling (Ref. 10).

Figure 7 presents a photograph and a schematic of an early tool collar design. The idea behind this design is to allow the collar to freely rotate with the tool. When the aluminum begins to buckle, the collar will come into contact with the buckled workpiece, and will no longer rotate. At this point, the applied downforce will also begin to act over the area of the collar, preventing the buckle from worsening to the point where the tool will punch through, so the collar behaves as a skid in front of the advancing tool. If the material does not buckle further, the collar will then begin to rotate with the tool once again.

Apparatus and Setup

Equipment Selection

A conventional 30-hP Kearney & Trecker milling machine configured in a vertical position is used for process feasibility and demonstration purposes to rotate the tool and provide applied down force. This milling machine moves the anvil in the transverse direction, rather than the tool itself. A photograph of the demonstration equipment setup is provided in Fig. 8. Within the spindle housing sits a HiTec Corp. donut-type load cell capable of reading loads up to 66.7 kN. A specially designed washer prevents the load cell from moving axially or spinning within the housing so that as a load is applied downward into the workpiece an equal and opposite force compresses the load cell within the washer.

A second, prototype FB unit has been procured by the Idaho National Laboratory from Transformation Technologies, Inc. (TTI). This model allows all of the common luxuries of modern processing equipment, e.g., almost unlimited data acquisition and types, real-time data display, and process feedback control. Use of the TTI unit is anticipated to further enhance the FB fabrication process for nuclear reactor fuel plates. This being said, knowledge and experience gained from using the modified Kearney & Trecker mill will prove invaluable for TTI startup, providing specific starting points and a clear cut operational envelope for this particular application. A photograph of the TTI unit is provided in Fig. 8 below the Kearney & Trecker mill.

Data Acquisition

The temperature inside the tool was recorded, along with the coolant inlet and outlet temperatures to the tool interior, by Omega Engineering Type K thermocouples. All data were acquired through an Agilent 34970A data acquisition unit at a frequency of 10 Hz, and logged to a desktop computer. An example of data collected from an FB run is provided in Fig. 9 for applied down force and coolant temperature above the tool face, and Fig. 10 shows data for the coolant inlet and coolant outlet temperatures. The profiles in both figures were obtained using a target applied down force of 44.5 kN, a tool rotational rate of 406 rev/min, and a tool traverse rate of 1.57 cm•s^{-1} (0.62 in.•s^{-1}).

Observation of Fig. 9 reveals that the tool temperature remains relatively stable over the course of a bond pass and over multiple passes. Conversely, the applied load varies significantly over the course of a bond pass, even though the average peak loads over multiple passes are relatively consistent with one another, i.e., close to the target load. The erratic nature of the applied load is the result of manual operator feedback, meaning that load control is manually applied after visual observation by the operator rather than by a process feedback computer control system.

Another observation from the typical process outputs is the increase in coolant inlet temperature over multiple bond passes — Fig. 10. The increase suggests that the cooling system is inadequate to remove the amount of heat input into the coolant by the process. Even with these initial equipment limitations, the process performs well with its intended application with a relatively low capital equipment and operational cost, to the point that fuel plate fabrication is considered ready for commercial demonstration and process scale-up.

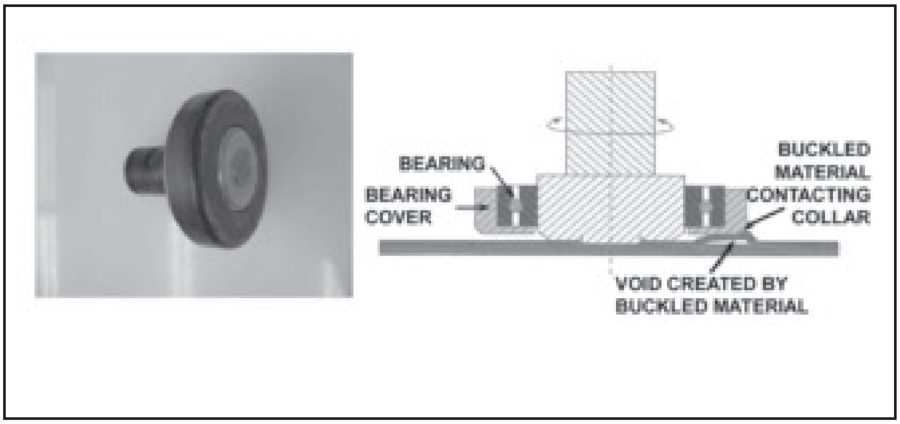


Fig. 7 — Photograph and schematic of an early tool collar design to prevent buckling of aluminum in advance of the FB tool. The modification was found to be extremely effective in minimizing buckling.

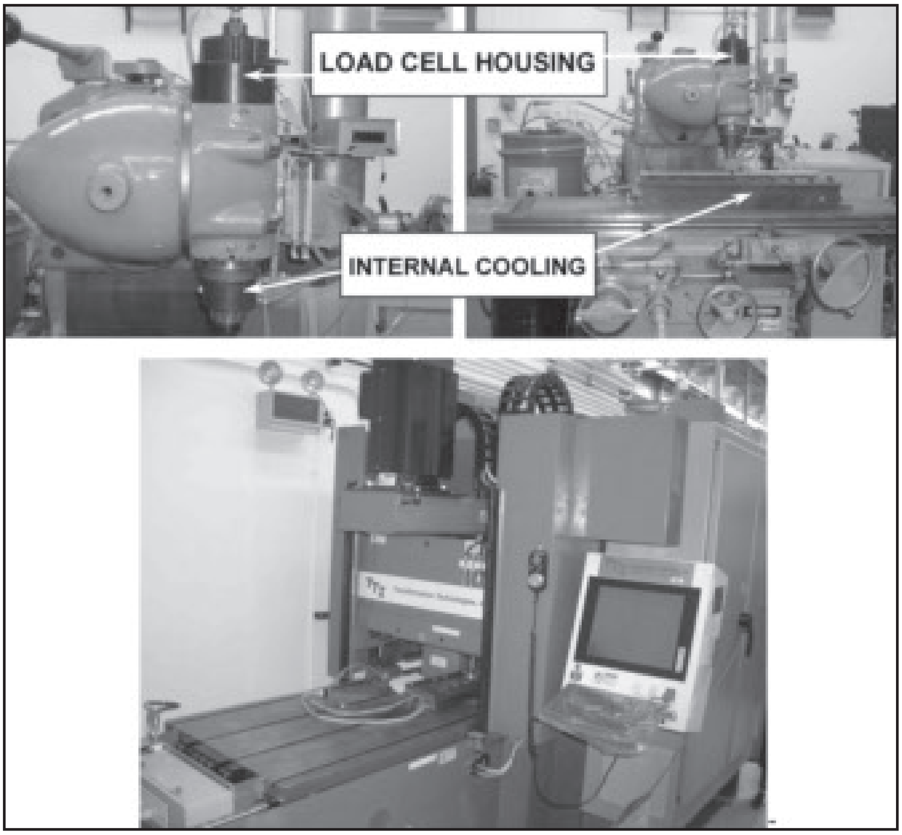


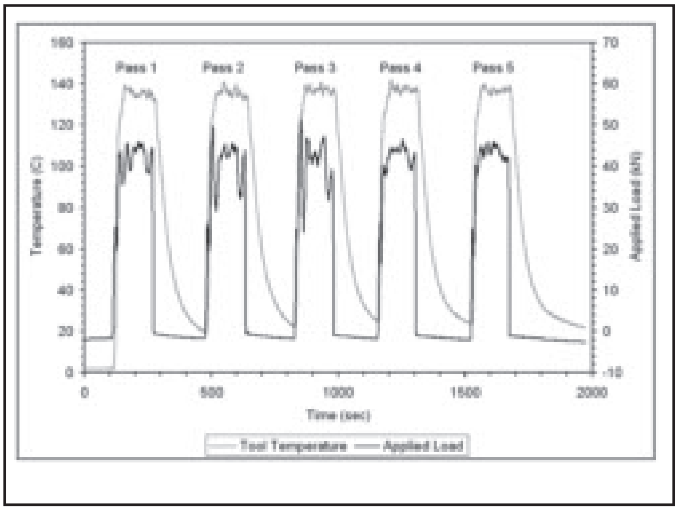
Fig. 8 — Photographs of the modified Kearney & Trecker mill showing the internally cooled tool holder and anvil base along with the load cell housing (top) and the TTI unit for next-generation commercial demonstration and scale-up (bottom).

Development of Process Parameters

Temperature Distribution

Typically, the two most frequently controlled process parameters for FSW are tool rotation rate and tool traverse speed. These parameters were found to be less influential on friction bonding than the applied load used to bond the cladding and fuel. The tool rotation rate is typically maintained at 406 rev/min, while the tool traverse speed is maintained at 1.57 cm•s^{-1} (0.62 in.•s^{-1}). These values are different from conventionally used and published FSW values, which can range from hundreds to thousands of rev/min and tool traverse speeds on the order of mm•s^{-1} rather than cm•s^{-1} . Increased tool traverse rates can significantly increase the weld coverage rate, resulting in less fabrication time and overall operational costs. However, process parameters to accomplish adequate bonding and acceptable surface finish will need to be optimized for a given process coverage rate, because the parameters affect material flow, temperature, and forging action. A similar increase in weld coverage rate was obtained by increasing the surface area of the tool, specifically, over the shoulder area because this portion of the tool does a majority of the work while the tool is in motion. For example, given a constant tool traverse rate and bond pass length, a larger tool diameter will provide more coverage area than a smaller tool diameter but will also increase the torque required to turn the tool. In addition, there is a trade-off between optimization of weld coverage rate and heat generation and temperature distribution across the tool surface.

This effect has been modeled thermodynamically, a graphical representation of which is provided in Fig. 11, and confirmed experimentally (Ref. 11). The effect can be improved by increasing applied downforce or tool rotational rate. However, applied down force is determined for the application by the monolithic fuel placed in the center. Minimally applied down force can result in insufficient bonding and disturbance to the foil by the ad-



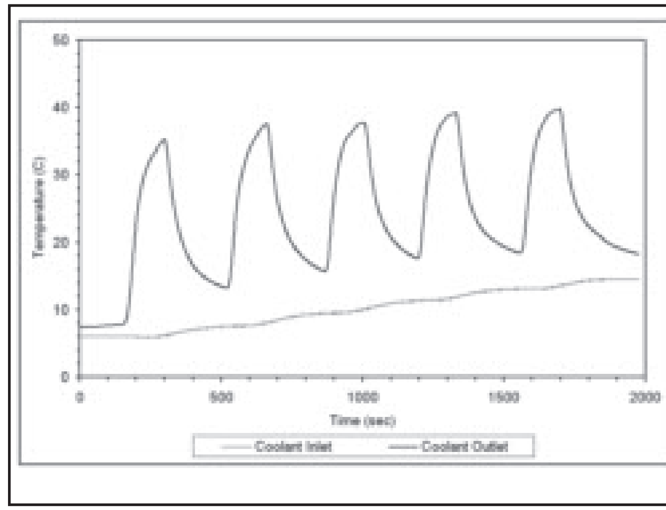


Fig. 9 — Typical data profile obtained from the load cell measuring applied down force of the tool and coolant temperature measured by the thermocouple placed directly above the tool face.

Fig. 10 — Typical data profile measured from in-line thermocouples for the coolant temperature going into the tool and coolant temperature coming out of the tool.

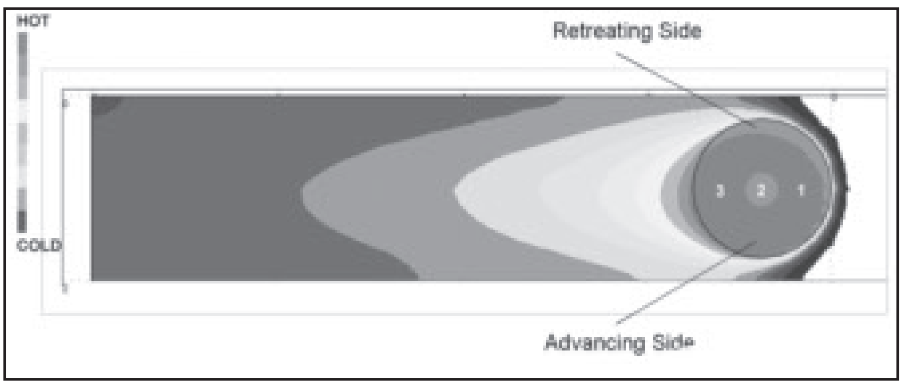


Fig. 11 — Thermodynamic model of the tool used for the current FB application. The snapshot shows that the advancing side of the tool is hotter than the retreating side and pin of the tool based on the grayscale coding map on the right. Model parameters were the same as those used for the experiment: 44.5 kN, 406 rev/min, and 1.57 cm•s^{-1}.

vancing edge of the tool because heating is caused primarily by the tool shoulder once the tool is in motion. Conversely, a higher applied down force can result in sufficient bonding, but this may cause damage to the foil due to increased heating contributions from the retreating edge and the pin that penetrates further into the thin workpiece.

Further examination of the thermodynamic model snapshot provided in Fig. 11 shows some intriguing properties of the tool geometry. Most notably, the advancing side of the tool is significantly hotter than the retreating side. This observation is opposite of what is typically expected of a FSW tool, where the retreating side of the tool is warmer than the advancing side of the tool (Ref. 12). The leading edge supplies heat to the cold material while the retreating edge supplies heat to preheated material. The short pin, however, still remains relatively cold, which is the case in geometries where a lengthy or threaded pin is employed. An example of a thermocouple trace placed at the joint interface under the mid-plane of the tool is provided in Fig. 12, which provides a graphical representation of the model. In Fig. 12, one can observe the preheating effect of the tool, the rapid increase in temperature as the advancing side of the tool passes over the thermocouple (location 1 in Fig. 11), followed by the drop in temperature as the pin passes over (location 2 in Fig. 11), and finally an increase in temperature, which is slightly greater than the advancing side, as the retreating side passes over (location 3 in Fig. 11). The most probable explanation for this difference lies in the thin geometry of the assembly being joined (i.e., approximately 1.6 mm (0.063 in.) as opposed to a more standard thickness of 6 mm (0.236 in.)) and because the anvil itself is cooled. Thus, the advancing edge of the tool still supplies heat to the cold material, increasing the temperature, but a portion of the heat is rapidly dissipated from the tool — at the substrate interface through the assembly — so that the retreating edge of the tool forges slightly cooler material. Basically, the tool geometry and application do not lend itself to preheating over the surface area of the tool, although some evidence of preheating ahead of the tool is believed to occur (Ref. 9). A photograph showing the narrow processing region from the advancing edge to the retreating edge is provided in Fig. 13.

Raster Pattern Effects

The raster pattern employed for fuel plate fabrication was also found to play a crucial role, both in fabrication economics and successful, high-yield fabrication rates. Typically, a one-way raster pattern is employed so that the passes made over the assembly surface are parallel to one another and all run in the same direction. This particular method requires a plunge and extraction at each end of the welding pass, increasing the time required for fabrication due to the travel from the extraction end back to the plunge end for a concurrent pass and the time required to plunge the tool into the workpiece because a dwell time is required to raise the bond area to the appropriate temperature. As many as nine passes may be required per side for bonding of a fuel plate 20 cm (8 in.) wide. Thus, anywhere from 4 to 8 min could be added to the time it takes to fabricate each fuel plate. The one-way raster pattern is illustrated graphically in Fig. 14.

A second raster pattern, referred to as a "true" raster, was investigated in order to save time. In other words, only one plunge and one extraction were made per side, which is also shown graphically in

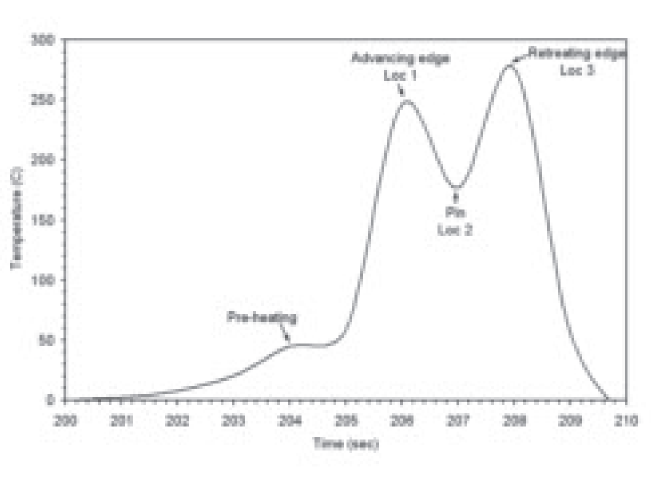


Fig. 12 — Single thermocouple trace at the joint interface under the midplane of the tool. A preheating effect can be observed prior to the arrival of the tool. The advancing edge (location 1), pin (location 2), and retreating edge (location 3) correspond to the locations of numbers 1, 2, and 3 in Fig. 11, and appear to correlate well with predicted temperature and behavior. The tool had a rotational rate of 406 rev/min, a traverse rate of 1.57 cm•s^{-1}, and an applied load of 44.5 kN.

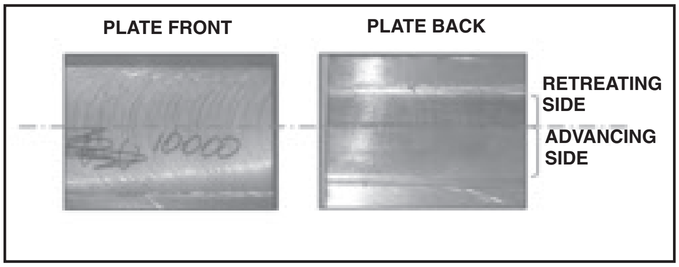


Fig. 13 — Photographs showing the nonuniformity in heat generation by the tool as observed on the bottom sheet being joined. Observation of the photograph on the left (the processed side or plate front) shows a uniform process region between the advancing side and retreating side. However, the photograph on the right (the nonprocessed side or plate back) shows a clear offset and lack of heat transfer from the retreating side of the tool.

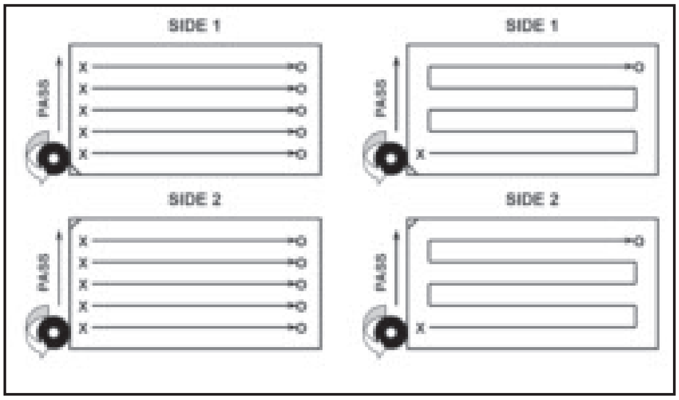


Fig. 14 — Schematic of two types of raster patterns investigated for the FB process. The two schematics on the left were found to produce assemblies with less warping since material movement is always in the same direction, producing less residual stress, but increases fabrication time because multiple insertions (X) and extractions (O) are required, in addition to increased tool travel time. The schematics on the right (true raster) were found to reduce fabrication time because only a single insertion (X) and extraction (O) is required, but this pattern tended to produce an assembly with greater warping and more residual stress because material movement changes direction as the tool traverse travel changes.

Fig. 14. The true raster pattern would not be possible for bonding of a 20-cm- (8-in.-) wide fuel plate without the cooled tool design because the tool would overheat and require extended pauses for heat to dissipate. Conditions between the workpiece surface and the tool could be adversely impacted if the tool were allowed to become too hot, similar to the example provided in Fig. 6A, including decreased friction coefficients, generation of hot spots and surface melting, and uncontrolled, detrimental tool penetration into the soft surface resulting in foil impact. One topic that has not been studied up to this point is the effect of raster pattern on the residual stress of the assembly. There are clear differences in the amount of buckling and twisting of the bound assemblies as a function of raster pattern, resulting from the material surrounding the bound area that is not subjected to the fabrication process, i.e., material left under the clamps. In most cases, the buckling and twisting is alleviated after the unbound material is sheared from the desired fuel assembly. However, future fabrication campaigns will require fabrication of curved fuel assemblies and as such, postfabrication buckling and twisting cannot be tolerated. Raster pattern and the influences this has on residual stress, bond integrity, and assembly buckling has been identified as crucial for fuel fabrication, and will be investigated in greater detail, although specific results are not available at this time.

Tool Tile Angle or Lack Thereof

Conventional FSW involves a slight tilt of the spindle toward the trailing edge of the tool. Tilting the spindle toward the workpiece ensures that the shoulder of the tool holds the stirred material by the threaded pin and, thus, efficiently moves material (Ref. 2). The spindle cannot be tilted for the current application because the tool design does not possess a sufficiently long pin and a shoulder diameter that amplifies the height differences between the front and back end of the tool for a given tilt angle, meaning it would only take a small angle before the shoulder depth would exceed the pin depth. Operation in this small angle window results in a material pileup at the outside of the tool, resulting in a wavy shape on the welded surface of the workpiece. The same wavy shape also occurs on the opposite side of the workpiece after welding, and, ultimately, material pileup on both sides of the workpiece results in a wavy monolithic foil. An example of a fuel plate fabricated using a tool with one degree of tool tilt, which illustrates this feature, is provided in Fig. 15. Also provided in Fig. 15 is an example of a fuel plate with the tool surface aligned perfectly parallel to the work surface, resulting in a uniform, straight monolithic foil encapsulated within the cladding. Furthermore, a majority of the longitudinal force is exerted by the tool shoulder and, thus, a zero-tilt angle requires less longitudinal force to accomplish the bond (Ref. 8).

Conclusions

This article shows how a simple modification of the FSW process is now well positioned for commercial fabrication of new research and test reactor nuclear fuel. Successful fabrication and qualification of this new plate-type nuclear fuel will enable the conversion of reactors currently operating on HEU to LEU, thereby decreasing nuclear proliferation concerns and risks. Solutions to challenges associated with this process, in addition to the novel process itself, offer information for

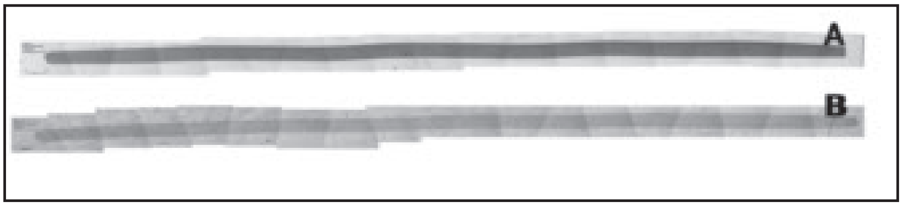


Fig. 15 — Example of a fuel plate fabricated with the weld tool oriented at approximately 1 deg to the normal of the weld surface resulting in a wavy foil (A) and of a fuel plate fabricated with the weld tool oriented at 90 deg to the weld surface, resulting in a significantly straighter foil (B).

users of the FSW process and a potential alternative fabrication technique for laminar composite structures.◆

Acknowledgments

This work was supported by the U.S. Department of Energy, Office of the National Nuclear Security Administration, under U.S. Department of Energy Idaho Operations Office Contract DE AC07 05ID14517. The FB process has been under continual development since 2004, and much of the progress could not have been made without continual support from the RERTR program and management. Furthermore, the authors would like to acknowledge Gaven Knighton for his role in the setup of initial scoping experiments, Michael Chapple who has continuously supported experiments, and Jared Wight who has been influential in the design of hardware for commercial demonstration of the process.

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Benefits of the Magnetic Pulse Process for Welding Dissimilar Metals

BY VICTOR SHRIBMAN AND MICHAEL BLAKELY

Since dissimilar metals can be joined with this method, complex joints may be replaced by simpler designs

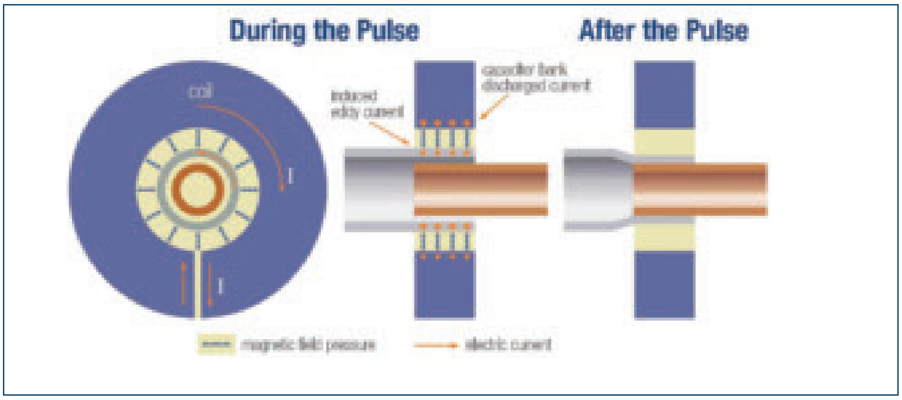

Fig. 1 — Basic concept of the magnetic pulse welding process.

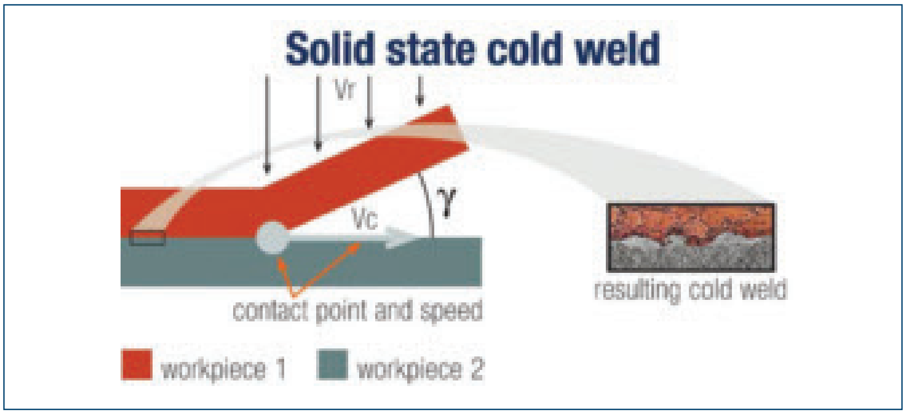

Fig. 2 — Solid-state cold weld.

The magnetic pulse welding (MPW) process, a cold solid-state welding process, is fast advancing toward industrial maturity with series production currently operating for a number of automotive projects.

During WW II, it was discovered that a hollow, conical metal-lined explosive charge could be used to create a high-energy, high-velocity jet to perforate armor plate (Refs. 1, 2). At the same time, ballistics research led to the discovery of welds produced by their oblique impact on metal targets (Ref. 3). These discoveries led to explosive welding (Refs. 4, 5) and, subsequently, when coil shattering was observed in nuclear research (Ref. 6), to its analogous process of MPW.

Magnetic pulse welding is accomplished by the magnetically driven, high-velocity, low-angle impact of two metal surfaces. At impact, the surfaces (which always have some level of oxidation) are stripped off and ejected by the closing angle of impact. The surfaces, which are now metallurgically pure, are pressed into intimate contact by the magnetic pressure, allowing valence electron sharing and atomic-level bonding. This process has been demonstrated in the joining of tubular configurations of a variety of metals and alloys.

Product designers are frequently constrained by the restrictions of traditional joining technologies, which place limitations on the type of joint, the materials that can be joined, and the quality of the joint. Solid-state welding allows manufacturers to significantly improve their product designs and production results by enabling both dissimilar and similar materials to be welded together, thus providing the opportunity to use lighter and stronger material combinations.

*VICTOR SHRIBMAN is with Pulsar Ltd., Yavne, Israel, and MICHAEL BLAKELY (*michaelblakely@hirotecamerica.com*) is with Hirotec America Inc., Auburn Hills, Mich.*

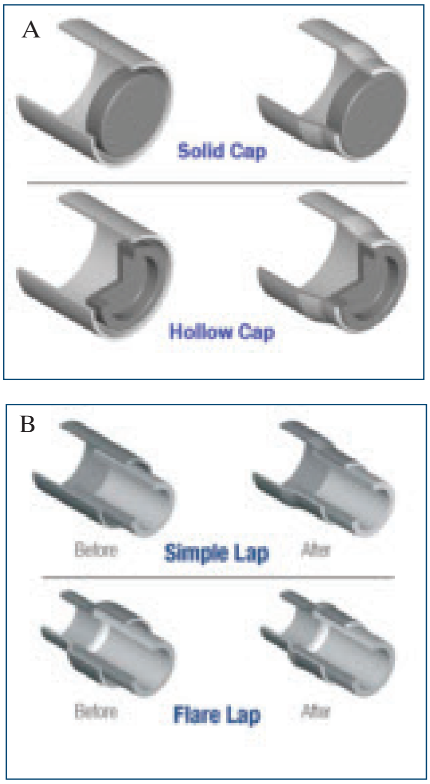

Fig. 3 — A — Capsule weld geometry; B — tube weld geometry.

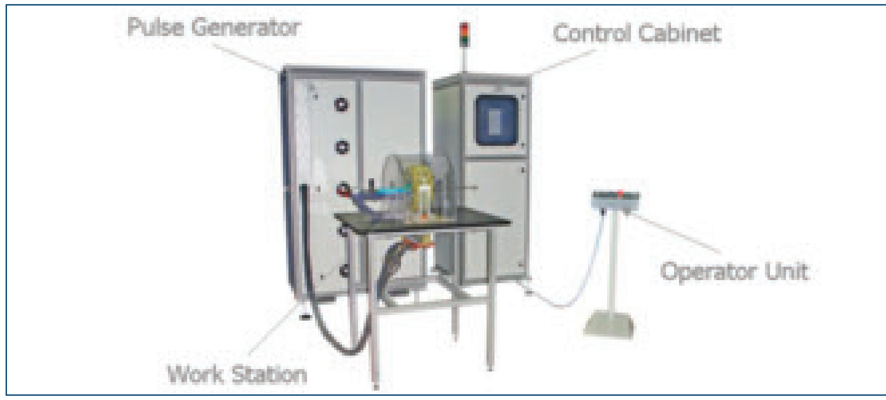

Fig. 4 — Typical system layout.

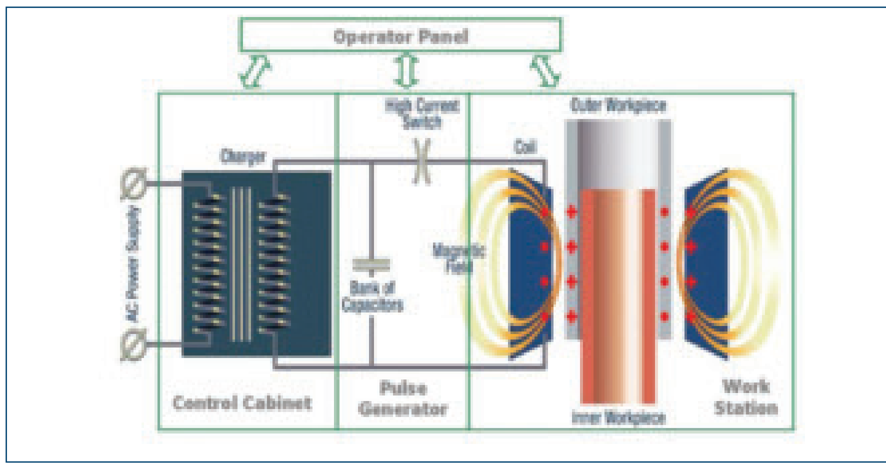

Fig. 5 — System schematic.

Basic Concepts of the Process

Figure 1 shows the essentials of the magnetic pulse system. A suitably high current is discharged through a cylindrical coil and as a result induces an eddy current on the outside surface of a conductive workpiece (outer part).

The two magnetic fields generated — one through the coil and the other on the conductive external part — strongly repel one another with a force proportional to the square of the discharge current. As a result, the external part is accelerated inward, away from the coil, with increasing high speed, pushing the metal well beyond its yield strength and into its plastic region. If the conditions are correct, i.e., tube velocity, collision point angle, and collision point velocity, jetting of the surface layers at the collision point occurs, resulting in a weld — Fig. 2.

As in explosive welding, a jet is created between the two bonded surfaces by the impact force acting upon them. This jetting action removes all traces of oxides and surface contaminants, allowing the magnetic-pressure-caused impact to plastically deform the metals for a short instant and to drive the mating surfaces together. This allows the impact of two virgin surfaces, stripped of their oxide layers, to be pressed together under very high pressure, bringing the atoms of each metal into close enough contact with each other, to allow the atomic forces of attraction to come into play. There are a number of explanations for the precise mechanism at the point of collision, but all agree that the metals momentarily behave like liquids, even though they remain solid. Due to the rapidity of the process, temperatures at the interface do not rise significantly. For this reason, it is possible to permanently bond widely dissimilar metals. The quality of the bond at the interface is a product of many parameters, among them the magnetic force, the collision angle, the collision point velocity, and the initial standoff distance between the mating surfaces. Typically, the pressures at the collision point between the mating surfaces are of the order of 100,000 MPa (~15 million lb/in.^{2}), as measured by explosive welding researchers.

Geometry of the Joint

Figure 3 shows the typical part geometries before and after the welding process, for both hermetically sealed capsules (Fig. 3A) and for tubes (Fig. 3B). In all cases the weld is a lap weld, in which there is an initial mandatory root opening between the surfaces to be welded. Note that the weld is always accompanied by deformation in the welded area, as shown in Fig. 3.

System Layout

A typical magnetic pulse system is shown in Fig. 4. The system consists of four units: pulse generator, control cabinet, operator unit, and workstation. In the system shown in Fig. 4, the workstation has the coil mounted on it with a horizontal axis. The coil may also be mounted with its axis in the vertical direction, depending on what the manual, semiautomatic, or automatic feeding system requires.

Magnetic pulse machines are designed and built to meet the safety requirements of EN 60204, *Safety of Machinery — Electrical Equipment of Machines*, ANSI C57.12.58-1999, and IEEE Standard C95.1, 1999 edition for EMF exposure compliance. The meeting of these specification requirements ensures the safety aspects of the machines and their operation.

The System Schematic

The basic pulse generator schematic is

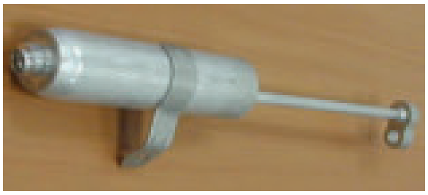

Fig. 6 — Automotive Al A/C receiver dryer.

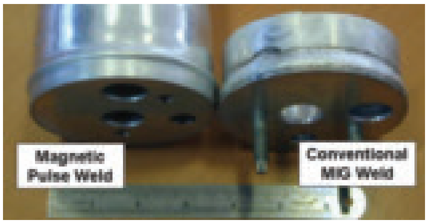

Fig. 9 — An automotive Al A/C accumulator built with MPW (left) and GMAW.

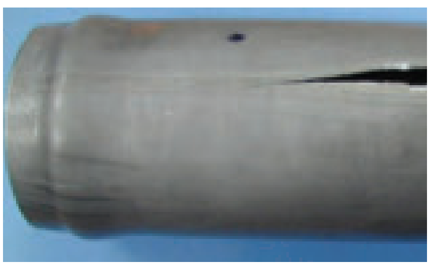

Fig. 12 — Burst test failure occurs in capsule remote from the weld.

shown in Fig. 5, in which the system is comprised of four parts: control cabinet, pulse generator, workstation, and operator panel. Each operation requires a charge/discharge cycle. With the high current switch open, an AC power supply (with a 16-A fuse or less) is applied to the charger, converted to DC, to charge up the bank of capacitors to the charge voltage, preset to precisely achieve the energy required for the weld operation. This process may take from tens of seconds down to a small number of seconds, depending on the power supply. When the system is charged to the precise energy level required, and the part to be treated is positioned correctly in the coil, creating the magnetic fields involved in the process, as described earlier, the switch is closed, current flows from the capacitor through the coil, causing magnetic flux to expand rapidly from the coil winding and outward. The pulse duration is measured in tens of microseconds. The operator panel controls this operation.

Typical Weld Applications

Magnetic pulse welding is particularly suitable for large series production and for automated feeding systems. For example, the application shown in Fig. 6, an automotive air-conditioner receiver dryer

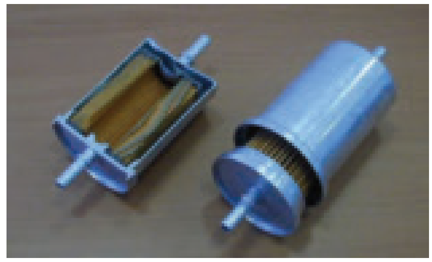

Fig. 7 — Automotive Al fuel filter.

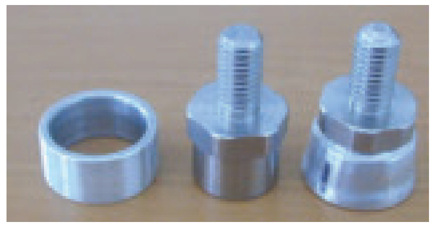

Fig. 10 — Automotive earth connector — Al/stainless steel.

made from Al 6061 material, is produced in production lots of 2000 to 3000 units per shift.

Figure 7 shows an automotive fuel filter manufactured from Al 1060 material. This product must survive 150,000 cycles at 7 bars pressure cycling to meet the specification requirements.

Figure 8 shows a high-pressure capsule manufactured from 7075-T6 material. This is a material that cannot be welded by conventional arc processes due to its zinc content. Figure 9 compares automotive air-conditioner accumulator MPW and gas metal arc (GMA) welds, both produced in 6061-T6. Apart from the higher strength of the joint, the higher quality seal produced, and the lower production defect level achieved, the MPW wins on aesthetics. In addition, no postweld finishing is required for MPW-produced parts. The process is also capable of producing rectangular and elliptical tubular Al weld cross sections, in addition to rounds.

Figure 10 shows the versatility of the process, through the creation of good welded joints between Al 6060-T7 and SS304, or Al 3003-H14 to SS304, for an automotive earth connector. This part is subsequently friction welded to the aluminum car chassis.

Weld Quality

Figures 11 and 12 show the high weld quality achieved by this solid-state cold welding process. Figure 11 shows the result of a torsion test made on an Al 6061-T6 OD 102 × 2.2-mm wall driveshaft. This part failed above 6000 Nm and also performed satisfactorily in torsional fatigue testing.

Fig. 8 — An Al 7075-T6 high-pressure capsule.

Fig. 11 — Torsion test failure occurs in shaft remote from the weld.

Figure 12 illustrates a good burst test result for a weld of an Al 6082-T6 CO_2 accumulator application. It is required to survive 264 bars pressure and normally fails at pressures in the region of 400 bars, remote from the weld.

Metallography

Figure 13A–D shows examples of metallographic sections of interfaces of various welds made by MPW. These show the high quality of this type of joint, without any sign of a heat-affected zone.

Weld Benefits

Magnetic pulse welding provides the following benefits:

- Simpler designs and also designs that were previously impossible by conventional means, e.g., Al to steel and stainless steel, or Al to Cu welds. It provides the advantage of higher strength-to-weight ratio.
- MPW provides a cold weld. A metallurgical bond is produced without any heat-affected zone. Therefore, the original heat treatment properties are maintained by this cold weld and thus, better joint properties are achieved.
- Dissimilar material combinations are available with this method and thus complex joints may be replaced by simpler joints.
- Apart from higher process weld speed, there is a significant quality improvement with this system, e.g., there is no corrosion problem in the welded area, a fact proven by salt spray testing.

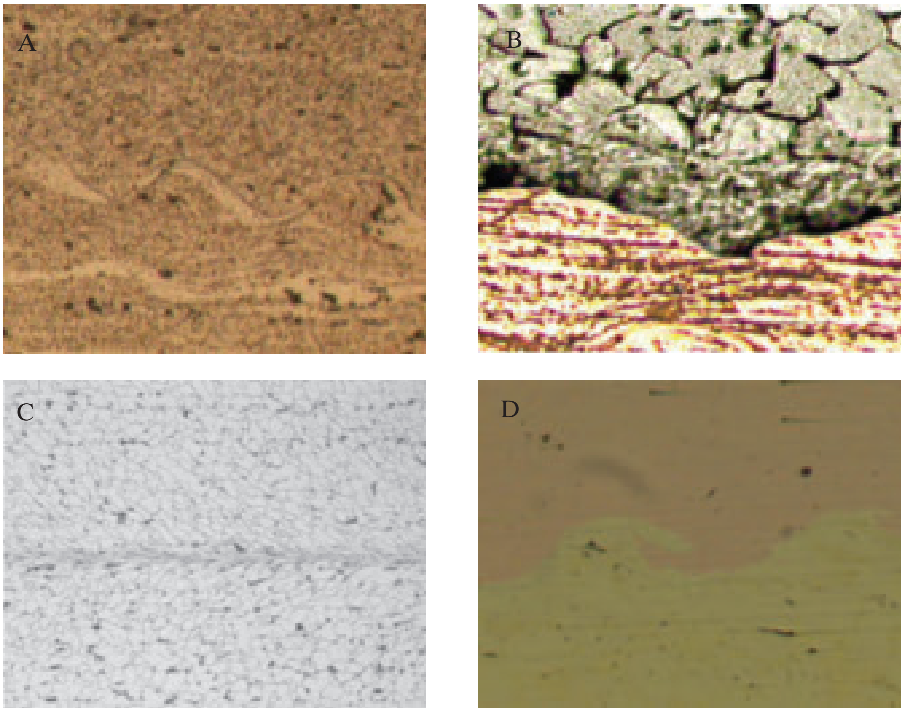

Fig. 13 — Metallographic sections of weld interfaces of various MP welds. A — Al 6082-T6 (etched); B — Al/steel (etched); C — low-carbon steel (etched); D — copper/brass (unetched).

• Parameters are stable and reliable with less parameters to control than with conventional processes, minimal rework is required and minimal scrap is produced.

Finally, in this "green" process, parts produced are more aesthetic than those of competing conventional processes and do not require any postweld cleaning or finishing. ◆

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Titanium Friction Stir Welding and Laser Welding Development for Commercial Aircraft
Daniel G. Sanders, Senior Technical Fellow, Director of M&P Science, Materials & Process Technology, The Boeing Co., Seattle, WA

Potential Uses for Fiber Lasers in Aerospace Applications
Paul Denney, Laser Researcher, Connecticut Center for Advanced Technology, Inc., East Hartford, CT

Friction Stir Weld Assembly of the Eclipse 500 Very Light Jet
Brent Christner, Manager, Materials and Process Engineering, Eclipse Aviation, Albuquerque, NM

Electron Beam System Technology for Welding and Additive Manufacturing
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Development of Third Generation of Aluminum Lithium Alloys
Michael Niedzinski, Director of Technology and Standardization USA, Alcan Aerospace, Chicago, IL

Returning to the Moon: Welding and Fabrication of the Ares I Upper Stage Hardware at Marshall Space Flight Center
Jeff Ding, Aerospace Welding Engineer, NASA Marshall Space Flight Center, Huntsville, AL

Path Independence of Friction Stir Welding
Dr. Dwight Burford, Senior Research Scientist, Director, Advanced Joining & Processing, National Institute for Aviation Research, Wichita State University, Wichita, KS

Aerospace Gas Tungsten Welding
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Eric Stiles, Applications Manager, IPG Midwest Operations, IPG Photonics, Wixom, MI

Laser Weldbonding of Thin Aluminum Structures
George Ritter, Technology Leader, Plastics and Adhesives, Edison Welding Institute, Columbus, OH

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Rich Plourde, Director, Aerospace and Defense Business Development, Optomec, Inc., Albuquerque, NM

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Michael Turner, Advanced Technical Sales, Olympus NDT, Kansas City, MO

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During the AWS Opening Session and 89th Annual Business Meeting, 2008 AWS President Gene E. Lawson will give the Presidential Report and Victor Y. Matthews will be inducted as AWS President for 2009. Following the induction, the 2008 Class of AWS Counselors and Fellows will also be introduced. This meeting is open to all AWS Members and Show registrants.

11:00 a.m. – Noon — Room S222

Comfort A. Adams Lecture — Welding in the Deep Oceans: Conquest of the Other Frontier!

Stephen Liu, PhD, CEng, FAWS, FASME, FASM, is this year's Adams Lecturer. Dr. Liu is a Professor of Metallurgical and Materials Engineering and Director, Center for Welding, Joining and Coatings Research at the Colorado School of Mines. He holds degrees in Industrial Chemistry and Metallurgical Engineering from the Escola Técnica Federal de Minas Gerais and the Escola de Engenharia da Universidade Federal de Minas Gerais in Brazil. He received his Ph.D. degree in Metallurgical Engineering from the Colorado School of Mines. 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.

11:30 a.m. – 1:30 p.m. — Room S223

Image of Welding Awards Ceremony

Join the AWS Image of Welding Committee (a subcommittee of the Welding Equipment Manufacturers Committee) and special guests as they salute this year's heroes of welding. Individuals and organizations will be honored at this special ceremony for their outstanding public initiatives and programs that promote the image of welding throughout their communities. To reserve your seat, RSVP by September 5 to AWS Image of Welding Awards at 800-443-9353, or e-mail image@aws.org.

6:30 – 8:00 p.m. Las Vegas Hilton Ballroom A

AWS Officers/Presidents/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, October 7
Noon – 1:30 p.m. • Price: $30 Room S223

AWS Awards/AWS Foundation Recognition Ceremony & Luncheon

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 is open to all registrants. For advance reservations, register on line 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.

2:00 – 3:00 p.m. Room S215/S216

AWS National Nominating Committee – Open Meeting

AWS Members are requested to submit their recommendations for National Officers to serve during 2010. 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.

Wednesday, October 8
10:00 a.m. (American Council of IIW meeting immediately following lecture at 10:30 a.m.) Room S231

R. D. Thomas, Jr., International Lecture – Global Relevance of International Standards

Carl-Gustaf Lindewald, Chair of IAB/WGA3a, Welder's Guidelines, and Finnish delegate for ISO/TC 44 and ISO/TC 44/SC 5 (testing of welds), SC 7 (terminology), SC 10 (welding procedures), and SC 11 (welding personnel), 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 illustrating the incorporation of global studies in the standardization of welding technology during the AWS Welding Show and at the Annual Assembly of the IIW.

Other Special Events

Sunday, October 5
8:30 a.m. Shotgun Start

Golf Outing — Las Vegas Paiute Golf Resort

Attendees and exhibitors are invited to play a round of golf at the pristine Las Vegas Paiute Golf Resort, located just 30 minutes northwest of downtown Las Vegas at the base of the picturesque Spring Mountains. This is a perfect opportunity to arrive a day early in Las Vegas to mix, mingle, and network with other industry professionals in an intimate setting before the show begins!

The fee is $175 per golfer, which includes greens fees, cart, range balls, continental breakfast, lunch, prizes, and transportation. The golf outing is open to everyone, but space is limited. Reservations will be taken on a first-come, first-served basis. For more information or to download a reservation form, visit one of the event Web sites today!

Monday, October 6
8:00 – 9:00 a.m.
Registration Code: K1 • FREE Room S233

Monday Keynote Address: Embracing the Challenges of Manufacturing in a Global Economy

Jim Waters, VP of Production Systems, Caterpillar

The world is getting smaller, causing many to question the future of manufacturing in the industrialized world. The expansion of global manufacturing poses many challenges, but also opens doors to numerous possibilities. As the world's largest maker of construction and mining equipment, Caterpillar has embraced globalism to become a stronger company that successfully manufactures on several continents. During this forward-looking presentation, hear Jim Waters offer reasons why we can, how we can, and why we must rise up and take advantage of this competitive challenge.

9:00 a.m. – Noon (morning session)
Registration Code: W95 • FREE Room S231
or 1:30 – 4:30 p.m. (afternoon session)
Registration Code: W96 • FREE Room S231

Learn About Thermal Spray Seminar

Presented by The International Thermal Spray Association (ITSA). Instructor: James Weber

This basic introduction to thermal spray benefits will cover four major areas: processes, equipment, applications, and industry usage.

- Processes covered will include molten metal flame spraying, powder flame spraying, wire flame spraying, ceramic rod flame spraying, detonation flame spraying, high-velocity oxy/fuel spraying (HVOF), cold spraying, plasma spraying, electric arc spraying, and RF plasma spraying
- Equipment will be on display. Several spray guns will be available for attendees to handle and discuss throughout the class. Other larger items such as complex systems and spray booths will be illustrated and discussed.
- Application examples will be presented for a variety of requirements from several different industries.
- Industry usage charts will be reviewed listing several processes and coating applications used by various industries.

Tuesday, October 7
8:00 – 9:00 a.m.
Registration Code: K2 • FREE Room S233

Tuesday Keynote Address: Inspiring Future Generations to Lead the World in Innovation

Dean Kamen, Founder of FIRST, President of DEKA Research & Development Corporation, Inventor

As an inventor and entrepreneur, Dean Kamen believes in the power of innovation. Innovation is the key to keeping U.S. manufacturing competitive in a global economy, but it depends on a well-educated and skilled workforce. During this high-impact presentation, Dean Kamen will discuss the importance of getting our nation's youth excited about careers in science, technology and engineering and cultivating an environment that encourages creativity and risk-taking. Drawing on his own extraordinary experiences and successes, he'll provide insights on what business leaders and society can do today to increase our capacity to innovate and ensure a strong manufacturing future for years to come.

Wednesday, October 8
8:00 – 9:30 a.m.
Registration Code: F1 Room S212
Breakfast provided. Advance registration is required.
$99 registration fee.

Executive Forum Breakfast

"Competing – and Winning – In the Changing Global Value Chain"
Bill Canis, Vice President, Manufacturing Institute
Manufacturing remains a pillar of the U.S. economy and is a major contributor to its growth. However, the pressure of a globalizing economy has many manufacturers seeking ways to be more competitive. During this important session, designed exclusively for company leaders and decision-makers, Bill Canis from the National Association of Manufacturers will highlight the costs that undercut U.S. manufacturers and discuss four major new growth opportunities in the changing supply chain that are crucial for all manufacturers who want to position their companies for success in today's global marketplace.

1:00 – 3:00 p.m.
FREE Room S231

Best Practices to Save Structural Steel Fabricators Money

Do you truly have control over your shop floor, or does profit leak from your operation after every unnecessary delay or error. After visiting over 1200 fabricators worldwide in the past five years, Mike Mauris and Terry Logan will guide you through ideas that will help today's fabricator. This session is for the fabrication and quality professional seeking better solutions. During this session, you will be introduced to some of the best methods observed in over 1000 structural steel shops worldwide. Sample some of the best opportunities to increase productivity and cost avoidance events from

- Smarter material handling practices
- Faster throughput from adjusting process flow
- Welding process selection and improvement
- Reduced cleanup
- Spotting trends with visual tools
- Paint process monitoring for cost savings

Learn sensible methods to target and beat persistent problems on the shop floor.

Free Business Improvement Seminars

Monday, October 6
12:30 – 1:30 p.m.
Registration Code: B1 • FREE Room S233

Taming the Product Liability Beast: Ten Things You Can Do to Protect Yourself

Gary M. Glass, Thompson Hine
Companies involved in metal forming, fabricating, and welding face enormous risks every day of potentially catastrophic product liability lawsuits. In this informative session, Thompson Hine product liability litigator Gary Glass will present you with the top ten things that your company can do — and should do — to protect itself. Drawing from real-life case studies, Glass will share some entertaining (and sometimes frightening) examples of what works and what doesn't.

Tuesday, October 7
12:30 – 1:30 p.m.
Registration Code: B2 • FREE Room S233

Helping Fabricators Make Sense of the Economy

Chris Kuehl, Global Economist
Economists and their statistics help us comprehend our world, but most people are overwhelmed by the contradictions and at a loss as to what to do with all the data. The challenge is to strip out all the fluff and generalities and get down to what impacts you and your industry. It doesn't matter what the national GDP is, or what the trade deficit might be — what matters is the production data in a specific sector and what trade opportunities do and do not exist. Kuehl will examine what's been driving the talk of recession, the weak dollar, and rising oil and commodity prices — and what it all means for sourcing decisions.

Wednesday, October 8
12:30 – 1:30 p.m.
Registration Code: B3 • FREE Room S233

Workforce Development — Today's Issues

Most fabricators have felt the sting of how tough it is to find, hire, and retain qualified welders and sheet metal fabrication workers. This panel will discuss the strategies to building a competitive manufacturing workforce. Hear representatives from the local government and academic community, as well as the manufacturing sector share what is working and what needs to be done to increase our skilled workforce. Learn how you can be part of the solution!
Panel Discussion:
James R. Warren, Director of Education, FMA
Granville L. Brown, Director, Technical & Industrial Education Programs, Division of Workforce & Economic Development, College of Southern Nevada
Joe Chiaramonte, Plant Manager, Midwest Metal Products
Terry Culp, Business Manager, Management Assistance

AWS Skills Competition Weld-Off

Monday & Tuesday, October 6–7
9:00 a.m. – 5:00 p.m.

Wednesday, October 8
9:00 a.m. – 3:00 p.m.
South Hall – 2nd Floor Booth 14000

The AWS Skills Competition Committee will showcase six finalists selected from 24 student welders who competed in the SkillsUSA Championships in 2007 and 2008. They will test their skills in this qualifying event for the WorldSkills Competition in Calgary, Alberta, Canada in 2009, and only three will advance to the next round.

Don't miss the chance to see competitors demonstrate their skills by completing standard test weldments (plate and pipe), sheet metal projects in aluminum and stainless steel, and a pressure vessel. Welds will be judged for soundness and appearance. Written skills and welding code interpretation will also be judged.

Ultimately, the 2009 TeamUSA Welder who will represent the U.S. at WorldSkills will be selected at the US Open Weld Trials in summer 2009. This winner will receive a four-year scholarship worth $40,000 from the AWS Foundation and sponsored by The Miller Electric Manufacturing Co., a four-year AWS membership, an AWS Certification, and up to $1,000 in AWS publications.

SHOW EVENTS AT A GLANCE

Monday, October 6

Tracks			8:00 a.m.	9:00 a.m.	10:00 a.m.	11:00 a.m.	12:00 p.m.	1:00 p.m.	2:00 p.m.	3:00 p.m.	4:00 p.m.	5:00 p.m.
AWS	Conferences	Welding Sessions		Welding Education Conference *(W80)*								
AWS	Conferences	Welding Sessions	New Technologies in Thermal Cutting Conference *(W81)*									
AWS	Seminars	Welding Sessions	Road Map Through the D1.1:2008 Structural Welding Code – Steel *(W84)*									
AWS	Seminars	Welding Sessions	Visual Inspection Workshop *(W85)*									
AWS	RWMA School	Welding Sessions										
AWS	Professional Program	Welding Sessions						Industrial Applications of Welding/Joining Technologies *(W90)*				
AWS	Professional Program	Welding Sessions						Welding Process Sensing & Control *(W90)*				
AWS	Professional Program	Welding Sessions						Weldability of Materials *(W90)*				
AWS	Free Programs	Welding Sessions		AWS Annual Business Meeting		Adams Lecture						
AWS	Free Programs	Welding Sessions				Image of Welding Awards						
AWS	Free Programs	Welding Sessions		Learn About Thermal Spray *(W95)*				Learn About Thermal Spray *(W96)*				
AWS	Free Programs	Welding Sessions		AWS Skills Competition Weld-Off								
Show Events		General	Keynote (K1) *Embracing the Challenges of Manufacturing in a Global Economy*	Show Opening Ceremony *8:45–9:00 a.m.*			Business Seminar *(B1)* *Product Liability*					
FABTECH	Educational Sessions	Automation										
FABTECH	Educational Sessions	Cutting										
FABTECH	Educational Sessions	Fabricating/ Forming			Roll Forming—Fundamentals *(F10)*			Roll Forming Tooling *(F20)*				
FABTECH	Educational Sessions	Lasers			**New** Laser 101 with Tech Tour *(F11)*			**New** Laser System Considerations for First-time Buyers *(F21)*				
FABTECH	Educational Sessions	Lean/ Operations			Lean 101 - Principles of Lean Manufacturing *(F12)*			Lean 202 – Advanced Value Stream Mapping *(F22)*				
FABTECH	Educational Sessions	Management			**New** Driving Up Productivity – *The Key is Increasing Employee Commitment & Engagement (F13)*			Strategic Planning for Job Shop Owners *(F23)* R&D Tax Credit *(F24)*				
FABTECH	Educational Sessions	Materials, Processes			Adding Powder Coating Capabilities to the Job Shop *(F14)*			Adding Liquid Paint Capabilities to the Job Shop *(F25)*				
FABTECH	Educational Sessions	Stamping						**New** What's New in Stamping with Tech Tour *(F26)*				
FABTECH	Educational Sessions	Tube & Pipe										

SHOW EVENTS AT A GLANCE

Tuesday, October 7

TRACKS: 8:00 a.m. · 9:00 a.m. · 10:00 a.m. · 11:00 a.m. · 12:00 p.m. · 1:00 p.m. · 2:00 p.m. · 3:00 p.m. · 4:00 p.m. · 5:00 p.m.

AWS — Welding Sessions

Conferences
- New Nondestructive Testing Technologies Conference *(W82)*

Seminars
- Why and How of Welding Procedure Specifications *(W86)*
- Metallurgy Applied to Everyday Welding *(W87)*
- Welding of Stainless Steels • *Day 1 (W88)*

RWMA School
- RWMA Welding School • *7:45 a.m. – 5:30 p.m. • Day 1 (W89)*

Professional Program
- Shipbuilding Research and Development *(W91)*
- Enhancing Corrosion Resistance of Weldments *(W91)*
- Welding/Joining in Automotive Applications *(W91)*
- Friction Stir & Solid-State Welding *(W91)*
- Welding Metallurgy *(W91)*
- Arc Welding Applications *(W91)*

Free Programs
- Education Sessions *(W97)*
- Plummer Lecture
- Higher Education Update
- AWS Awards/Foundation Recognition Ceremony
- Updates on AWS Education Activities
- National Nominating Committee
- AWS Skills Competition Weld-Off

Show Events

General
- Keynote *(K2)* *Inspiring Future Generations to Lead the World in Innovation*
- Business Seminar *(B2)* *Helping Fabricators Make Sense Out of the Economy*

FABTECH — Educational Sessions

Automation
- New Productive Robotics 101 for Fabricators with Tech Tour *(F30)*
- Automated Non-contact & Vision with Tech Tour *(F40)*

Cutting
- Comparative Cutting with Tech Tour *(F31)*
- Laser Cutting Technology *(F41)*
- Waterjet Cutting Advancements *(F50)*

Fabricating/Forming
- New Coil Slitting with Tech Tour *(F32)*
- New Coil Leveling with Tech Tour *(F42)*
- New Punch Presses with Tech Tour *(F51)*

Lasers

Lean/Operations
- Lean 203 – 5S Workplace Organization and Standardization *(F33)*
- Demand Pull in the Fabrication Job Shop *(F43)*
- Total Productive Maintenance for the Fabrication Job Shop *(F52)*
- New Machine Safeguarding with Tech Tour *(F53)*

Management
- New Why Lean Manufacturing is Green Manufacturing *(F34)*
- New Economist Playbook for Growing your Accounts *(F35)*
- New Market Warfare: Tactics to Increase Leads, Sales & Margins *(F44)*
- New Seven Deadly Mistakes Manufacturers Make and How to Avoid Them *(F54)*

Materials, Processes
- Fabricating of Stainless Steel *(F45)*

Stamping
- Introduction to Metal Formability *(F36)*
- New Evaluating to Purchase New or Used Equipment *(F46)*
- Solutions for Stamping Press Operations & Set-up *(F55)*

Tube & Pipe
- New Tube & Pipe Production with Tech Tour *(F37)*
- New Tube & Pipe Fabrication with Tech Tour *(F47)*
- New Tube Fabrication 101 *(F56)*

Wednesday, October 8

SHOW EVENTS AT A GLANCE

	TRACKS	8:00 a.m.	9:00 a.m.	10:00 a.m.	11:00 a.m.	12:00 p.m.	1:00 p.m.	2:00 p.m.	3:00 p.m.	4:00 p.m.	5:00 p.m.
AWS – Conferences	Welding Sessions	Friction Stir Welding Conference *(W82)*									
AWS – Seminars	Welding Sessions	Welding of Stainless Steels • *Day 2 (W88)*									
AWS – RWMA School	Welding Sessions	RWMA Welding School • *8:00 a.m. – 4:00 p.m.* • *Day 2 (W89)*									
AWS – Professional Program	Welding Sessions	Advances in Welding in South America *(W92)*	Welding Research Needs in the Energy Industry *(W92)* Filler Metal Research and Development *(W92)* Electron Beam Welding *(W92)*				Welding Process and Properties Modeling *(W92)* Laser Beam Welding *(W92)* Weld Joint Properties and Design *(W92)*				
AWS – Free Programs	Welding Sessions		Education Session: Education in Energy *(W97)* AWS Skills Competition Weld-Off	Thomas Lecture/ IIW Meeting							
Show Events	General	Executive Forum Breakfast (F1) *Competing and Winning – in the Changing Global Value Chain*				Business Seminar *(B3)* *Workforce Development*					
FABTECH Educational Sessions	Automation										
	Cutting	Plasma Plate & Structural Cutting *(F60)*									
	Fabricating/ Forming	Press Brakes with Tech Tour *(F61)*		*New* Troubleshooting Press Brakes *(F70)*							
	Lasers										
	Lean/ Operations	Optimizing High Variation Operations: Lessons for Fabricators and Specialty Manufacturers *(F62)*		*New* Cost Estimating for Job Shops *(F71)*							
	Management	*New* Lean Leadership *(F63)*		Lean Accounting and Metrics: Scorecards for High Performance *(F72)*							
	Materials, Processes	*New* Fabricating of HSS (High Strength Steels) *(F64)*									
	Stamping	*New* Press Maintenance *(F65)*		*New* Die Maintenance *(F73)*							
	Tube & Pipe	*New* Cost Effective Hydroforming Applications *(F66)*									

The 2008 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 stir welding, thermal cutting, NDE technology, 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 2008 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, or PMA: $225; Nonmember: $360 (Code W93)
3-day Student Professional Program for Member of AWS, FMA, SME, NAM, or PMA: $75; Nonmember: $90 (Code W94)
1-day Professional Program (Monday [W90], Tuesday [W91], or Wednesday [W92] only) for Member of AWS, FMA, SME, NAM, or PMA: $150; Nonmember: $285

Monday, October 6
8:00 a.m. – noon **Room S228**

Panel Chair: Dr. Y. Flom, NASA Goddard Space Flight Center

Panel Discussion: Evaluation of Strength Margins and Allowables in Brazed Joints (Professional Program registration not required for attendance at this session.)

Monday, October 6
1:30 p.m. – 5:00 p.m.

Session 1: Room S225
INDUSTRIAL APPLICATIONS OF WELDING/JOINING TECHNOLOGIES

Chair: Todd E. Holverson, Miller Electric Mfg. Co. Appleton, Wis.

A. 1:30 p.m. **"Thermal Spray Technology, Serving as Modern Surfacing and Repair Method in Modern Industry"**
by Fred van Rodijnen, Sulzer Metco OSU GmbH, Duisburg, NRW, Germany

B. 2:00 p.m. **"Applying Lean to Wire Dispensing for GMAW"**
by Viwek Vaidya, Air Liquide Canada, Inc., Montreal, Canada, and Ed Cooper, Elco Enterprises, Inc., Jackson, Mich.

C. 2:30 p.m. **"Cold-Metal Transfer (CMT) — Applications in the Automotive Industry"**
by Gerald Obritzberger, Fronius USA, Brighton, Mich.

D. 3:00 p.m. **"Shielding Gas Blends for Welding in Face of Helium Shortage"**
by Viwek Vaidya, Air Liquide Canada, Inc., Montreal, Canada, Bryan George, Air Liquide, Palm Coast, Fla., and Charles Caristan, Air Liquide Industries US LP, Houston, Tex.

E. 3:30 p.m. **"Magnetic Pulse Welding: Principles and Applications"**
by Jianhui Shang, Hirotec America, Inc., Auburn Hills, Mich., and Victor Shribman, Pulsar, Ltd., Yavne, Israel

F. 4:00 p.m. **"Integrated Internet Tracking of Manufactured Components Using Unique Machine Readable Identification"**
by Kevin McGushion, Exel Orbital Systems, Inc., Simi Valley, Calif.

Session 2: Room S226
WELDING PROCESS SENSING AND CONTROL

Chair: Yu-Ming Zhang, University of Kentucky, Lexington, Ky.

A. 1:30 p.m. **"Spatter Reduction of Stainless Steel Sheets GMAW Using CBT Process"**
by Matthew Brooks, OTC DAIHEN Inc., Tipp City, Ohio, Tetsuo Era and Tomoyuki Ueyama, OTC DAIHEN Corp., Kobe, Japan, and Yoshinori Hirata, Osaka University, Osaka, Japan

B. 2:00 p.m. **"Measurement of Weld Pool Surface in P-GMAW: A Preliminary Study"**
by Xiaoji Ma and Yu-Ming Zhang, Center for Manufacturing, Dept. of ECE, Lexington, Ky.

C. 2:30 p.m. **"GMAW Sensor Fusion: Development of Sensor Correlations and Quality Differentiating Algorithms"**
by Paul Boulware, EWI, Columbus, Ohio

D. 3:00 p.m. **"Automated Monitoring of Metal Transfer for Real-Time Control"**
by Zhenzhou Wang, Yan Shao, and Yu-Ming Zhang, Center for Manufacturing, Dept. of ECE, Lexington, Ky.

E. 3:30 p.m. **"Automated Welding and Data Acquistion Initiative: A Key Enabler for Next Generation Nuclear Reactors"**
by James Dowalo and Larry Zirker, Idaho National Laboratory, Idaho Falls, Idaho

Session 3: Room S227
WELDABILITY OF MATERIALS

Chair: Thomas J. Lienert, Los Alamos National Laboratory, Los Alamos, N.Mex.

A. 1:30 p.m. **"Effect of Molybdenum and Niobium Additions on the Ductility-Dip Cracking Susceptibility of High-Cr, Ni-Base Filler Metals: Strain-to-fracture testing and advanced characterization techniques have been used to determine the beneficial effects of Mo and Nb"**
by John C. Lippold, The Ohio State University, Columbus, Ohio, Samuel D. Kiser, Special Metals Welding Products Co., Newton, N.C., and Antonio J. Ramirez, Synchrotron Light National Laboratory, Campinas, Brazil

B. 2:00 p.m. **"An Investigation on X80 Pipeline Steel HAZ"**
by Joel Pepin, University of Alberta, Edmonton, Canada, Hani Henein, Douglas Ivey, and J.B. Wiskel, University of Alberta, Edmonton, Canada, and Christopher Penniston, IPSCO Inc., Regina, Canada

C. 2:30 p.m. **"Elevated Temperature Ductility of Alloy C22: Solid-State Cracking Investigation"**
by Morgan Gallagher, The Ohio State University, Houston, Tex., and John C. Lippold, The Ohio State University, Columbus, Ohio

D. 3:00 p.m. **"Investigation of HAZ Cracking in Haynes 230"**
by Thomas J. Lienert, William L. Stellwag, Jr., Carl T. Necker, and Paul Burgardt, Los Alamos National Laboratory, Los Alamos, N.Mex.

E. 3:30 p.m. **"Direct Observation of Ductility-Dip Cracking Phenomena of Ni-Base Filler Metals: In-situ High Temperature Deformation Observation in Electron Microscope of DDC Phenomenon on Ni-Base Filler Metals FM-52 and FM-82"**
by Antonio J. Ramirez, Edwar A. Torres, and Fellipe G. Peternella, Brazilian Synchrotron Light Laboratory, Campinas, Brazil, and Rubens Caram Jr., State University of Campinas, Campinas, Brazil

F. 4:00 p.m. **"Pipe Welded Joint Mechanical Property and Corrosion Resistance"**
by Estela Silvia Surian, UNLZ and Regional Faculty San Nicolas-UTN, Buenos Aires, Argentina, Monica Zalazar, UNCo, Cipolietti, Argentina, and Mabel Ramini de Rissone, UTN, San Nicolas, Argentina

G. 4:30 p.m. **"Microstructural Control for the Improved Resistance to Weld Metal Cold Cracking"**
by Hee Jin Kim, Hoi Soo Ryoo, and Jun Seok Seo, Korea Institute of Industrial Technology, ChonAnSi, Korea

Tuesday, October 7
8:00 AM – 5:00 PM

Session 4: Room S225
SHIPBUILDING RESEARCH AND DEVELOPMENT

Chair: Johnnie J. DeLoach Jr., Naval Surface Center, West Bethesda, Md.

A. 8:00 a.m. **"Materials Properties Evaluation of Aluminum-Magnesium-Scandium Welds"**
by Kim N. Tran, NSWCCD, West Bethesda, Md.

B. 8:30 a.m. **"Evaluation and Comparison of Laser and Arc Cladding Technologies for the Cladding of Seawater Exposed Components in Submarine Manufacture"**
by Todd A. Palmer, Applied Research Laboratory, State College, Pa., Kenneth Meinert, Pennsylvania State University, State College, Pa., and Bruce Horn, Michael Myers, and Brian Fowler, Concurrent Technologies Corporation, Johnstown, Pa.

C. 9:00 a.m. **"Hybrid Laser Arc Welding of DH-36 and EH-36 Steel: Characterization of the Macrostructure, Mircostructure, and Welding Parameters"**
by Caleb T. Roepke and Stephen Liu, Colorado School of Mines, Golden, Colo.

D. 9:30 a.m. **"Mitigating Distortion of Shipyard SAW Applications"**
by Kevin J. Roossinck, Lee Kvidahl, and Tim Warren, Northrup Grumman Shipbuilding, Pascagoula, Miss.

Session 5: Room S226
ENHANCING CORROSION RESISTANCE OF WELDMENTS

Chair: John N. DuPont, Lehigh University, Bethlehem, Pa.

A. 8:00 a.m. **"Optimizing Corrosion Performance of Welds: 6 wt-% Mo Superaustenitic Stainless Steels"**
by Andrew W. Stockdale and John DuPont, Lehigh University, Bethlehem, Pa.

B. 8:30 a.m. **"Effect of Welding Parameters on Duplex Stainless Steel Performance: Development of Quantitative Standards for Weldment Microstructures"**
by Matthew Yarmuch, Alberta Research Council, Edmonton, AB, Canada, Kimberley Sandy, Master Flo Valve Inc., Edmonton, AB, Canada, and Galen Wright, G. Wright's Welding Ltd., Edmonton, AB, Canada

C. 9:00 a.m. **"Higher Interpass Temperatures for Austenitic Stainless Steel Weldments: Increase Temperature, Increase Productivity, and Maintain Quality"**
by Iulian Radu, PCL Industrial Contructors Inc., Nisku, Canada, Kenneth Armstrong, PCL Industrial Constructors Inc., Nisku, Canada, and Matthew Yarmuch, Alberta Research Council, Edmonton, AB, Canada

D. 9:30 a.m. **"Sulfide Stress Cracking in Welded Joint of Carbon Steel"**
by Denyse Elaine Quinto Herrera, Bucaramanga, Santander, Colombia, and Gabriel Orlando Porras Arevalo, Giron, Colombia

Session 6: Room S227
WELDING/JOINING IN AUTOMOTIVE APPLICATIONS

Chair: Yoni Adonyi, LeTourneau University, Longview, Tex.

A. 8:00 a.m. **"Post-Weld Baking Effects on Resistance Spot Weld Properties in Two Automotive High Strength Steels"**
by Murali Tumuluru, United States Steel Corporation, Munhall, Pa., and Ming Jian Hua, University of Pittsburgh, Pittsburg, Pa.

B. 8:30 a.m. **"Performance of DP780 Single-Side Resistance Welds: Effects of Process Parameters"**
by Ramakrishna (Rama) Koganti, Sergio Angotti, and Arnon Wexler, Ford Motor Company, Dearborn, Mich., and Yan (Jack) Sang and Chonghua (Cindy) Jiang, AET Intergration, Inc., Wixom, Mich.

C. 9:00 a.m. **"Double-Sided Arc Welding of 5182 Aluminum Tailor Welded Blanks"**
by Jeffrey A. Moulton and David C. Weckman, University of Waterloo, Waterloo, ON, Canada

D. 9:30 a.m. **"Advances in Drawn-Arc Nut, Bracket & Stud Welding"**
by Chris Hsu, Doug Phillips, and Torsten Ehrentreich, Nelson Stud Welding, Inc., Elyria, Ohio

Session 7: Room S225
FRICTION STIR WELDING AND SOLID-STATE WELDING

Chair: Wangen Lin, Pratt & Whitney, E. Hartford, Conn.

A. 1:30 p.m. **"Liquation of Mg Alloys in Friction-Stir Spot Welding"**
by Sindo Kou, Department of Materials Science and Engineering, Madison, WI, Y.K. Yang, H. Cao and Y.A. Chang, University of Wisconsin, Madison, Wis., and H. Dong, Dalian University of Technology, Dalian, China

B. 2:00 p.m. **"Coupled Model of Heat Transfer and Plastic Deformation in Friction Stir Welding: Scaling results predict trends in friction stir welding"**
by Karem E. Tello, Colorado School of Mines, Golden, Colo., Thomas J. Lienert, Los Alamos National Laboratory, Los Alamos, NM, and Patricio F. Mendez, Colorado School of Mines, Golden, Colo.

C. 2:30 p.m. **"Friction Stir Welding of Dissimilar Titanium Alloy Sheet Materials"**
by Matthew Gonser and William Baeslack, The Ohio State Univeristy, Columbus, Ohio

D. 3:00 p.m. **"Simulation of Friction Stir Weld Microstucture in Steels Using Hot Torsion: Hot torsion experiments in the Gleeble have been successful in simulating the stir zone and TMAZ in HSLA-65 and Type 304 stainless steel"**
by John C. Lippold, The Ohio State University, Columbus, Ohio, Matthew Sinfield and David Forrest, Navy Surface Warfare Center, West Bethesda, Md., and David Failla, The Ohio State University, Columbus, Ohio

E. 3:30 p.m. **"Microstructural Corrosion Evaluation of Friction Stir Processed and Gas Metal Arc Welded Nickel Aluminum Bronze"**
by Jennifer Wolk and Richard Park, Naval Surface Warfare Center, Bethesda, Md., and Matthew Krupa, Naval Research Laboratory, Key West, Fla.

F. 4:00 p.m. **"Ultrasonic Metal Welding of Advanced Alloys: The Weldability of Stainless Steel, Titanium, and Nickel-Based Superalloys"**
by Matthew Bloss, The Ohio State University, Columbus, Ohio, and Karl F. Graff, Edison Welding Institute, Columbus, Ohio

Session 8: Room S226
WELDING METALLURGY

Chair: Ernesto E. Indacochea, University of Illinois at Chicago, Chicago, Ill.

A. 1:30 p.m. **"Determination of the Critical Temperatures in Creep Strength Enhanced Ferritic Power Plant Steels"**
by Jonathan Kilpatrick Tatman, Boian Alexandrov, John Lippold, and Vincent Arnet, The Ohio State University, Columbus, Ohio

B. 2:00 p.m. **"Microstructural Development of Single Cystral Welds"**
by Timothy Anderson and John N. DuPont, Lehigh University, Bethlehem, Pa., and Tarasankar DebRoy, Pennsylvania State University, University Park, Pa.

C. 2:30 p.m. **"In-situ Thermite Welding of Boiler Tubing: A New Application for a Proven Process"**
by John Nickell and Stephen Liu, Colorado School of Mines, Golden, Colo.

D. 3:00 p.m. **"HAZ Toughness Improvement for High Strength Linepipe Steels"**
by Christopher Penniston, Laurie Collins, and Fathi Hamad, IPSCO R&D, Regina, Canada

E. 3:30 p.m. **"Thermal Analysis of Phase Transformations during Welding: Quantifying the Amount of Transformations in Welding"**
by John W. Gibbs and Patricio F. Mendez, Colorado School of Mines, Golden, Colo.

F. 4:00 p.m. **"Properties of Super Martensitic Stainless Steel Welds: Properties of Welds with Matching SMAW Electrode"**
by Takahashi Atsushi, Material Engineering Group, EN Technology Center, Yokohama, Japan, Sasaguchi Hiroaki and Hosoya Keizo, EN Technology Center, Yokohama, Japan, and Sango Tetsuya and Saito Teiichiro, NIPPON Welding Rod Co., Hamamatsu, Japan

G. 4:30 p.m. **"Effective Grain Size of Acicular Ferrite in Ferritic Weld Metal"**
by Hee Jin Kim, Ka-Hee Kim, Hoi Soo Ryoo, and Jun Seok Seo, Korea Institute of Industrial Technology, ChonAnSi, Korea

Session 9: Room S227
ARC WELDING APPLICATIONS

Chair: Howard W. Ludwig, Caterpillar, Inc., Peoria, Ill.

A. 1:30 p.m. **"The Relationship between Heat Transfer and Metal Transfer in GMAW"**
by Erik Soderstrom and Patricio Mendez, Colorado School of Mines, Golden, Colo.

B. 2:00 p.m. **"Study of Hybrid Double-Sided Arc Welding"**
by Jinsong Chen, Yu-Ming Zhang, and Kun Qian, Center for Manufacturing, Dept. of ECE, Lexington, Ky.

C. 2:30 p.m. **"Heat Transfer Regions and Non-Linear Effects in Electrode Extension in GMAW: The effect of variable materials properties is quantified and generalized"**
by Greg Lehnhoff and Patricio F. Mendez, Colorado School of Mines, Golden, Colo.

D. 3:00 p.m. **"Study and Analysis of Metal Transfer Phenomena in Double-Electrode GMAW"**
by Kehai Li, ESAB Welding and Cutting, Florence, S.C.

E. 3:30 p.m. **"A Process Control System in Pulse GMA Welding Al-Mg Alloys of Aircraft on the Basis of Process Stability and Process-Integrated Quality Assurance"**
by S. Rajasekaran, Vinayaka Missions University, Tamilnadu, India

Wednesday, October 8
8:00 a.m. – 5:00 p.m.

PLENARY PRESENTATION: ADVANCES IN SOUTH AMERICA — Room S225

8:00 a.m. – 9:00 a.m. **"Advances in Welding in South America: Trends in Research and Development"**
Antonio Ramerez, Ph.D., Electron Microscopy Laboratory, Brazilian Synchrotron Light Laboratory

Session 10: Room S225
WELDING RESEARCH NEEDS IN THE ENERGY INDUSTRY

Chair: Fredrick Noecker, ExxonMobil Development Company, Houston, Tex.

A. 9:00 a.m. **"Research Needs in Materials and Welding in the Coal and Nuclear Power Generation Industry"**
by John DuPont, Lehigh University, Bethlehem, Pa.

B. 9:30 a.m. **"Welding Research at ExxonMobil"**
by Doug Fairchild, A. Kumar, and W. Cheng, ExxonMobil Upstream Research Company, Houston, Tex.

C. 10:00 a.m. **"Welding Guidelines for Oil, Refinery, Chemical, and Gas Industries"**
by Dong S. Kim, Materials, Corrosion and Integrity, Shell Global Solutions, Houston, Tex.

D. 10:30 a.m. **"Pipeline Welding Challenges in the Oil and Gas Industry"**
by Jonathan Regina, Dan Lillig, Geoff Dunn, Brian Newbury, and Mark Crawford, ExxonMobil Development Company Materials and Corrosion, Houston, Tex.

E. 11:00 a.m. **Panel Discussion**

Session 11: Room S226
FILLER METAL RESEARCH AND DEVELOPMENT

Chair: Stephen Liu, Colorado School of Mines, Golden, Colo.

A. 8:00 a.m. **"Development of a Ni-Cu Consumable for Reduction of Hexavalent-Cr Emissions during Stainless Steel Welding"**
by Jeffrey W. Sowards, Boian T. Alexandrov, Dong Liang, Gerald S. Frankel, and John C. Lippold, The Ohio State University, Columbus, Ohio

B. 8:30 a.m. **"Electro-Slag Cladding with Hardfacing Wire Electrodes Using Twin Wire Gun"**
by Rghvendra Mohan Srivastava and R.V. Kumar, University of Cambridge, Cambridge, United Kingdom, and Dorival Tecco, Welding Alloys Ltd., Fowlmre, United Kingdom

C. 9:00 a.m. **"Mircostructural Evolution and Mechanical Properties of a New High Strength Steel for Defense Applications"**
by Jeffrey Farren and John N. DuPont, Lehigh University, Bethlehem, Pa.

D. 9:30 a.m. **"Influence of TiC Additions on the Microstructure, Corrosion Resistance, and Hydrogen Cracking Susceptibility of Fe-Al-Cr Weld Overlay Coatings"**
by Kenneth D. Adams and John N. DuPont, Lehigh University, Bethlehem, Pa.

E. 10:00 a.m. **"Automated Stellite Overlay with Advanced TIG Process: How to improve quality without compromising the process efficiency?"**
by Laurent Rimano, Air Liquide Canada, Inc., Montreal, Canada

F. 10:30 a.m. **"Effects of Ga-Al, Ga-Ag on Wettability of Sn-9Zn-X-Y Lead-Free Solders"**
by Xue Songbai, Wang Hui, Han Zongjie, and Wang Jianxin, Nanjing University of Aeronautics and Astronautics, Nanjing, China

Session 12: Room S227
ELECTRON BEAM WELDING

Chair: Patrick W. Hochanadel, Los Alamos National Laboratory, Los Alamos, N.Mex.

A. 8:00 a.m. **"Pulsed Electron Beam Welding of Stainless Steel: Initial Studies"**
by Patrick W. Hochanadel, Douglas D. Kautz, Jesse N. Martinez, Nathaniel G. Dozhier, and Paul Burgardt, Los Alamos National Laboratory, Los Alamos, N.Mex.

B. 8:30 a.m. **"Melting Efficiency in Ni Base Alloys"**
by John DuPont and Tim Anderson, Lehigh University, Bethlehem, Pa.

C. 9:00 a.m. **"EB Welding in the European and Asian Automotive Industry"**
by Guenther Schubert, PTR-Precision Technologies, Inc., Enfield, Conn., and Klaus-Rainer Schultze, PTR Prazisiontecknik GmbH, Maintal-Doernigheim, Germany

D. 9:30 a.m. **"EB Welding Trends for Gas Turbine Components: New Parts Manufacturing & Component Repair Applications"**
by John Rugh, PTR-Precision Technologies, Inc., Enfield, Conn.

E. 10:00 a.m. **"Manufacturing Advantages for Airframe Structures Using Electron Beam Welding/Free Form Fabrication"**
by Kenn Lachenberg and S.D. Stecker, Sciaky, Inc., Chicago, Ill.

Session 13: Room S225
WELDING PROCESS AND PROPERTIES MODELING

Chair: Patricio Mendez, Colorado School of Mines, Golden, Colo

A. 1:30 p.m. **"Modeling and Optimization of Induction Brazing Process: Induction Brazing WC/SS420 Joint Using BAG-22"**
by Di-Shyang Chou, National Taiwan University of Science and Technology, Taipei, Taiwan, Chon L. Tsai, The Ohio State University, Columbus, Ohio, and John Tsai, National Taiwan University of Science and Technology, Taipei, Taiwan

B. 2:00 p.m. **"Capturing Numerical Models and Experiments with Closed From Expressions: Data mining techniques help discover scaling laws in complex problems"**
by Patricio F. Mendez, Colorado School of Mines, Golden, Colo.

C. 2:30 p.m. **"Optimization of GMAW Welding Parameters in Duplex Stainless Steel Welds: Modeling and Measurements"**
by Carolina Payares-Asprino, Universidad Simon Bolivar, Caracas, Venezuela, and John P.H. Steele, Colorodo School of Mines, Golden, Colo.

D. 3:00 p.m. **"Modeling of Weld Penetration at High Productivity GTAW"**
by Ustün Duman and Patricio F. Mendez, Colorado School of Mines, Golden, Colo.

E. 3:30 p.m. **"Model Predictive Control of Plasma Pipe Welding Process"**
by Kun Qian, Yu-Ming Zhang, and Jinsong Chen, Center for Manufacturing, Dept. of ECE, Lexington, Ky.

F. 4:00 p.m. **"Mathematical Modeling of Weld Bead Profile Shapes: Modeling and Measurements"**
by John P.H. Steele, Colorado School of Mines, Golden, Colo., and Carolina Payares-Asprino, Universidad Simon Bolivar, Caracas, Venezuela

Session 14: Room S226
LASER BEAM WELDING

Chair: Todd Palmer, Applied Research Laboratory, Pennsylvania State University, State College, Pa.

A. 1:30 p.m. **"Behavior of Dissimilar Alloy & Strength Stainless Welds"**
by Gerald A. Knorovsky, Sandia National Laboratories, Albuquerque, N.Mex., and Rick Cottrell, Honeywell Federal Manufacturing & Technologies, Kansas City, Mo.

B. 2:00 p.m. **"Suppression of the Spiking Defect in Single-Mode Fiber Laser Welds: Sinusoidal laser power modulation can prevent weld penetration variation"**
by Dave F. Farson, Matt Reiter, Katherine Mantkowski and Chuck Violand, The Ohio State University, Columbus, Ohio

C. 2:30 p.m. **"Energy Absorption in Pulsed Laser Welding"**
by Charles V. Robino and Jerome T. Norris, Sandia National Laboratories Albuquerque, N.Mex.

D. 3:00 p.m. **"Laser Triggered Nanoscale Electrical Discharges for Materials Processing: Controlled electrical arcs at scanning nanoprobe tips are used for sub-microscale surface melting"**
by Dave F. Farson, Stan Rokhlin, Jian Chen, and Ningyu Wang, The Ohio State University, Columbus, Ohio

E. 3:30 p.m. **"Prediction of Surface-Active Elements for Exotic Metal Systems under Welding Conditions"**
by Erik M. Lord, David L. Olson, and Stephen Liu, Colorado School of Mines, Golden, Colo.

F. 4:00 p.m. **"Effect of Base Metal Residual Stress on Distortion Control in Laser Beam Welding: Study and utilize the reciprocal effect of two competitive stresses, i.e., base metal cold-working stress and welding residual stress, to control the distortion in precision laser beam welding process"**
by Li-Jen Liu, Kuang-Hua Hou, and Chi-Te Li, Chang Gung University, Tao-Yuan County, Taiwan

Session 15: Room S227
WELD JOINT PROPERTIES AND DESIGN

Chair: Mike L. Santella, Oak Ridge National Laboratory, Oak Ridge, Tenn.

A. 1:30 p.m. **"Effect of Weld Joint in Boiler Tube Failure During the Explosive Cleaning Practice: Weld joint and base material characterization and the effect of carbides during boiler tube cleaning"**
by Juan Carlos Madeni, Stephen Liu, Vilem Petr, Collin Trickel, and David Olson, Colorado School of Mines, Golden, Colo.

B. 2:00 p.m. **"Evaluating the Strength of Welded T-Joints: Comparing Experimental and Analytical Approaches"**
by David J. Eby, Exponent, Farrington Hills, Mich.

C. 2:30 p.m. **"Incorporating Residual Stress in the FFS Fracture Assessment Procedure: Fitness-for-Service Assessment of Welded Pressure Vessels"**
by Ben N. Lee, Det Norske Veritas (USA) Inc., Houston, Tex., Dong S. Kim, Shell Global Solutions (US) Inc., Houston, Tex., and Chon L. Tsai, The Ohio State University, Columbus, Ohio

D. 3:00 p.m. **"Application of Master S-N Curve Approach for Weld Fatigue: Generating data for weld fatigue life prediction"**
by Dean Flynn and W. John Evans, Swansea University, Swansea, United Kingdom, Yi Gao, Corus Automotive, Corus Group Limited, Coventry, United Kingdom, and David Panni, J. C. Bamford Excavators, Rocester, United Kingdom

CONFERENCES

NEW TECHNOLOGIES IN THERMAL CUTTING CONFERENCE

This roundup of advancements in the world of cutting will include such processes as oxyfuel cutting, plasma arc cutting, laser beam cutting, and waterjet cutting. A great deal is happening in computer control. Cuts are far more precise, more repeatable, more accurate, and much faster than ever before. Accompanying the improvements in machines and controls are improvements in torches, consumables, and cutting heads. A presentation will weigh the relative merits of the many fuel gases that can be put to work on oxyfuel cutting lines. This conference demonstrates that we have entered a new era in thermal cutting.

Monday, October 6
8:50 a.m. – 4:05 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $345
Nonmembers: $480
Registration Code: W81 **Room S221**

8:50 a.m. – 9:00 a.m.
Welcome and Introduction
Chairman: Robert R. Irving; Co-Chairman: John Dawson

9:00 a.m. – 9:35 a.m.
Quality Flame Cutting after 107 Years
John Dawson, Consultant, ESAB Cutting Systems

9:35 a.m. – 10:10 a.m.
State-of-the-Art of Mechanized Plasma Cutting Technology
James Colt, Strategic Accounts Manager, Hypertherm Inc.
Mechanized plasma arc cutting has been commercially used since the early 1960s for a variety of applications. Plasma has always had a reputation as the "Productivity Process" due to its ability to cut a wide range of materials and thicknesses at high speeds. Advancements in the last ten years have further developed plasma into a more refined process that provides dramatically higher cut part accuracy, high cutting speeds, full automation capability…all at a lower cost per foot of cut.

10:10 a.m. – 10:45 a.m.
How Nesting Solutions Develop a Positive Impact on Thermal Cutting Processes
Marius Pienaar, Director, SigmaTEK Services
This particular CAD/CAM software is designed to achieve the following: integration for scheduling, estimating, engineering, and costing; improved part quality; improved utilization of materials; and improved cutting flow.

10:45 a.m. – 11:00 a.m. Refreshment Break

11:00 a.m. – 11:35 a.m.
Introduction to Industrial Lasers
Lou Derango, Icon Machine Tool
An introduction to basic laser workings and considerations with follow up in a few typical metal applications. This presentation is meant to be a primer for those interested in pursuing laser technologies. The follow-up of the presentation will include a few samples of laser processing quality with question-and-answer period.

11:35 a.m. – 12:10 p.m.
Computerized Pipe and Tube Cutting
Jim Blackburn, General Manager, Vernon Tool Co., a business of Lincoln Electric Co.
Using a Powerpoint® presentation, the speaker will briefly discuss current pipe cutting methods with attendant efficiencies. Specific industries dictate different machine configurations, computer controls, and cutting methods. Recommendations for designing an efficient "burn rack" will be disclosed. The speaker will address improvements in mechanized cutting machines, material handling alternatives and CAD/CAM data flow from popular isometric and structural modeling software. Machine operations and features are a guide to effective, efficient shop production and labor saving opportunities. Thirty-five years of management provide historical perspective of machine evolution, from simple gear-driven machines to 6-axis CAD/CAM driven work cells.

12:10 p.m. – 1:30 p.m. Lunch

1:30 p.m. – 2:05 p.m.
Waterjet Systems Can Cut a Wide Variety of Materials
Wiktor Stepien, Vice President-Sales, and Bob Pedrazas, Marketing Manager, KMT Waterjet Systems
Waterjet cutting systems are able to cut virtually any material. Waterjet machining offers many advantages compared to other technologies, including colder cutting, increased precision, and a greater variety of applications. This presentation will be centered on the use of waterjet cutting applications for flat stock metals (aluminum, stainless steel), ceramics, stone, plastics, and composites for the aerospace, automotive, job shop, electronic, stone, glass, and metal industries. Video examples will be included within the presentation to demonstrate how waterjet technology can help improve the quality, speed, and efficiency of these manufactured products.

2:05 p.m. – 2:40 p.m.
Innovative CNC Control on State-of-the-Art Plasma Shape Cutting Technology
Mark Osowski, Product Manager, Burny/AMC Business Unit, ITT Cleveland Motion Controls
Innovative features developed in Burny CNC controls are tightly coupled to Kaliburn plasma systems in order to create a fully automatic shape cutting motion control process. This talk will detail how ITT Cleveland Motion Controls is striving for new technology that takes the waste, both in time and material, out of the shape cutting process. Learn how you can save on labor and operating expenses in your plasma application.

2:40 p.m. – 2:55 p.m. Refreshment Break

2:55 p.m. – 3:30 p.m.
Fuel Gases, Piping, and a Little OSHA
John Dawson, President, Thermal Cutting Consulting Inc.
The decision as to which fuel gas to use in a specific cutting operation is not always an easy one. The choice is extensive. It includes acetylene, propane, natural gas, propylene, MAPP, LPG, etc. However, the appropriate choice can be made based on the best performance/cost ratio. In addition, users of fuel gases who have them piped into their plants are facing problems with certain OSHA regulations. This situation will be explained.

3:30 p.m. – 4:05 p.m.
The Use of CAD/CAM Software to Program Robots to Cut Structural Steel and Pipe
Chris Anderson, Technology Leader-Welding, Motoman
Typically, robots are programmed manually with teach pendants creating point-to-point programs. Offline programming is done in a similar fashion, just in a virtual environment. Cutting machines use CAD/CAM software to generate shapes and often automate programming tasks such as nesting multiple shapes in an optimized pattern on a sheet. Utilizing a conversion routine, these shape patterns can be converted to robot programs without the use of traditional programming methods. This allows paths from CAD software such as AutoCad to be converted into cut paths. Cut paths can also be created from G-code generated out of CAM software. Robotics brings the advantage of six degrees of freedom for positioning so beveling and contours can be cut on 3D parts such as structural shapes and pipe.

4:05 p.m. – Adjournment

NEW NONDESTRUCTIVE TESTING TECHNOLOGIES

Among the technologies to be discussed are new versions of ultrasonic testing, including time-of-flight diffraction, alternating current field measurement, phased array inspection, and *guided wave examination. Attendees will also hear about a new UT system that is being used to inspect austenitic welds in LNG storage tanks. Other presentations will include the use of acoustic emission to inspect the welds in bridge construction, and a talk on digital radiography, including a system for shipbuilding that uses computed radiography techniques.*

Tuesday, October 7
8:50 a.m. – 4:00 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $345
Nonmembers: $480
Registration Code: W82 **Room S221**

8:50 a.m. – 9:00 a.m.
Welcome and Introduction
Chairman: Robert R. Irving; Co-Chairman: Ron Kruzic

9:00 a.m. - 9:40 a.m.
Ultrasonic Technique for the Examination of 9% Nickel Inner Shells of Large-Diameter Liquid Natural Gas (LNG) Storage Tanks
Ronald W. Kruzic, Senior Welding Engineer/Corporate NDT Level III, CB&I
A semiautomatic, first-of-its-kind ultrasonic examination technique that is currently being utilized for the examination of the high-nickel alloy welds of 9% Ni LNG tanks will be described. It is currently being utilized to examine the world's largest LNG tanks,190,000 m^3, and will shortly be applied to a 200,000-m^3 storage tank. This technique takes the volumetric examination of the shell welds off the critical path and places the welding operation in its place.

9:40 a.m. – 10:20 a.m.
Computed Radiography – Innovations for Film Quality Results in Industrial Applications
Terry Plasek, Western Regional Manager, Fujifilm NDT Systems
This paper addresses the evolution of computed radiography dedicated to Industrial use and applications. Discussion on the improvements in systems resulting in the ability to achieve results equal to or in some cases better than conventional wet film radiography. System specifications and example imaging are also included.

10:20 a.m. – 10:35 a.m. Refreshment Break

10:35 a.m. – 11:15 a.m.
Eddy Current Array and Ultrasonic Phased-Array Technologies as Reliable Tools for FSW Inspection
Michael Moles, Senior Technology Manager, and André Lamarre, Business Development Director, Aerospace and Defense, Olympus NDT
Ultrasonic phased-array technology has demonstrated over the years its capabilities to reliably inspect aluminum friction stir welds (FSW) as many aerospace manufacturers have used it during their manufacturing process. Recent developments in eddy current array technology added new perspectives to the FSW evaluation. It is now possible to characterize the tool penetration and minimize the presence of an oxide layer, the so-called kissing bond. This presentation will summarize results of both technologies for the evaluation of FSW.

11:15 a.m. – 11:55 a.m.
Use of Acoustic Emission for Field Inspection of Welds for In-Service Bridges
Richard Gostautas, Infrastructure Group Leader, Physical Acoustics Corp.
This presentation includes a few case studies that describe and illustrate how acoustic emission (AE) monitoring was used as a NDE tool for condition assessment of defects and discontinuities (e.g., cracks) in welds on different types of in-service bridges.

11:55 a.m. – 1:00 p.m. Lunch

1:00 p.m. – 1:40 p.m.
Advancements in NDE at Edison Welding Institute
Kevin M. Clear, Project Engineer–NDE Technology, Edison Welding Institute
This presentation will discuss the advancements in nondestructive evaluation at Edison Welding Institute. It will provide a brief overview of linear and matrix phased array, digital computed radiography, phased array eddy current, and microwave inspection techniques.

1:40 p.m. – 2:20 p.m.
Practical Applications of the Time-of-Flight Diffraction (TOFD) Ultrasonic Technique
David Dechene, NDE Level III for U.S. Operations, Sonomatic
Originally developed in the late 1970s for the nuclear industry as a very accurate flaw sizing tool, the time-of-flight diffraction (TOFD) ultrasonic technique has also gained popularity over the years for its other unique abilities, such as one-scan weld inspections, corrosion mapping, hydrogen damage detection, and rapid screening of vessel shells, to name a few. This presentation is designed to explain what TOFD is, how it differs from pulse echo UT, its advantages/disadvantages and its applications for industry today.

2:20 p.m. – 2:35 p.m. Refreshment Break

2:35 p.m. – 3:15 p.m.
An Introduction to Alternating Current Field Measurement
Robert E. Cameron, Manager, Quality Assurance and Training, TWI North America, LCC
ACFM is an electromagnetic test technique used for the detection and sizing of surface-breaking cracks. It was initially conceived for use underwater to detect flaws in offshore structures and proved to be very effective. Now ACFM is used to inspect structures both in and out of the water. ACFM has the advantage, over some other NDT methods, that the surface requires minimal cleaning. Also, ACFM can be applied to surfaces that are painted, or have other coatings up to about 5 mm in thickness. ACFM is used not only to detect and size surface-breaking cracks, but also to monitor crack growth.

3:15 p.m. – 3:55 p.m.
Emerging Ultrasonic Guided Wave Applications in NDT, Structural Health Monitoring (SHM), and Weld Inspection
Joseph L. Rose, Paul Morrow Professor, Engineering Science & Mechanics Department, Pennsylvania State University. Dr. Rose is also Senior Scientist, FBS Inc.. Dr. Rose's paper will be presented by Michael Moles, Senior Technology Manager, Olympus NDT Canada
Ultrasonic guided waves have always been of interest for decades but little used in NDT and SHM. Today, however, with significant advancements in theoretical understanding and computational efficiency the road ahead for guided waves is clear. Phased array utilization has advanced guided wave applications even further. Sample problems in pipeline, aircraft, and rail will be covered along with special emphasis on newly developed phased array scanning of an entire plate from a single sensor position and weld inspection with simple single line scan at any arbitrary distance from the weld.

4:00 p.m. – Adjournment

FRICTION STIR WELDING CONFERENCE

If you and your company are just starting out with friction stir welding (FSW), or if you are interested in learning more about FSW, this is the seminar for you. This seminar will not be a gathering of academics talking about theory. The aim of this *seminar is to provide those interested in considering use of FSW with pertinent information on the process so they can evaluate its feasibility for their applications.*

Wednesday, October 8
8:25 a.m. – 2:30 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $345
Nonmembers: $480
Registration Code: W83 Room S232

8:25 a.m. – 8:30 a.m.
Welcome and Introduction
Chairman: Thomas J. Lienert, Ph.D

8:30 a.m. – 9:00 a.m.
Friction Stir Welding History and Licensing
Iain Smith, TWI Ltd.
This presentation will contain a brief review of the history of the early development of FSW and its rapid take-up by industry. It will also discuss the approach TWI uses for the control and exploitation of the intellectual property. Finally, it will briefly review the very large number of patents filed by FSW users.

9:00 a.m. – 9:30 a.m.
Friction Stir Welding Tool Designs
Iain Smith, TWI Ltd.
This presentation will describe the evolution of FSW tool designs from the simple forms used to establish the process through to the most popular types used today, and some indications of the future challenges for tools.

9:30 a.m. – 10:15 a.m.
Friction Stir Welding and Processing
Murray Mahoney, Consultant
General discussion of FSW including metal flow and defect avoidance, temperature gradient issues, lap vs. butt joints, some tool material and tool design considerations, current applications, FSW limitations, benefits such as properties and the solid-state benefits of welding unweldable alloys and zero emissions, all as they apply to Al, Cu, and Fe based alloys. A description of friction stir processing (FSP) and its benefits will also be discussed.

10:15 a.m. – 10:30 a.m. Refreshment Break

10:30 a.m. – 11:00 a.m.
Advances in Friction Stir Welding Tool Technology
Scott Packer, Advanced Metal Products
Limitations of FSW have included the feasibility of joining high-melting-temperature materials such as steels, stainless steels, and nickel-base alloys. Tool materials able to withstand the high temperatures along with adequate wear resistance during the joining process are required. Generally, there have been two distinct material systems used including polycrystalline cubic boron nitride (PCBN) and tungsten-based materials such as tungsten rhenium alloys. This paper will present the development of PCBN materials for FSW, and the development of composite tungsten rhenium alloys with PCBN and diamond reinforcement.

11:00 a.m. – 11:30 a.m.
Friction Stir Welding Machines and Configurations
Tim Haynie, Transformation Technologies, Inc.
Friction stir welding is performed on a variety of equipment types ranging from simple milling machine to highly sophisticated, purpose-built FSW systems with specialized features and advanced control algorithms. In this presentation, the requirements of the FSW process and the implications on the equipment selection are discussed. The basics of force control and position control modes are presented and the advantages of each control mode are discussed. Commercially available machine configurations from several manufacturers are presented. These include simple two-axis seam welders through multi-axis complex contouring machines with advanced pin-control features.

11:30 a.m. – 12:00 p.m.
Eddy Current Array and Ultrasonic Phased-Array Technologies for FSW Inspection
Michael Moles, Olympus NDT
Ultrasonic phased-array technology has demonstrated over the years its capabilities to reliably inspect aluminum friction stir welds (FSW) as many aerospace manufacturers have used it during their manufacturing process. Recent developments in eddy current array technology added new perspectives to the FSW evaluation. It is now possible to characterize the tool penetration and minimize the presence of an oxide layer, the so-called kissing bond.

12:00 p.m. – 12:30 p.m. Lunch & Q&A/Panel Discussion

12:30 p.m. – 1:00 p.m.
Cost/Benefit Analysis for Friction Stir Welding
Jeff DeFalco, ESAB
A cost/benefit comparison is made between conventional fusion-type welding processes to FSW by evaluating their relative production output, production costs, and weldability attributes in various heavy industry applications. Applications will include joining both low and high melting point alloys while assigning numbers to each evaluation.

1:00 p.m. – 1:30 p.m.
Robotic Friction Stir Welding, Friction Stir Processing, and Supporting Operations
John Hinrichs & Christopher Smith, Friction Stir Link
FSW and FSP are relatively new processes. Principles of the friction stir welding process and FSW and FSP with robots will be discussed. Several FSW robotic applications and an FSP robotic application will be discussed. In addition, robotics used to support manufacturing of FSW products will be described.

1:30 p.m. – 2:00 p.m.
Friction Stir Welding Standards and Specifications Used in Today's U.S. Manufacturing and Fabrication
R. Jeffrey Ding, NASA Marshall Space Flight Center
Discussions will include the AWS FSW Specification for Aerospace Applications. The presentation will also cover standards used in private industry.

2:00 p.m. – 2:30 p.m.
Q&A / Panel Discussion

SEMINARS

Five unique seminars will give you opportunities to gain practical knowledge on welding and inspection in a lively forum with expert instructors. Seminars are discounted for members of AWS, SME, FMA, NAM, or PMA.

Monday, October 6
8:30 a.m. – 4:30 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $345
Nonmember: $480
Registration Code: W84 Room S219

ROADMAP THROUGH THE D1.1/D1.1M:2008 STRUCTURAL WELDING CODE — STEEL

This one-day program provides a comprehensive overview of the new AWS D1.1:2008, *Structural Welding Code — Steel*. Each code section, including General Requirements, Design of Welded Connections, Pre-qualification, 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 D1.1:2008 to improve their job effectiveness.

Attendees must bring their own copy of D1.1:2008, *Structural Welding Code — Steel*. Order it online at *http://www.awspubs.com/* or contact The AWS Store at (888) 935-3464.

Monday, October 6
8:30 a.m. – 4:30 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $345
Nonmember: $480
Registration Code: W85 **Room S232**

VISUAL INSPECTION WORKSHOP

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, October 7
8:30 a.m. – 4:30 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $345
Nonmember: $480
Registration Code: W86 **Room S231**

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:

- Specifying essential and nonessential variables commonly used in sample AWS, ASME, and API code formats
- Using standards when preparing procedures
- Documenting welding variables and qualification tests
- Avoiding the pitfalls in revising previously qualified procedures.

Tuesday, October 7
8:30 a.m. – 4:30 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $345
Nonmember: $480
Registration Code: W87 **Room S232**

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.

Tuesday & Wednesday, October 7-8
8:30 a.m. – 4:30 p.m.
Member of AWS, FMA, SME, NAM, or PMA: $550
Nonmember: $685
Registration Code: W88 • Room S219

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.

EDUCATION SESSIONS

Mostly free sessions that highlight the latest developments in welding education and training programs.

Monday, October 6
9:00 a.m. – 4:00 p.m.
Conference fee: $149
Registration Code: W80 **Room S214**

WELDING EDUCATION CONFERENCE

Presented in conjunction with the National Center for Welding

Education and Training (Weld-Ed), this conference is designed to bring together educators for professional development and networking opportunities. Weld-Ed's focus is on the preparation of welders, welding technicians, and welding engineers to meet the needs of industry.

This paid conference will include presentations on topics such as workforce needs of the welding industry, recruitment tools for educators, welding education program highlights, curriculum overviews, virtual welding equipment and applications, distance learning and its place in the welding field, new technology applications, and interactive demonstrations.

Tuesday, October 7
10:00 a.m. – 11:00 a.m.
Registration Code: W97 FREE Room S213

PLUMMER MEMORIAL EDUCATION LECTURE – WHY IS WELDING IMPORTANT?

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 Professor Thomas W. Eagar, Massachusetts Institute of Technology (MIT). He has been as a professor at MIT since 1976 and served as the chair of the Materials Science and Engineering Department from 1995 to 2000. Although most of Eagar's research involves welding and joining, an increasing amount of work involves other aspects of materials manufacturing and engineering systems. Examples of recent research include fundamentals of transient liquid phase diffusion bonding, control of melting during GMAW, effects of welding fume on health of workers and stresses generated during joining of dissimilar materials.

Eagar is a Fellow of AWS, ASM International, and the American Association for the Advancement of Science, and is a Member of the National Academy of Engineering. He has been recognized for many AWS honors and awards including the Comfort A. Adams Lecturer (1992), the Adams Memorial Membership Award (1979–1983), the Charles H. Jennings Memorial Medal (1984, 1992, 2004), the William Spraragen Award (1991, 1994), the Warren F. Savage Award (1991, 1996), the William Irrgang Award (1993), and the Silver Quill Award (2002).

Tuesday, October 7
11:15 a.m.– 11:45 a.m.
Registration Code: W97 FREE Room S213

HIGHER EDUCATION WELDING UPDATE

Experience the new technology and delivery methods that higher education is using to advance our students to new heights. Professor W. Warke of LeTourneau University will explain how LeTourneau is preparing tomorrow's workforce, today.

Tuesday, October 7
1:00 p.m. – 4:00 p.m.
Registration Code: W97 FREE Room S213

UPDATES ON AWS EDUCATION ACTIVITIES

Presenters will give overviews of federal programs related to training and education of welding personnel.

1:00 p.m. - 1:50 p.m.
Session 1: National View of Perkins 4 Program
Dr. John Foster, CEO of NOCTI and Board Member of ASTS

2:00 p.m. – 2:50 p.m.
Session 2: Discussion on Perkins 4 Program
Dusty Heritage, Associate Dean, Eastern New Mexico University-Roswell

3:00 p.m. – 3:50 p.m.
Session 3: Status on NSF Grant for National Center of Excellence in Welding Training & Education
Ken Smith, Loraine Community College

Wednesday, October 8
9:00 a.m. – 11:00 a.m.
Registration Code: W97 FREE Room S213

TRAINING AND EDUCATION OF WELDING PROFESSIONALS FOR THE ENERGY INDUSTRY

Prominent speakers from various sectors of the energy industry will provide overviews of their successful training and education programs for welders and welding professionals.

9:00 a.m. – 9:10 a.m.
Introductions and Opening Remarks

9:10 a.m. – 9:50 a.m.
Session 1
John Mendoza, CPS Energy and AWS Vice President

9:50 a.m. – 10:20 a.m.
Session 2
Larry Zirker, INL

10:20 a.m.– 11:00 a.m.
Session 3
Neal Chapman, Entergy and AWS District 6 Director

RESISTANCE WELDING SCHOOL

This two-day resistance welding school is sponsored by the American Welding Society and the Resistance Welding Manufacturing Alliance, and conducted by industry specialists. The basics of resistance welding and real-life application of the process are covered. Participants learn at their 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 at lunchtime both days, demonstrating the latest resistance welding products offered by RWMA member companies.*

Tuesday, October 7
7:45 a.m. – 5:30 p.m.

Wednesday, October 8
8:00 a.m. – 4:00 p.m.

Member AWS, FMA, SME, NAM, or PMA: $425
Nonmembers: $660
Registration Code: W89 Room S222

Chair: *Bruce Kelly, President, Kelly Welding Solutions, Grand Ledge, Mich.*

Tuesday, October 7
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 I"**

8:30 a.m. – 11:00 a.m **"Electrodes and Tooling"**
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 Brafford 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, LLC, Greer, S.C.

This discussion focuses on the selection, descriptions, and applications of welding timers, contactors, and accessories. Packed with a punch, Don Sorenson drives home $H = I^2 RT$ in a way you'll never forget. He shows you how this invaluable formula is used in every resistance welding application — everyday — every cycle — all the time!

12:15 p.m. – 1:45 p.m.
Lunch and Tabletop Exhibits

1:50 p.m. – 2:50 p.m. **"Welding Controls" (continued…)**

3:00 p.m. – 5:30 p.m. **"Electrical Power Systems"**
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 Siehling helps you understand this very important part of the resistance welding process that will keep you on the edge of your seat!

Wednesday, October 8
7:00 a.m. – 8:00 a.m.
Sign-in

8:00 a.m. – 10:00 a.m. **"Welding Processes and Machines"**
Tim Foley, Sr. Applications Engineer, Automation International, Inc., Danville, IL

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 II"**

11:00 a.m. – 12:15 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 Kelly 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.

12:15 p.m. – 1:45 p.m.
Lunch and Tabletop Exhibits

1:45 p.m. – 3:45 p.m. **"Initial Machine Setup"**
Robert Matteson, Director - Product Development, Taylor–Winfield, Inc., Brookfield, Ohio

Robert Matteson 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.

3:45 p.m. – 4:00 p.m.
Question and Answer Session

POSTER SESSION

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.

Monday – Wednesday, October 6-8
FREE
During show hours • Outside Professional Program Session Area and on Show Floor near the AWS Skills Competition.

UNDERGRADUATE-STUDENT LEVEL

Cryogenic Cooling on Microstructure and Strength of Brazed Joints: Cryogenic Thermal Cycling Effect
by Chris Faith, Eli Gould, and Anthony McNeal, The Ohio State University

Effect of Heat Input with Spray Transfer, Pulsed-GMAW, and Pulsed-Cold Metal Transfer on Distortion of T-Joints
by Howah Lui, Brian Ricks, and Joe Walko, The Ohio State University

Experiments with Linear Vibration Welding of PMMA to ABS and PMMA to PC

by Andrew Green, David Harmon, and David Schick, The Ohio State University

A Study in Brazing Titanium Heat Exchangers: Applying Low Melting Filler Metal by Thermal Spray

by Marc Purslow, Geoff Murray, and Melissa Rubal, The Ohio State University

Microscale Fiber Laser Weld in Austenitic Stainless Steel Spiking and Porosity Suppression Techniques
by Matt Reiter, Chuck Violand, and Kate Mantkowski, The Ohio State University

Optimized Back Bead Geometry: Robotic V-Groove Welding Without a Backing Strip
by Trent Moyer, Stephen Forrest, and Stephen Truska, The Ohio State University

Low Distortion in Thick Plate GMAW Fabrication: Decoupling Heat Input from Nugget Area
by Todd Renz, Mathew White, and Chris Wright, The Ohio State University

Cause of Porosity in LENS-Processed Material
by Nick Balzer, Vince Arnett, Jon Reid, and Benjamin Spengard, The Ohio State University

Heat Affected Zone Control in 9% Ni Steel
by Pat Varga, Ian Gilmore, and Mike Wise, The Ohio State University

Electrode Weldability Across Different Power Supplies: Investigation of Transformer-Rectifiers and Inverters
by Michael Skrjanc and Steven Leopold, The Ohio State University

Joining Aluminum to Carbon Fiber
by Joshua G. Bollin, John Brunnett, and Ryan Bucurel, The Ohio State University

Design Optimization of Nuclear Fuel Rods with End Plug Welds
by Travis Grohoske and Lennon Meyer, The Ohio State University

Examination of Phase Transformations during PWHT of Steel P91
by John Siefert and Bridget King, The Ohio State University

GRADUATE DEGREE STUDENT LEVEL

Friction Stir Processing of Ti-5111
by Melissa J. Rubal, John C. Lippold, and Mary C. Juhas, The Ohio State University

Wide Gap Braze Repair of High Temperature Steels
by Christopher Wilkins and Stephen Liu, Colorado School of Mines

Stability of Explosively Bonded Titanium-Steel Clads: Effects of High Pressure and High Oxidizing Service Environment
by Brian Hansford, Colorado School of Mines

Physical Simulation of Ferrous Friction Stir Welds: Focusing on Grain Size Evolution in HSLA-65
by David Failla, The Ohio State University

Effect of Purity of Al_2O_3 to Joining-Ability to Copper
by Michikatsu Akagami, Yuki Sano, Tomohiro Ishii, Hiroaki Zaima, Yasuyuki Miyazawa and Tadasi Ariga, TOKAI University

Brazing of A1N Ceramics to Copper under Ar-Gas Atmosphere
by Kazuhiro Uehira, Takayuki Otuka, Keisuke Seto, Yousuke Aoki, Yasuyuki Miyazawa and Tadashi Ariga, TOKAI University

Brazing-Ability of Cd-Free Cu-Based Brazing Filler Metal to Copper
by Kazuhiko Kaneko, Noriko Akahoshi, Tetsu Yanai, Lamphanh Ssamouth, Yasuyuki Miyazawa and Tadashi Ariga, TOKAI University

Interfacial Reaction between Steel and Heat Resistant Cu-Fe Alloy with Brazing
by Kohei Ozawa, Tomoyuki Kurokawa, Fauzun, Yasuo Miyamoto, Yasuyuki Miyazawa, and Tadashi Ariga, TOKAI Unversity

Brazing of Ferritic Stainless Steel with Using Ni-Based Brazing Filler Metal
by Syuuji Ujiie, Naoaki Umeyama, Seiji Kato, Yasuyuki Miyazawa, and Tadashi Ariga, Tokai University

Effect of Ag Content to Soldering-Ability of Pb-Free Sn-Ag-Cu Solder
by Yoji Kanaya, Tomohiro Kimura, I Gusti Bagus Budi Dharma, Tadashi Sawamura, Yasuyuki Miyazawa, and Tadashi Ariga, TOKAI Unviversity

PROFESSIONAL/COMMERCIAL LEVEL

Development of Novel Fe-Cr Based Brazing Filler Metal
by Kotaro Matsu, Yasuyuki Miyazawa, and Tadashi Ariga, Tokyo Braze Co., Ltd.

DeltaSpot – A Perfect Solution to Weld Aluminum: Resistance Spot Welding with Process Tape
by Stefan Mayr, Fronius USA

ISO-Intensity Contour vs. ISO Laser Beam Representation
by Danny O. MacCallum and Gerald Knorovsky, Sandia National Laboratories

AWS VOLUNTEER COMMITTEES

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

Sunday, October 5

AWS Foundation (H)
8:00 a.m. • Hilton Ballroom G

Education Committee (H)
8:00 a.m. • Conference Rooms 2 & 3

Districts Council (H)
1:30 p.m. • Hilton Ballroom D & E

C7B Subcommittee on High Energy Beam Welding and Cutting (H)
2:00 p.m. – 4:00 p.m. • Conference Room 9

C7 Committee on Electron Beam Welding and Cutting (H)
5:00 p.m. – 6:00 p.m. • Conference Room 9

Monday, October 6

D15C Subcommittee on Track Welding (H)
8:00 a.m. – 5:00 p.m. • Conference Room 8

Panel Discussion: Evaluation of Strength Margins and Allowables in Brazed Joints (C)
8:00 a.m. – 12:00 noon • Room S228

Welding Handbook Committee (C)
1:00 p.m. – 4:00 p.m. • Room S216

D10 Committee on Piping and Tubing (C)
9:00 a.m. – 12:00 noon. • Room S216

AWS Opening Session & Annual Business Meeting (C)
9:30 a.m. – 11:00 a.m. • Room S222

A5K Subcommittee on Titanium and Zirconium Filler Metals (H)
1:00 p.m. – 5:00 p.m. • Conference Room 7

C5 Committee on Arc Welding and Cutting (H)
1:00 p.m. – 5:00 p.m. • Conference Room 6

D14I Subcommittee on Hydraulic Cylinders (C)
8:00 a.m. – 5:00 p.m. • Room S215

D18 Committee on Welding in Sanitary Applications (H)
1:00 p.m. – 5:00 p.m. • Conference Room 10

G2D Subcommittee on Reactive Alloys (H)
1:00 p.m. – 5:00 p.m. • Conference Room 7

Tuesday, October 7

D16 Committee on Robotic and Automatic Welding (C)
7:30 a.m. – 9:00 a.m. • Room S228

B1 Subcommittees on Inspection (H)
8:00 a.m. – 12:00 p.m. • Conference Room 6

D14G Subcommittee on Welding of Rotating Equipment (H)
8:00 a.m. – 5:00 p.m. • Conference Room 1

C3 Committee on Brazing and Soldering (H)
8:00 a.m. – 5:00 p.m. • Conference Rooms 2 & 3

C3 Brazing Subcommittees (H)
8:00 a.m. – 5:00 p.m. • Conference Rooms 2 & 3

D9 Committee on the Welding, Brazing, and Soldering of Sheet Metal (H)
9:00 a.m. – 5:00 p.m. • Conference Room 9

Global Exchange Forum (formerly PACWI/POCWA) (C)
10:00 a.m. – 5:00 p.m. • Room S228

C6 Committee on Friction Welding (H)
11:00 a.m. – 1:00 p.m. • Conference Room 7

B1 Committee on Methods of Inspection (H)
1:00 p.m. – 5:00 p.m. • Conference Room 6

D14B Subcommittee on General Design and Practices (H)
9:00 a.m. – 1:00 p.m. • Conference Room 8

D14C Subcommittee on Earthmoving and Construction Equipment (H)
2:00 p.m. – 6:00 p.m. • Conference Room 8

C2 Committee on Thermal Spraying (H)
2:00 p.m. – 5:00 p.m. • Conference Room 7

National Nominating Committee [open session] (C)
2:00 p.m. – 3:00 p.m. • Rooms S215 & S216

Technical Papers Committee (C)
5:30 p.m. – 6:30 p.m. • Room S223

Wednesday, October 8

Brazing & Soldering Manufacturers' Committee (C)
7:30 a.m. – 8:00 a.m. • Room S228

D14 Committee on Machinery and Equipment (C)
8:00 a.m. – 12:00 noon • Room S215

PFQC Committee on Personnel & Facilities Qualifications (C)
8:00 a.m. – 12:00 noon • Room S216

C3 Committee on Brazing and Soldering (H)
8:00 a.m. – 5:00 p.m. • Conference Rooms 2 & 3

C3 Brazing Subcommittees (H)
8:00 a.m. – 5:00 p.m. • Conference Rooms 2 & 3

D15A Subcommittee on Freight Cars and Materials (H)
8:00 a.m. – 5:00 p.m. • Conference Rooms 7 & 8

D17 Committee on Welding in the Aircraft and Aerospace Industries (H)
8:00 a.m. – 5:00 p.m. • Conference Rooms 9 & 10

A9 Committee on Computational Weld Mechanics (C)
12:00 noon – 2:00 p.m. • Room S216

American Council of the IIW (C)
Preceded by Thomas Lecture at 10:00 a.m.
10:30 a.m. • Room S231

Standards Council (H)

Professional Development Council (H)

Communications Council (H)

Role and Missions Committee (H)
(rolling meeting format, followed by Board of Directors meeting)
2:00 p.m. – 4:00 p.m. • Hilton Ballroom F & G

Board of Directors – Day 1 (H)
4:00 p.m. • Hilton Ballroom D & E

Thursday, October 9

Board of Directors – Day 2 (H)
8:00 a.m. • Hilton Ballroom D & E

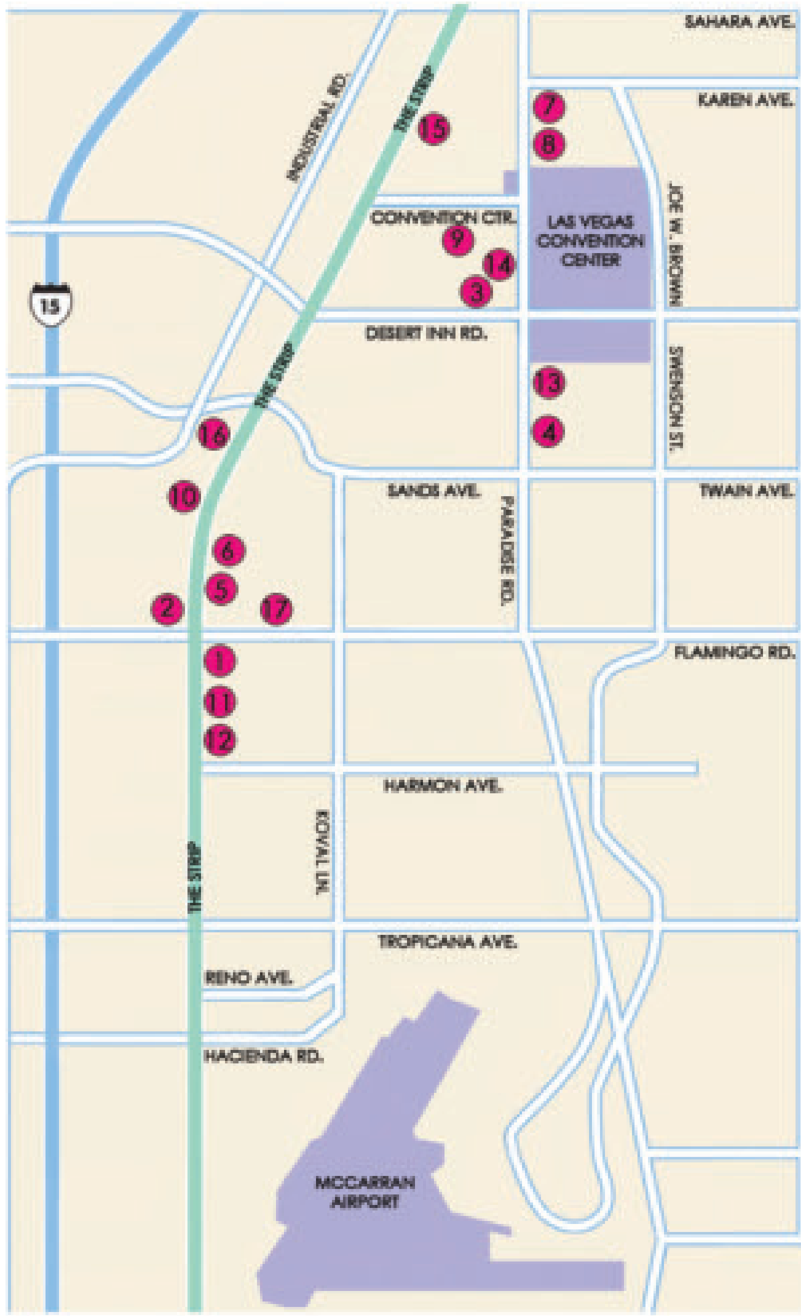
D15 Committee on Railroad Welding (H)
8:00 a.m. – 5:00 p.m. • Conference Room 7 & 8

D15A Subcommittee on Freight Cars and Their Materials (H)
8:00 a.m. – 5:00 p.m. • Conference Room 7 & 8

D17 Committee on Welding in the Aircraft and Aerospace Industries (H)
8:00 a.m. – 5:00 p.m. • Conference Room 9 & 10

Key:
(H) = Las Vegas Hilton
(C) = Las Vegas Convention Center

HOTEL LOCATIONS



1. Bally's Casino Resort $171
2. Caesars Palace $209
3. Courtyard by Marriott $154
4. Embassy Suites Convention Center $179
5. Flamingo $159
6. Harrah's Hotel Las Vegas $165
7. Hilton Grand Vacation $159
8. Las Vegas Hilton $188 (official AWS headquarters hotel)
9. Marriott Suites $169
10. Mirage $199
11. Paris $185
12. Planet Hollywood $175
13. Renaissance Las Vegas $209
14. Residence Inn by Marriott $159 (5 night stay required)
15. Riviera Hotel $99
16. Treasure Island $169 ($219 for Fri. & Sat. night)
17. Westin Casuarina Las Vegas $179

Quoted rates are for single/double rooms only and do not include tax, which is currently 9% (subject to change). Please keep in mind there is a limited number of rooms available in each hotel. Reservation requests and changes are subject to availability. For complete hotel descriptions and to reserve your hotel room, or a block of rooms, visit www.aws.org/show

FABTECH INTERNATIONAL & AWS WELDING SHOW

Introducing METALFORM

October 6 – 8, 2008
Las Vegas Convention Center, Las Vegas, Nevada USA

SHOW REGISTRATION FORM

- **Register by September 12, 2008 to receive your badge by mail. Register after this date and pick up your badge onsite.**
- **Online registrants will receive an immediate e-mail confirmation. Fax/Mail-in registrants will receive a confirmation within 3 business days.**
- **Register onsite and pay the $50 registration fee.**
- **Students: DO NOT use this form to register. Please call (800) 733-4763 for assistance.**
- **No one under 16 years of age admitted.**

3 EASY WAYS TO REGISTER:

ONLINE: www.aws.org/show
FAX: (708) 344-4444
MAIL TO:
FABTECH/AWS Welding Show 2008
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. Are you a first-time visitor to the show?

A ❏ Yes B ❏ No

2. Check if you are a member of:

A ❏ AWS B ❏ FMA C ❏ SME D ❏ NAM E ❏ None of the above

3. Check your ONE primary job function:

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

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 ❏ Welding Machines

5. 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

6. 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

CODE: W01

A ❏ FREE EXPO REGISTRATION

❏ 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 communications outside of the show.

Special Events

❏ **FREE Keynote** (K1) Mon., Oct. 6
❏ **FREE Keynote** (K2) Tues., Oct. 7

FREE Business Seminars

❏ Taming the Product Liability Beast (B1) Mon., Oct. 6
❏ Helping Fabricators Make Sense of the Economy (B2) Tues., Oct. 7
❏ Workforce Development **–** Today's Issues (B3) Wed., Oct. 8
❏ **Executive Forum Breakfast** (F1) Wed., Oct. 8 **$99**

(use other side to pay)

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

October 6–8, 2008 • Las Vegas Convention Center

FABTECH INTERNATIONAL & AWS WELDING SHOW — Introducing METALFORM

PAID PROGRAMS REGISTRATION FORM

Entry into the exposition is included in paid-event fee. **If faxing this form to register, please fax both sides.**

CODE: W01

Please indicate your name and member number to receive full pricing benefits.

Name____

Company____

I am a member of: ❑ AWS ❑ FMA ❑ SME ❑ PMA ❑ NAM ❑ Nonmember

Member Number ____

AWS PROGRAMS

Welding Education Conference

Conference fee $149

❑ (W80) Mon., Oct. 6

Other AWS Conferences

AWS/FMA/SME/NAM/PMA Member: $345

Nonmember: $480 includes 2-year AWS membership

New Technologies in Thermal Cutting Conference

❑ (W81) Mon., Oct. 6

New Nondestructive Testing Technologies

❑ (W82) Tues., Oct. 7

Friction Stir Welding Conference

❑ (W83) Wed., Oct. 8

One-Day Seminars

AWS/FMA/SME/NAM/PMA Member: $345

Nonmember: $480 includes 2-year AWS membership

Road Map through the D1.1

❑ (W84) Mon., Oct. 6

Visual Inspection Workshop

❑ (W85) Mon., Oct. 6

Why & How of Welding Procedure Specifications

❑ (W86) Tues., Oct. 7

Metallurgy Applied to Everyday Welding

❑ (W87) Tues., Oct. 7

RWMA Resistance Welding School

AWS/FMA/SME/NAM/PMA Member: $425

Nonmember: $660 includes 2-year AWS membership

❑ (W89) Tues. & Wed., Oct. 7-8

Two-Day Stainless Steel Seminar

AWS/FMA/SME/NAM/PMA Member: $550

Nonmember: $685 includes 2-year AWS membership

Welding of Stainless Steels

❑ (W88) Tues. & Wed., Oct. 7-8

Three-Day Professional Program

AWS/FMA/SME/NAM/PMA Member: $225

Nonmember: $360 includes 2-year AWS membership

❑ (W93) Mon.-Wed., Oct. 6-8

Three-Day Student Professional Program

AWS/FMA/SME/NAM/PMA Member: $75

Nonmember: $90 includes 1-year AWS student membership

❑ (W94) Mon.-Wed., Oct. 6-8

One-Day Professional Program

AWS/FMA/SME/NAM/PMA Member: $150

Nonmember: $285 includes 2-year AWS membership

❑ (W90) Mon., Oct. 6 ❑ (W91) Tues., Oct. 7

❑ (W92) Wed., Oct. 8

Free AWS Programs

Learn About Thermal Spray

❑ (W95) Mon., Oct. 6 at 9 a.m. *or* ❑ (W96) 1:30 p.m.

Free Education Program

❑ (W97) Tues. & Wed., Oct. 7-8

FABTECH EDUCATIONAL SESSIONS

❑ **1 Session** FMA/AWS/SME/NAM/PMA Member $165; Nonmember $200

❑ **2 Sessions** FMA/AWS/SME/NAM/PMA Member $295; Nonmember $350

❑ **3 Sessions** FMA/AWS/SME/NAM/PMA Member $395; Nonmember $470

❑ **4 Sessions** FMA/AWS/SME/NAM/PMA Member $475; Nonmember $570

❑ **5-7 Sessions** FMA/AWS/SME/NAM/PMA Member $695; Nonmember $795

Select the FABTECH Technical Sessions below you would like to attend. See page 53 for codes. 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 Sept. 19 and on-site, add $25 to the purchase price of FABTECH Technical Sessions only.

Mon., Oct. 6

AM Sessions: 10:30 AM-12:30 PM

❑(F10) ❑(F11) ❑(F12) ❑(F13) ❑(F14)

PM Sessions: 1:30-3:30 PM

❑(F20) ❑(F21) ❑(F22) ❑(F23)❑(F24) ❑(F25) ❑(F26)

Tues., Oct. 7

AM Sessions: 8:00-10:00 AM

❑(F30) ❑(F31) ❑(F32) ❑(F33)

❑(F34) ❑(F35) ❑(F36) ❑(F37)

AM Sessions: 10:30 AM-12:30 PM

❑(F40) ❑(F41) ❑(F42) ❑(F43)

❑(F44) ❑(F45) ❑(F46) ❑(F47)

PM Sessions: 1:30-3:30 PM

❑(F50) ❑(F51) ❑(F52) ❑(F53) ❑(F54) ❑(F55) ❑(F56)

Wed., Oct. 8

AM Sessions: 8:00-10:00 AM

❑(F60) ❑(F61) ❑(F62) ❑(F63)

❑(F64) ❑(F65) ❑(F66)

PM Sessions: 10:30 AM-12:30 PM

❑(F70) ❑(F71) ❑(F72) ❑(F73)

❑ **EXHIBITS ONLY**

Free if pre-registered. • $50 on-site.

Complete the form on other page.

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 only 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.

Cancellation Policy

Cancellations must be made in writing and faxed to Attn: FABTECH Intl & AWS Welding Show Conference Cancellation at 313-425-3404 no later than Sept. 19, 2008 to receive a full refund minus a $50 administration fee. Cancellations received after this date are non-refundable.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The future of welding technology is here.
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 parts in **low volume production**.
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October 6-8, 2008, Las Vegas, NV
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For Info go to www.aws.org/ad-index

Welding Show 2008
Exhibit Highlights

This alphabetical listing of exhibitors in the 2008 AWS Welding Show offers a preview of what they will display in each booth. AWS Sustaining Member Companies are highlighted in color.

AAF International (American Air Filter) 12177

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

AAF International will exhibit its high-quality solutions for dust control needs. The company provides cartridge collectors, baghouses, RotoClone® wet collectors, shaker-bag collectors, mist collectors, and more. It further provides replacement parts and filters for all makes.

A & A Manufacturing Co., Inc. 10143

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

A & A Manufacturing will offer GOR-SPOT, the spot welding holder from Gortite. This is a cost-effective replacement for balancers and manipulators in welding applications that require speed and flexibility. It features four axis adjustability for pivot, 360-deg rotation, 360-deg swivel and height. Also, the product replaces gantry rails, balancers, and long cabling, while working off of conventional power.

ABB Robotics 10048

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

ABB is a supplier of industrial robots, modular manufacturing systems, and service. At its booth, visitors can learn 10 compelling reasons to invest in robotics. The company has more than 160,000 robots installed worldwide in a variety of applications including welding, painting, material handling, machine tending, picking, packing, palletizing, and more. Other services include remote monitoring, reconditioned robots, and leasing programs.

ABICOR Binzel Corp. 15077

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

Visit ABICOR Binzel's booth to review its complete line of air/water-cooled automatic and semiautomatic GMA guns, robotic torches, and accessories. The new iCAT and iSTM torch mount, good for the latest generation of welding robots, will be displayed. Visitors can ask about its IGNITE Program and ABI-Fit, long-lasting consumable parts that can make cost savings for popular torches.

Ace Industrial Products 14063

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

Ace will highlight its line of fume extraction equipment for the welding industry. The company's portable fume extractors, mobile source capture units, powerful downdraft tables, and overhead ambient air cleaners have all been designed to help meet or exceed today's OSHA and EPA requirements for clean air.

AIM, Inc. 8165

502 S. Vista Ave., Addison, IL 60101-4423
(630) 458-0008; FAX (630) 458-0730
www.aimmachines.com

AIM will showcase the AFM series 3D wire bender. The AFM 3D8-T Ultra will demonstrate high-quality performance in CNC wire bending. Visitors to the company's booth will also get to see its newest product unveiled for the first time in North America, the low-cost AFC-8.

Airflow Systems, Inc. 14162

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

The company will offer solutions to industrial mist, smoke, dust, and odor problems from manufacturing processes such as machining, welding, and fabrication. Airflow Systems can provide compact portable units, machine mountable mist/dust collectors, to large central systems including low pressure source pick-up hoods to high pressure vacuum systems.

Air Liquide 10106

2700 Post Oak Blvd., Ste. 1800
Houston, TX 77056-5797
(800) 820-2522; FAX (713) 896-2390
www.us.airliquide.com

As a large industrial gas supplier, Air Liquide will feature its ability to deliver high purity cutting and welding gases, alternative furnace atmospheres, and turn-key advanced laser technologies to improve quality, productivity, and efficiency. The company has a team of cutting, welding, and heat treatment applications specialists who routinely perform process optimizations and plant audits.

Air Products and Chemicals, Inc. 13192

7201 Hamilton Blvd., Allentown, PA 18195-1501
(800) 654-4567; FAX (800) 272-4449
www.airproducts.com/microbulk

Exhibited will be CryoEase® microbulk solutions from Air Products. This offers a cost-effective, reliable alternative to cylinders for argon, nitrogen, oxygen, or carbon dioxide needs. It features specially designed delivery tankers for smaller volume drops in tight access areas and innovative on-site storage systems with turn-key gas delivery installations from point of supply to point of use.

Air Quality Engineering, Inc. 11135

7140 Northland Dr. N., Brooklyn Park, MN 55428-1520
(800) 328-0787; FAX (763) 531-9900
www.air-quality-eng.com

Air Quality Engineering will introduce the GrindMaster 1250 portable down draft table. This product is a self-cleaning 3 x 3 ft nominal table that has a 250 ft/min face velocity average on the table allowing greater capture of particulate generated from grinding, deburring, or other processes. Five inch locking casters allow it to be moved from workstation to workstation.

Ajax TOCCO Magnethermic Corp. 5249

1745 Overland Ave., Warren, OH 44483-2860
(330) 372-8511; FAX (330) 372-8608
www.ajaxtocco.com

Ajax TOCCO Magnethermic will exhibit its induction melting and heating equipment. Its advanced technologies are used for the melting of ferrous and nonferrous metals, heating for forging, mill processes, pipe and tube, coating, and the heat treatment of steel.

AKS Cutting Systems 5100

4905 Rocky River Dr., Cleveland, OH 44135-3245
(216) 267-1818; FAX (216) 267-1850
www.akscutting.com

AKS Cutting Systems will provide live plasma cutting demonstrations. The accu-kut precision plasma systems offer near-laser cut quality and accuracy at a fraction of the cost. The dura-kut gantry type cutting systems offer high quality plasma and oxyfuel cutting over larger cutting areas. All systems are designed and manufactured to heavy duty exacting machine tool standards.

Alaark Robotics 12204

16344 W. Glendale Dr., New Berlin, WI 53151
(262) 797-8085; FAX (920) 452-8140
www.alaarkrobotics.com

Alaark Robotics specializes in ABB industrial robot systems. The company's team of experienced technicians will be available to answer your questions. It services and sells refurbished robots and components for all ABB robot systems as well.

AlcoTec Wire Co. 14003

2750 Aero Park Dr., Traverse City, MI 49686-9263
(231) 922-1214; FAX (231) 941-1040
www.alcotec.com

AlcoTec Wire will feature aluminum welding wire. As a fully integrated aluminum welding and brazing wire producer, the company has the capabilities to shave, draw, spool, cut, test, and distribute its products.

Alfra USA LLC 8018

2112 Stonington Ave., Hoffman Estates, IL 60169-2017
(847) 252-7886; FAX (847) 252-7892
www.alfra.us

The company will exhibit its high-quality manufactured metal cutting saws, magnetic base drills, annular cutting devices, saw blades, hole saws, bevellers, hydraulic punches, hydraulic pumps, and deburring devices.

ALM Corp. 14195
200 Benchmark Industrial Dr., Streator, IL 61364-9400
(815) 673-5546; FAX (815) 673-2292
www.almcorp.com

ALM will showcase its manufactured material handling lifts and positioners for the manufacturing, welding, and assembly processes. This includes single and multicolumn positioners as well as lifting positioners. The product line also includes assembly line loading and unloading lifts. The company specializes in custom design mobile lifting systems for unique applications, too.

Almco, Inc. 4295
507 W. Front St., Albert Lea, MN 56007-2700
(507) 377-2102; FAX (507) 377-0451
www.almcoinc.com

The company's SBB-12 round bowl vibratory finishing machine with a helical bottom tub design will be displayed. Also shown will be the Almco/Kleentec PW-125HSS-U agitation/ultra-sonics parts cleaners.

Americ Corp. 11167
785 Bonnie Ln., Elk Grove Vlg., IL 60007-2222
(847) 364-4642; FAX (847) 364-4695
www.americ.com

Americ will highlight its ventilators designed for fume/smoke removal, man cooling, and bringing in fresh air. The company's ventilators are portable, lightweight, and designed for extreme environments. They are available in 8, 12, and 20 in. models, 848 to 8000 ft^3/min. Drum and pedestal fans are also available.

America Fortune Co. 10005
6600 Sands Point Dr., Ste. 121, Houston, TX 77074-3712
(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 an experienced supplier of Chinese made aluminum cylinders, CGA valves, regulators, and other welding supplies.

American Technical Publishers 11137
1155 W. 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. 13205
6212 29th St. E., Bradenton, FL 34203-5304
(941) 753-7557; FAX (941) 753-6917
www.americantorchtip.com

American Torch Tip is a domestic manufacturer of six major cutting and welding technologies, including plasma, GMA, GTA, laser, oxy fuel, and thermal spray. It now offers a full line of replacement GMA guns, including Tweco, Bernard, Tregaskiss, and a planetary drive push pull gun.

American Welding Society 11251
550 NW LeJeune Rd., Miami, FL 33126-5649
(305) 443-9353; FAX (305) 446-4424
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, brazing, soldering, cutting, thermal spraying, and allied processes. 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 organi-

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Ultra-Web technology is the world standard for advanced nanofiber air filtration. Ultra-Web filter cartridges, only from Donaldson® Torit®, are the preferred filter for cleaner air, longer filter life and greater energy savings.
Longest life—Performing in the field for 25 years and counting.
Proof is in the patents—Ultra-Web technology is backed by 80 issued & pending patents worldwide.
Savvy engineers' filter—More than 1 billion square feet of filter media used.
For all popular collectors—Ultra-Web replacement filters ship in 24 hours.
Improves lives—Ultra-Web technology is also used in medical research, M1 Abrams tanks and more.
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Visit us at FabTech & AWS Welding Show Booth #7020

zations 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 11251.

AWS Foundation. In 2006, the American Welding Society Foundation inaugurated the Welding for the Strength of America Capital Campaign to add financial support to assist with the critical shortage of welders in the United States workforce. The effort has dual goals: establish additional scholarships to support entry-level students and those already involved in the welding profession; and build funding to support the AWS Welder Workforce Development Program. The predicted 200,000 welder shortage by 2010 must be addressed and AWS has assumed this critical role, but to do so we must have financial support from our industry partners. Since the start of the AWS Foundation scholarship program in 1991, we have awarded more than \$3.7 million for welding training to more than 2500 individuals. The diversity of the awards is varied, but the major emphasis is welder workforce development. For the 2008-2009 school term, awards were made to more than 300 students for more than \$360,000. We need your help to respond at more significant levels of support. To date, we have raised more than \$3 million, but that is just an initial need if we are significantly going to impact the welder workforce shortage. We appeal to you, your company, and others you know that are adversely impacted by the welder shortage, to join us. Call Sam Gentry at (800) 443-9353, ext. 331, or visit us in the AWS Foundation Booth #11251. Join the “Welding for the Strength of America” Capital Campaign. Let us tell you more about our efforts and personally enlist your financial support. We need you!

Education. Includes conferences, 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.

Membership. AWS services more than 53,000 individual members and nearly 1800 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 \$192 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 180 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. 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.

AMET, Inc. **14049**
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 standalone products. The company uses Digital Signal Processing to provide precision process/motion control and process verification. The XM controller seamlessly integrates with Lincoln's ArcLink for complete digital power supply control. AMET produces "turn-key" standard and custom welding systems including seamers, lathes, and manipulator/positioner systems as well as standalone AVC, wire feeders, oscillators, and seam trackers.

AMNS Production Co. **15170**
41745 Elm St., Ste. 202, Murrieta, CA 92562
(877) 574-6341; FAX (866) 610-3260
www.amnstools.com

AMNS Production will highlight its small diameter, slim cut-off wheels featuring good quality and price.

A&N Welding Positioners **11194**
PO Box 40, Grimsby, ON, Canada L3M 4G1
(905) 643-4212; FAX (905) 643-4217
www.reddarc.com

The company will offer its welding positioners, manipulators, and rotating turning rolls.

Applied Cybernetics **15106**
5302 Clark Cir., Westminster, CA 92683-1758
(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. Some will be in the booth for welding demonstrations. The weld heads range from ⅛-in. tube through 6-in. pipe featuring high though-put, ruggedness, and ergonomics. Other accessories include weld head collets, multibrand collet adapters, and custom fixturing.

Aquasol Corp. **15100**
80 Thompson St., N. Tonawanda, NY 14120-5307
(716) 564-8888; FAX (716) 564-8889
www.aquasolcorporation.com

Aquasol will offer products for weld purging from water soluble paper and tape to preformed and self-adhesive water soluble purge dams sized from 2 to 72 in., purge gas retaining tape, cleaning wipes to reduce weld contamination, fiberglass backing tape, clamps, oxygen monitors, and water soluble socket weld spacer rings.

Arc Machines Inc. **14184**
10500 Orbital Way, Pacoima, CA 91331-7129
(818) 896-9556; FAX (818) 890-3724
www.arcmachines.com

ArcOne **11094**
85 Independence Dr., Taunton, MA 02780-1076
(508) 884-9600; FAX (508) 884-9666
www.arc1weldsafe.com

ArcOne will exhibit a variety of variable and single shade autodarkening welding helmets and accessories, inverter power sources, and NIOSH approved powered air and supplied air respiratory and safety products.

ARCON Welding Equipment LLC **11093**
2203 Northwood Dr., Bldg. 10
Salisbury, MD 21801-8829
(410) 572-6000; FAX (410) 572-6027
www.arconweld.com

ARCON Welding Equipment will feature its Workhorse line of portable, inverter arc and stud welding machines designed for harsh environments such as shipyards, mines, power plants, oil rigs, and paper mills, as well as fabrication and maintenance operations. The company will also offer complete welding packages for SMA, GTA, GMA, and stud welding machines. Along with a 3-year limited warranty, every ARCON power supply has built-in corrosion protection with a 5-year guarantee against corrosion-related failures in natural environments.

Arc Products **10053**
1245 30th St., San Diego, CA 92154-3477
(800) 770-0063; FAX (619) 628-1028
www.ap-automation.com

Arc Products will display its manufactured components as well as entire systems to enable easy conversion from manual GMA, sub arc, GTA, or plasma processes to a rugged and affordable automated process. The company will showcase seam tacking systems, orbital GTA, magnetic arc control, AVC, GTA wire feed, and weld process controllers.

ARC Specialties, Inc. 12111
1730 Stebbins Dr., Houston, TX 77043-2807
(713) 631-7575; FAX (713) 356-0844
www.arcspecialties.com

ARC Specialties has been a supplier for engineering services, process and procedure development, systems integration, service, parts, and training. Robot, CNC, and PLC systems will be on display, as well as parts welded with GTAW, PTAW, SAW, and RSW processes.

Ardleigh Minerals, Inc. 10221
3645 Warrensville Center Rd., Ste. 223
Shaker Heights, OH 44122
(216) 921-6500; FAX (216) 921-3840
www.ardleigh.net

Ardleigh Minerals will highlight its abilities as a specialty recycler that provides one-stop recycling services for aerospace manufacturers and their suppliers. Recyclable materials include thermal and plasma spray, HVOF powders, and dust collector fines that include materials and mixtures containing cobalt, copper, indium, molybdenum, nickel, and tungsten, among others. Recyclable materials also include blast media (alox, glass, plastic, shot, silicon carbide), filters, grinding wheels, and metal chips/grindings/turnings/swarf. The company provides certified destruction of component parts as well.

Arro-Mark Co. LLC 5268
158 W. Forest Ave., Englewood, NJ 07631-4526
(201) 567-4112; FAX (201) 567-1373
www.arromark.com

Arro-Mark will introduce a wide variety of environmentally-friendly products based on its innovative Water Base marking pen technology similar to traditional xylene-based markers, but with low VOCs and no odor. Visit its booth for the new FLOMASTER® industrial grade water-base metal marker and BLEED-THRU markers for use with water-base primers.

Asiamet, Inc. 10171
9 Evelyn Ct., Syosset, NY 11791-6816
(516) 942-3884; FAX (516) 942-4058

Astro Arc Polysoude, Inc. 13181
24856 Ave. Rockefeller, Valencia, CA 91355-3467
(661) 702-0141; FAX (661) 702-0632
www.astroarc.com

Astro Arc Polysoude provides orbital and mechanized welding solutions. The company will feature the new P4 power source with its latest tube, pipe, and tube sheet weld heads.

Atema, Inc. 10063
742 N. LaSalle Dr., Ste. 400, Chicago, IL 60654
(312) 642-8362; FAX (216) 373-7297
www.atema.com

Atema offers distinctive training and management assistance to companies interested in improving their quality management system and meeting various certification requirements. It also helps build and launch quality initiative programs designed to suit needs. Visitors can ask about its Continuing Education for Welding Inspectors and CWI Refresher Course. The company represents several international fabricators looking for project partners in the U.S. as well.

ATI Garryson 15192
1 Teledyne Pl., La Vergne, TN 37086-3529
(615) 641-4206; FAX (615) 641-4441
www.garryson.com

ATI Industrial Automation 15067
1031 Goodworth Dr., Apex, NC 27539-3869
(919) 772-0115; FAX (919) 772-8259
www.ati-ia.com

ATI Industrial Automation will exhibit its automatic tool changers, multi-axis force/torque sensing systems, robotic collision sensors, robotic deburring tools, and compliance devices.

Auburn Manufacturing, Inc. 15004
PO Box 220, Mechanic Falls, ME 04256-0220
(800) 264-6689; FAX (207) 345-3380
www.auburnmfg.com

Auburn Manufacturing will feature its manufactured heat resistant textiles for use in a variety of hot work/welding applications, along with hot work protective fire blankets.

AutoCrib, Inc. 12186
3011 S. Croddy Way, Santa Ana, CA 92704-6304
(800) 671-6501; FAX (714) 274-0400
www.autocrib.com

AutoCrib will display its industrial vending machines and tool crib/stores software that assists manufacturers in controlling tooling, safety, and other MRO supplies.

AVS Industries LLC 11174
21 Bellecor Dr., Ste. C, New Castle, DE 19720-1743
(302) 221-1720; FAX (302) 221-1721

Visitors to AVS Industries booth can review the company's diverse portfolio of high-temperature textiles for industrial welding and cutting protection. Specialty engineered fabrics will also be available for continuous high temperature applications to 2000°F (1100°C). Its high-temperature applications specialists look forward to addressing needs with cost effective high temperature solutions.

Axis Automation, Inc. **15221**
96 Corporate Park, Henderson, NV 89074
(702) 362-2228; FAX (702) 384-8785
www.axisautomationinc.com

Axis Automation is a manufacturer of good quality plasma cutting and waterjet equipment. The company will be demonstrating its PC-30510 at the show.

Baileigh Industrial, Inc. **5164**
PO Box 531, Manitowoc, WI 54221-0531
(920) 684-4990; FAX (920) 684-3944
www.bii1.com

BASF Catalysts LLC Surface Technologies **10173**
199 Ridgeview Center Dr., Duncan, SC 29334-9342
(864) 486-9311; FAX (864) 486-9307
www.basf.com

Behringer Saws, Inc. **3151**
721 Hemlock Rd., Morgantown, PA 19543-9768
(610) 286-9777; FAX (610) 286-9699
www.behringersaws.com

The company will be demonstrating the latest in bandsawing and coldsawing technology with its automatic, semiautomatic, and miter cutting horizontal bandsaws and Behringer Eisele circular cold saws to meet challenging applications. It is also suppliers of Vernet Behringer equipment for plate, beam, and angle processing for the structural steel market.

Beijing Advanced Metal Materials Co., Ltd. **10081**
B2-507 No. 18 Suzhoujie, Beijing, China 100080
86-10-8260-9309; FAX 86-10-8260-9308
www.bam.com.cn

Beijing Advanced Metal Materials will showcase the following: spherical fused tungsten carbide powders, crushed fused tungsten carbide powders, macrocrystalline tungsten carbide powders, and open arc cored wires for hardfacing; tungsten carbide, chrome carbide based powders, and molybdenum wires for thermal spraying; hafnium wires for plasma cutting; tungsten electrodes WTh, WLa, WZr, WCe, WX, oxyfuel cutting tips, and ceramic backings; shiny titanium welding wires, CuSi, CuAl, CuSn, CuZn, and ER5356, ER5183, ER4043, etc.

Beijing Aurora Safety & Protection Technology Ltd. **11256**
11/F ZhongKe A Bldg. No. 22
ZhongGuanCun Ave Hai Dian Dis
Beijing, China 100190
86-10-62524522; FAX 86-10-62572030-890
www.aurosfty.com

Beijing Aurora Safety & Protection Tech. is a professional autodarkening welding filters manufacturer that will offer digital displayed products corresponding to the EN379 standard.

Beijing Jinying Welding Alloys Co. Ltd. **10095**
No. 7th Fusheng Rd., Shahe Changping Dist.
Beijing, China 102206
86-10-80718648; FAX 86-10-80722991
www.alloywelding.com.cn

Beijing QLP Techno Development Co., Ltd. **10107**
Rm. 205 Block A Youyan Bldg.
Xinjiekouwai St., Xicheng District
Beijing, China 100088
86-10-820-22202; FAX 86-10-820-22202
www.bj.qlp.com

Beijing QLP holds technologies for production of Hf and Zr materials. The Hf and Zr wires for air plasma cutting, the main products of the company, will be highlighted. The targets and oxides for vacuum coating will also be provided.

Bernard Welding Equipment **13083**
449 W. Corning Rd., PO Box 667
Beecher, IL 60401-3127
(800) 946-2281; FAX (708) 946-6726
www.bernardwelds.com

Bernard Welding Equipment will showcase its new HD Q™ and S™ Series GMA guns and heavy-duty Centerfire™ consumables. The HD Q-guns and S-guns feature a durable and maneuverable rubber grip for high-deposition welding. A locking, armor protected trigger and optional dual-schedule switch provide durability and reduce operator fatigue. Heavy-duty Centerfire consumables feature removable nozzle cones, heat-resistant insulating material, and increased nozzle wall thickness.

Beyond 6 Sigma **13222**
41B Bisbee Ct., Santa Fe, NM 87508
(505) 660-3052; FAX (505) 424-3174
www.beyond6-sigma.com

Beyond6 Sigma will offer QualitySentinel™, a powerful hardware, sensing, and software platform that enables new levels of performance in quality for manufacturing. This product combines machine data and process data to create a total picture of process dynamics and part quality using data analysis techniques. It has been used on various processes, including linear friction welding, rotary friction welding, gas tungsten arc welding, gas metal arc welding, and laser welding.

Blackjack Machine and Fab, Inc. **15154**
PO Box 93, Oakhurst, TX 77359-0093
(936) 377-4839; FAX (936) 377-2065

Blastec, Inc. **5290**
4965 Atlanta Hwy., Alpharetta, GA 30004-2922
(770) 475-2700; FAX (770) 475-2336
www.blastec.com

Blastec will feature its high-quality, heavy-duty shot blasting systems for descaling and surface preparation. As innovators of an efficient shot blast wheel, it provides cleaning capabilities for industries requiring and processing plate, bridge, and structural steel.

Bluco Corp. **10142**
3500 Thayer Crt, Aurora, IL 60504
(800) 535-0135; FAX (630) 637-1847
www.bluco.com

Bluco will exhibit the 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. Useful for prototypes, spares, and other short run jobs.

BMM Welding Material Co. 10101
No. 5 Fangzhuang Lu, Beijing, China 100078
8610-676-49947; FAX 8610-676-44579
www.bjmmt.com

BMM Welding Material will display its ferrous and nonferrous alloy welding wires, rods, and strips.

Bohler Welding Group USA, Inc. 15024
10401 Greenbough Dr., Stafford, TX 77477-5014
(281) 499-1212; FAX (281) 499-4347
www.bohlerweldinggroupusa.com

At the Bohler Welding Group booth, visitors can discuss the applications, specifications, and approvals needed by today's international welding community for petrochemical, power generation, and fabrications as well as maintenance and repair. Also, visitors can learn more about the company's electrodes, wires, strip, and flux cored wires. The four brands — Bohler, T-PUT, Soudokay, and UTP — are sold and stocked in the U.S.A. and are supported through a technical sales organization that has application answers.

Bolduc Leroux 15204
3365 Boul Des Entreprises
Terrebonne, QC, Canada J6X 4J9
(450) 477-3413; FAX (450) 477-3380
www.bolducleroux.ca

Bolduc Leroux will offer a solid line of industrial downdraft tables. The company is a manufacturer in the steel industry. Its 50,000-sq-ft manufacturing plant combined with 3000-sq-ft assembly plant offers the capabilities to build special orders with ease.

Bonal Technologies, Inc. 11225
1300 N. Campbell Rd., Royal Oak, MI 48067-1573
(248) 582-0900; FAX (248) 582-0901
www.bonal.com

Bonal is showcasing its Pulse Puddle Arc Welding® equipment and the Meta-Lax® 2700-CC computerized stress relief equipment. Benefits of these include less weld distortion and weld cracking, greater ductility, no size or weight limits, and portability for field use.

Bortech Corp. 10001
66 Victoria St., Keene, NH 03431-4212
(603) 358-4030; FAX (603) 358-4007
www.bortech.com

Bortech will exhibit BoreWelders that repair worn bores, pins, shafts, faces, and conical seats with I.D.'s ranging from 0.5 in. to 12 ft, by applying GMA weld cladding. The company's BoreClads, to be highlighted as well, provide ID cladding of round parts such as nozzles and tubes using stainless steel or nickel alloys. BoreClads are also used in circular joining applications. Other machines can provide weld cladding in pipe of up to ten foot lengths. Local demonstrations and training are available.

Bosch Power Tool Corp. 15066
1800 W. Central Rd., Mt. Prospect, IL 60056-2230
(224) 232-2000; FAX (224) 232-2571
www.boschtools.com

Bosch will feature a complete line of power tools and accessories to survive any job site conditions. Tool categories include grinders/metalworking, saws, cordless, hammers/hammer drills, and drills/fastening.

Bosch Rexroth Corp. 8042
5150 Prairie Stone Pkwy.
Hoffman Estates, IL 60192-3707
(847) 645-3612; FAX (847) 645-3612
www.boschrexroth-us.com

Bosch Rexroth is a supplier of products and services for machining, forming, and fabricating markets. The company will offer its manufactured hydraulic, components, systems, and associated electronics, as well as closed loop pressure control and weld equalization controls for welding applications, integrated weld control packages to ISO standards, weld-resistant tubing and fittings, and vacuum technology.

Bowlin Engineering 15056
600 Burlington Rd., Saginaw, TX 76179-1310
(817) 232-2020; FAX (817) 232-4081
www.bowlinengineering.com

The company will display its smoke/dust collectors that recycle plant air, save energy and create a healthier plant environment. Its Bowlin Water tables for plasma cutting also will be displayed. The Zoned Down Draft Cutting Tables are useful to get a job done. Heavy, durable construction using a minimum of ¼-in. plate combined with a full length fixture gives its tables an absolutely straight and level table over its entire length.

Bradford Derustit Corp. 14061
21660 Waterford Dr., Yorba Linda, CA 92887-2650
(503) 691-9721; FAX (503) 692-1634
www.derustit.com

Bradford Derustit will exhibit its manufactured metal cleaners and pickling products.

Bren, Inc. 4196
8401 Covington Rd., College Groove, TN 37046-9198
(615) 794-6825; FAX (615) 794-7478
www.breninc.com

The company will feature electronic stencil, sign, and decal machines and materials; automated coding and marking systems; and synthetic stencil, lettering, and masking materials.

Broco, Inc. 13058
10868 Bell Ct., Rancho Cucamonga, CA 91730-4835
(909) 483-3222; FAX (909) 483-3233
www.brocoinc.com

Broco and Rankin Industries make a wide range of maintenance and repair welding, cutting, and wear-resistant products. Broco provides exothermic cutting and underwater welding systems. Rankin Industries is a designer and manufacturer of quality hardfacing and wear solutions products. It now manufactures a line of automatic and semiautomatic tungsten carbide Vibratory Feeder Systems for GMA application. Its family of products include oxygen cutting systems, portable welding machines, gouging electrodes, joining wires, hardfacing alloys, and delivery systems.

Bruker AXS Handheld 13302
415 N. Quay St., Ste. 1, Kennewick, WA 99336
(509) 783-9850; FAX (509) 735-9696
www.brukerhandheld.com

The S1 Tracer manufactured by Bruker AXS Handheld will be featured. This is a handheld XRF analyzer that provides rapid identification and analysis of alloys. The point and shoot analysis covers all elements important to alloy chemistry from Mg through U. This allows the identification and analysis of very similar alloys such as CP Ti and Grade 7 or B1900 and B1900Hf.

Bug-O Systems/ 15049
Cypress Welding Equipment
280 Technology Dr., Canonsburg, PA 15317
(412) 331-1776; FAX (412) 331-0383
www.bugo.com

The company will display its systems 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.

Burny and Kaliburn 13019
7550 Hub Pkwy., Cleveland, OH 44125-5705
(216) 524-8800; FAX (216) 642-2199
www.burny.com

Burny and Kaliburn will showcase its complete line of shape cutting control solutions and plasma arc cutting systems for plasma and waterjet cutting machines. In addition to fully integrated plasma cutting systems, it services users with a one-stop shop approach for seamless solutions.

CAR-BER Testing Services 12131
911 Michigan Ave., Point Edward, ON, Canada N7V 1H2
(519) 336-4498; FAX (519) 336-2649
www.carbertesting.com

CAR-BER Testing Services will highlight the company's specialty isolation and hydrotesting services to the pressure piping industry.

Carpenter Powder Products 10229
600 Mayer St., Bridgeville, PA 15017-2705
(412) 257-5102; FAX (412) 257-5154
www.cartech.com

Carpenter Powder Products will offer a variety of alloys covering nearly every application. The company has the ability to control the alloy's chemistry and particle size to meet stringent requirements. Good consistency is provided within and between production lots.

CENIT North America, Inc. 13220
691 N. Squirrel Rd., Ste. 275
Auburn Hills, MI 48326-2846
(248) 276-8540; FAX (248) 377-1652

The company will feature CATIA CAD/CAM solutions, DELMIA digital manufacturing solutions, offline programming for multiaxis laser, trimming, robotic spot welding, and arc welding, digital product engineering, and data management.

Cepro International 11232
Parallelweg 38 PO Box 183
Rijen NL-5120 AD, Netherlands
31161-226-472; FAX 31161-224-973
www.cepro.biz

Cerbaco Ltd. 11124
809 Harrison St., Frenchtown, NJ 08825-1122
(908) 996-1333; FAX (908) 996-0023
www.cerbaco.com

Cerbaco will provide samples from its line of 500+ configurations of nonmetallic weld backings that permit finished-quality, full-penetration welds from one side. Where one-sided welding is not desirable, the backings eliminate the need for arc gouging or heavy grinding prior to second-side welding. The company specializes in furnishing custom configurations and formulations. Technical assistance and free custom design services will be offered.

CGW-Camel Grinding Wheels USA 11140
7525 N. Oak Park Ave., Niles, IL 60714-3819
(800) 447-4248; FAX (800) 447-3731
www.cgwheels.com

The company will exhibit abrasive products for manufacturing, welding, fabricating, and construction. This will include flap discs along with flap wheels, resin fibre discs, 2 to 20 in. cut offs, all types of depressed center grinding wheels, bench grinding wheels, and more.

Changzheng Projector Carbon Electrodes Co. 10079
Huzhou City - Zhejiang Prov., Huzhou 313009
86 572-307-0288; FAX 86 572-301-1768
www.czcarbon.com

Changzheng Projector Carbon is a large manufacturer of gouging rods in China. Its main products to be featured are jointed, pointed, and flat gouging electrodes.

Changzhou Asia Science & Technology Co. Ltd. 10115
8-608 NanYong Sauone
Changzhou Jiangsu, China 213161
86-519-6301676; 86-519-6305876
www.cn-goldenglobe.com

Changzhou Asia Science & Technology is a foreign trade company that will showcase welding tools and accessories.

Changzhou Haijing Mechanical & Electrical Products 11113
1102 Unit C, Bldg. 11, Hejing Garden
Changzhou Jiangsu, China 213000
86519-86620382; FAX 86519-86620762
www.hjwelding.com

The company will highlight its manufactured welding and cutting products.

Changzhou Huarui Welding & Cutting Equip. Co. Ltd. 10113
Nanzai Panjia Town, Changzhou Jiangsu, China 213178
86519-620-1365; FAX 86519-620-3167
www.huarui-ca.com

Changzhou Huaya Aluminium Co. Ltd. 10087
Yuzhuang Village Yaoguan Town
Changzhou Zhejiang, China
86-519 8870 9358; FAX 86-519 8870 9323
www.huaya-cz.com

Changzhou Zhongjiang Welding Wire Co. Ltd. 12175
Chuangye Rd. Baizhang Town New
North, Changzhou Jiangsu, China 213034
86-519-85860999; FAX 86-519-85861034
www.zjwelding.com

Chart Industries, Inc. 13141
407 Seventh St. NW, New Prague, MN 56071-1010
(952) 758-4484; FAX (952) 758-8275
www.chart-ind.com

Chart will highlight its manufactured broad line of cryogenic products for the liquefaction, storage, transportation, and use of gases such as helium, nitrogen, argon, oxygen, carbon dioxide, natural gas, and hydrogen for a multitude of industrial, commercial, and scientific end users. The company's products serve many diverse markets including chemicals, materials, semi-conductors, biomedical, food, entertainment, aerospace, and alternative fuels.

Chinese Mechanical Engineering Society, The 10129
2-5-1607 Lianhuaxiaoqu, Haidian District
Beijing, China 100036
8610-639-72404; FAX 8610-639-80554
www.essen.cmes.org

The Chinese Mechanical Engineering Society is one of the largest engineering societies in China. Its major tasks are holding technical conferences and exhibitions, as well as conducting academic exchanges.

C. H. Symington & Co. Inc. 13010
6063 Frantz Rd., Ste. 103, Dublin, OH 43017-3369
(614) 766-2602; FAX (614) 766-2715
www.chsymington.com

C. H. Symington & Co. will be displaying its full range of air-carbon-arc equipment and related welding accessories; automatic, semi-automatic, and manual gouging torches, including consumables; exothermic cutting equipment, both torches and rods; and the Symex heavy duty ground clamp, cable connector, and GMA torch.

Chung I Silver Solder Co. Ltd. 15220
23 Hsin Ai Rd. An-Ping Ind Pk.
Tainan Taiwan ROC 702
886629-107-06; FAX 886626-371-67
www.chung-i.com

Chung I Silver Solder is a professional producer of silver brazing alloy and phos copper alloy. Not only silver brazing but CuPSn solder together with other multilayer contact alloy will be offered.

Cincinnati Thermal Spray, Inc. 10181
5901 Creek Rd., Cincinnati, OH 45242-4011
(513) 699-3863; FAX (513) 793-4254
www.cincinnatithermalspray.com

CK Worldwide, Inc. 14101
3501 C St. NE, Auburn, WA 98002-1702
(800) 426-0877; FAX (253) 939-1746
www.ckworldwide.com

The company will exhibit a large line of GTA torches and accessories, featuring gas saver consumables for standard GTA torches, fingertip amperage controls, wedge collet, cold wire feed systems, large diameter clear nozzles for titanium welding, flexible purge chamber, tungsten electrodes, tungsten grinder, super flex cables, Flex-Loc torches, turbine torch, long neck extended reach torches, and patented Dinse connectors.

Clean Air Consultants/Filter 1 12110
2525 National Dr., Garland, TX 75041-2351
(972) 278-2664; FAX (972) 278-1810
www.filter-1.com

Filter 1 will feature its air pollution solutions that have solved problems in a wide range of industries including aircraft manufacturing, maintenance, repair, and overhaul operations, precision sheet metal manufactures, fabrication/machine shops, foundries, food processing, paper handling, fiberglass manufacturing, wood shops, and many others.

Cleveland Steel Tool Co. 4018
474 E. 105th St., Cleveland, OH 44108-1378
(216) 681-7400; FAX (216) 681-7009
www.clevelandsteeltool.com

The company will display its manufactured punches, dies, and related tooling for the metal fabrication industry; a complete line of Ironworkers from 25 to 120 tons; and portable fabricating equipment including portable punches, mag drills, and annular cutting devices.

CM Industries, Inc. 15138
505 Oakwood Rd., Lake Zurich, IL 60047-1534
(847) 550-0033; FAX (847) 550-0444
www.cmindustries.com

CM Industries will exhibit complete lines of GMA and GTA air and water cooled torches, semiautomatic and robotic, along with smoke extractor guns, water coolers, pneumatic nozzle cleaning stations for robotic and semiautomatic welding, and push-pull GMA welding guns.

CML USA Inc. Ercolina 4179
3100 Research Pkwy., Davenport, IA 52806
(563) 391-7700; (563) 391-7710
www.ercolina-usa.com

CML USA will feature its high-quality Ercolina tube, pipe, and profile bending equipment; mandrel and nonmandrel rotary draw benders; and manual and hydraulic operated angle rolls. Pipe and tube notchers, portable magnetic drills, and centerfree annular cutting devices will also be available.

CMW, Inc. 13176
70 S. Gray St., Indianapolis, IN 46201-4200
(317) 634-8884; FAX (317) 715-2120
www.cmwinc.com

CMW manufactures a broad line of resistance welding consumables (holders, shanks/adapters, electrodes/caps, etc.). To be displayed are the company's GCAP®, an economical electrode cap available for high production welding of galvanized steel without the necessity of dressing; its manufactured Elkonite® copper-tungsten material, which it also incorporates into its electrodes to extend the life many times over; and Elkaloy® 20 Dispersion Strengthened Copper that has proven to provide longer life, reduced power consumption, and stable start up.

COB Industries, Inc. 7149
PO Box 36-1175, Melbourne, FL 32936-1175
(800) 431-1311; FAX (321) 984-8455
www.cob-industries.com

COB Industries, a manufacturer and distributor of specialty piping and welding products, will showcase weld purging equipment such as water soluble purge dams, Argweld purge monitors and purge bladders, purge plugs, flexible welding enclosures, backing tapes, trailing shields, and more. Also included will be the Multi Strike nonthoriated tungsten electrodes and the lifetime warranted TEGIII tungsten electrode grinders, and weld force gauges for robotic and manual applications. Other specialty piping products will include pressure test plugs for pipe. Pipe freezing systems will be available in liquid CO_2 and liquid nitrogen kits.

Cold Jet **13195**
455 Wards Corner Rd., Loveland, OH 45140-9033
(513) 831-3211; FAX (513) 831-1209
www.coldjet.com

Cold Jet will highlight its produced dry ice blasting and dry ice pellet production equipment as well as its offered dry ice delivery, machine rental, and contract cleaning services to a large variety of industries (automotive, aerospace, foundries, food, packaging, rubber, plastics, tires, etc.).

Comau, Inc. **14210**
21000 Telegraph Rd., Southfield, MI 48033-4280
(248) 368-6933; FAX (248) 368-2511
www.comau.com

As a member of the Comau Group, the company is part of a large full-service automation supplier. It will offer a range of products and services in joining and assembly technologies, powertrain machining and assembly, metalcutting, aerospace, robotics, and maintenance services.

COMEQ, Inc. **4123**
PO Box 207, White Marsh, MD 21162-0207
(410) 933-8500; FAX (410) 933-1600
www.comeq.com

COMEQ will offer metal fabricating machinery including the following: GEKA Ironworkers and CNC controlled punch positioning systems, ROUNDO angle and plate bending rolls, ADIRA press brakes and shears, PRIMELINE press brakes and shears, AMERICOR bending rolls and notchers, and more.

Computer Engineering, Inc. **11089**
509 NW 5th St., Blue Springs, MO 64014-2705
(816) 228-2976; FAX (816) 228-0680
www.computereng.com

Computer Engineering is a long standing provider of welding documentation software. It will offer the highest level of code checking currently available and can also quickly generate accurate WPSs, PQRs, and WPQs in accordance with AWS D1.1 and ASME Section IX. Other features include its welder management, continuity tracking, report system, and technical support.

Computers Unlimited **12129**
2407 Montana Ave., Billings, MT 59101-2336
(406) 255-9500; FAX (406) 255-9595
www.cu.net

Computers Unlimited provides integrated software solutions for the industrial gas and welding supply industry throughout the U.S., Canada, and Mexico. Displayed will be TIMS for Windows® that runs on the industry standard Windows Server 2008 and Microsoft® SQL 2005 database. A single solution integrates order entry, inventory and warehouse management, cylinder control and advanced cylinder management, electronic price updates, mobile delivery, e-docs, credit and collections, credit card processing, document imaging, integrated financials, and powerful business intelligence tools.

CONCOA, Inc. **14141**
1501 Harpers Rd., Virginia Beach, VA 23454-5303
(757) 422-8330; FAX (757) 422-3125
www.concoa.com

The company will introduce its next generation of gas management systems, the fully-automatic IntelliSwitch assist gas switchover that reduces liquid cylinder waste. Other featured products will include the 632 industrial gas automatic switchover system, the new 629 vent kit, 630 cryogenic manifold, and nexGen Laser Wizard software.

Controlled Automation, Inc. **1311**
PO Box 888, Bryant, AR 72089-0888
(501) 557-5109; FAX (501) 557-5618
www.controlledautomation.com

Controlled Automation will showcase its manufactured steel fabricating machinery and controls.

Coral S P A **11212**
Corso Europa 597, 10088 Volpiano (Torino), Italy
39-011982-2000; FAX 39-011982-2033-044
www.coral.biz

The company will provide pollution control systems for all types of mist, dust, and fume applications for a healthier environment. All of its systems meet OSHA's requirement for the removal of hexavalent chromium.

Cor-Met, Inc. 11204

12500 Grand River Rd., Brighton, MI 48116-8326
(810) 227-3251; FAX (810) 227-9266
www.cor-met.com

Cor-Met will feature high alloy flux cored wire and electrodes. The product line includes nickel and cobalt base alloys. Stainless steel, tool steel, maintenance and repair alloys, hardfacing products, and forge die repair alloys will be offered. The company will also showcase the following new products: COR-ALLOY AISI 4140 and AISI 4340 electrodes.

Coxreels Inc. 12219

6720 S. Clementine Ct., Tempe, AZ 85283-4323
(800) 269-7335; FAX (800) 229-7335
www.coxreels.com

Coxreels manufactures heavy duty industrial grade hose reels, cord reels, and cable reels of high quality. Its selection of reels will include spring retractable hose reels and electric extension cord reels, hand crank hose reels and cable reels, motor driven hose reels, and its patented EZ-Coil Safety Series retractable hose reels with controlled rewind. The company serves and supplies reels to OEM, welding, industrial, automotive, agricultural, petroleum markets, and more.

Crosby Group, Inc., The 4028

2801 Dawson Rd., Tulsa, OK 74110-5040
(918) 834-4611; FAX (918) 832-0940
www.thecrosbygroup.com

The Crosby Group will highlight blocks and fittings to be used with wire rope, chain, and synthetic slings. Products include the following: hooks, shackles, wire rope clips, turnbuckles, hoist rings and eye bolts, blocks and sheaves, and now the Crosby/IP lifting clamps for use in moving and handling plate steel.

Cryostar USA 11107

5897 Colony Dr., Bethlehem, PA 18017-9349
(484) 281-3401; FAX (484) 281-3402
www.cryostar.com

Cryostar will provide products and services covering cryogenic pumping, expansion turbines, and filling stations (LNG, LH2, industrial gas). The company also provides LNG applications such as shipboard compressors or hydrocarbon turbines, and develops applications dedicated to clean energy (geothermal, pressure letdown).

C-spec 13056

PO Box 5188, Concord, CA 94524
(877) 977-7999; FAX (925) 930-8223
www.weldoffice.com

C-spec will demonstrate WeldOffice and WeldOffice.NET for fast and consistent creation of welding procedures, welder qualifications, and NDE reports. They are equipped with extensive materials databases and automated verification of ASME, AWS, and ISO code requirements, along with being continuously developed, verified, and maintained by welding engineers and code committee members providing good performance, support, and training. The company provides complete solutions for QA/QC management of plants, fabrication shops, and construction projects.

CS SI 12230

5 Rue Brindejonc des Moulinais, BP 15872 Toulouse Cedex 5, France 31506
33561-176-496; FAX 33561-176578
http://wave.c-s.fr

CS SI will demonstrate CS WAVE, the virtual welding environment dedicated to train the welding motion to beginners.

CS Unitec, Inc. 15173

22 Harbor Ave., Norwalk, CT 06850-4210
(203) 853-9522; FAX (203) 853-9921
www.csunitec.com

CS Unitec will offer its new line of power tools and abrasives that achieve good surface quality in less time. Innovations in machine design and abrasive materials offer new grinding and polishing methods for finishing steel, stainless steel, and metals. PLANTEX/TRIMTEX flap discs have patented hemp compound backing plates. The high-tech hemp is self trimming. Hemp is a sustainable raw material that counteracts greenhouse emissions.

Cyl-Tec, Inc. 11210

950 Industrial Dr., Aurora, IL 60506-1150
(630) 844-8800; FAX (630) 844-5100
www.cyl-tec.com

Cyl-Tec will offer a one-stop source for compressed gas cylinders, cylinder services, and cylinder accessories. Cylinder sales include DOT/TC high-pressure cylinders, acetylene cylinders, aluminum cylinders, portable cryogenic, and beverage carbonation cylinders. Cylinder services include DOT approved hydrostatic and ultrasonic testing, portable cryogenic cylinder repair, acetylene cylinder re-

qualification, and aluminum cylinder refinishing. Cylinder accessories include valves, caps, siphon tubes, cryogenic repair parts, Acrylex fast-dry cylinder paints, and other related cylinder products.

Daido Steel America, Inc. 15082
1111 N. Plaza Dr., Ste. 740, Schaumburg, IL 60173-6000
(847) 517-7950; FAX (847) 517-7951
www.daido.co.jp/english

Daido Steel will display its "G-coat," a specially developed titanium wire for GMA welding offering higher efficiency than GTA welding. Also displayed will be a new ferritic stainless steel welding wire, WSR42KF, featuring fine grain weld metal microstructure combined with low spatter.

Dantherm Filtration, Inc. 11228
102 Transit Ave., Thomasville, NC 27360-8927
(800) 533-5286; FAX (336) 821-0890
www.danthermfiltration.us

Dantherm Filtration specializes in complete turn-key system air filtration design, including: collectors, ducting, fans, spark detection equipment, and more. They have more than 30,000 installations worldwide and sell a complete line of expandable collectors ranging from 500 to over 100,000 ft^3/min.

DataWeld, Inc. 15052
1909 Citizens Bank Dr., Bossier City, LA 71111-3429
(318) 746-6111; FAX (318) 746-0323
www.dataweld.com

DataWeld will feature its software, service, and support to meet the specific needs of welding supply distributors. Its services include accounting, cylinder tracking, and mobile order processing as either an integrated package or in its individual components. Solutions will be offered for both large and small businesses.

Davi North America/Promau 3281
5291 Zenith Pkwy., Loves Park, IL 61111-2727
(815) 282-8550; FAX (815) 282-8675
www.davi.com

The Davi booth will detail its CNC sheet and plate rolls machines suitable for both job shop and high-production specialized applications. Also featured will be its double beam folding machines.

Deloro Stellite, Inc. 11095
1201 Eisenhower Dr. N., Goshen, IN 46526-5311
(574) 534-2585; FAX (574) 534-3417
www.stellite.com

Deloro Stellite will display its lines of high-quality wear- and corrosion-resistant STELLITE® and DELORO® alloys supplied as castings, rods, powders, and wires. Also featured will be its equipment for hardsurfacing applications and its specialty services.

Delta Computer Systems, Inc. 11299
11719 NE 95th St., Ste. D, Vancouver, WA 98682-2444
(360) 254-8688; FAX (360) 254-5435
www.deltamotion.com

The company will showcase its RMC150 multiaxis motion controllers — the latest addition to its line of motion controllers.

Dengensha America Corp. 13211
7647 First Pl. Dr., Bedford, OH 44146-6701
(440) 439-8081; FAX (440) 439-8217
www.dengensha.com

Dengensha America will be showcasing its new MFDC Servo weld guns along with its new standard NDX pedestal welding machines, vibratory nut feeders, weld controls, weld monitoring equipment, and products in its welding consumables line.

DE-STA-CO 10110
1025 Doris Rd., Auburn Hills, MI 48326-2614
(248) 836-6700; FAX (248) 836-6740
www.destaco.com

DE-STA-CO will display its new 2000 Series hold-down clamps, new electric clamps and pivot units, plus many other products.

Dezhou Tejing Tungsten & Molybdenum Co., Ltd. 10091
North of Jinghua Rd., Dezhou Economic Dev. Zone
Dezhou 253000, China
86-534-2729167; FAX 86-534-2729097

The company's booth will display its extensive lines of tungsten electrodes featuring high quality and competitive pricing.

D & H Machinery, Inc. 5256
723 Phillips Ave., Bldg. D2, Toledo, OH 43612-1362
(419) 841-3586; FAX (419) 841-2986
www.dnhmach.com

The D & H Machinery booth will feature its services specializing in new and used coil processing equipment.

Diagraph MSP An ITW Company 12269
5307 Meadowland Pkwy., Marion, IL 62959-5893
(618) 997-1754; FAX (618) 997-1766
www.diagraphmsp.com

Dinse/Nu-Age Plant Services 10043
5750 Marathon Dr., Ste. B, Jackson, MI 49201
(517) 990-0665; FAX (517) 990-0663
www.nu-age.com

The company's booth will display its quality torch product line distributed by Nu-Age Plant Services, including welding guns for a wide variety of robotic and manual welding applications. Also presented will be details on Nu-Age's complete robotic cell maintenance services, dry ice blasting, weld cell products, and innovative data-acquisition solutions.

Direct Wire & Cable 13104
PO Box 57, 22 Industrial Way, Denver, PA 17517-0057
(717) 336-2842; FAX (717) 336-0505
www.directwire.biz

Direct Wire & Cable will display two types of Class K welding cables plus cords, jumper cables, Ultra-Flexible Whip lines, and extension cords.

Dissolvo 12263
12830 S. Dixie Hwy., Bowling Green, OH 43402-9697
(419) 373-4888; FAX (419) 354-0514
www.dissolvo.com

Dissolvo will display its economical purge-dam material for gas tungsten arc welding of steel, steel alloys, and aluminum pipes. Personnel will describe the simple technique for applying the product and its removal after making the weldment.

Diversi-Tech, Inc. 11084
2025 52e Av., Lachine, QC H8T 3C3, Canada
(800) 361-3733; FAX (514) 631-9480
www.diversitech.ca

Diversi-Tech will display its complete lines of air-filtration and air-handling products, including downdraft tables, dust collectors, portable smoke and fume collectors, clean air workstations, dust booths, filter cleaning equipment, as well as a complete line of fans.

Donaldson Torit/ Donaldson Co. Inc. **7020**
PO Box 1299, 1400 W. 94th St., Minneapolis, MN 55440
(800) 365-1331; FAX (952) 887-3054
www.donaldsontorit.com

Donaldson Torit will display its self-cleaning fume control systems using portable or stationary fume collectors. Also to be shown are its Ultra-Web filters with nanofiber technology for controlling hexavalent chrome fume.

Doringer Cold Saws **4008**
13400 Estrella Ave., Gardena, CA 90248-1513
(310) 366-7766; FAX (310) 366-7490
www.doringer.com

Featured at the Doringer booth will be its Models D300 (12 in.) and D350 (14 in.) circular cold sawing machines for cutting steel, stainless steel, and aluminum. Displayed will be manual, semiautomatic, and fully automatic machines.

Drossbach LLC **15176**
1500 Commerce Dr., Stow, OH 44224-1712
(330) 688-8460; FAX (330) 688-8465
www.reikuna.com

The Drossbach booth will present products in the Reiku® North America cable-protection systems, flexible electrical conduit, cable jackets, and cable management systems, offering protection against dirt, chemical, and mechanical damage. The products are specified for the robotics and automation industries, aviation, vehicle construction, shipbuilding, and industrial applications.

DualDraw LLC **15228**
5900 E. 58th Ave., Unit A, Commerce City, CO 80022
(303) 853-4083; FAX (303) 853-4086
www.dualdraw.com

DualDraw will showcase its indoor air-quality equipment featuring downdraft tables and booths using symmetrical airflow design to maximize the capture of harmful particulates such as welding smoke, grinding dust, and fumes.

Durum USA **10219**
11133 I-45 S., Bldg. I, Conroe, TX 77302
(936) 539-2630; FAX (936) 539-2470
www.durumusa.com

Durum will display its tungsten carbide-based Durmat® lines of hardfacing products, including welding powders, rods, wires, and electrodes used in deep drilling, steel, foundries, mining, dredging, agriculture, chemical, aluminum, excavation, pump manufacture and repair, and many other industries.

Dynabrade, Inc. **3238**
8989 Sheridan Dr., Clarence, NY 14031-1490
(716) 631-0100; FAX (716) 631-1167
www.dynabrade.com

Dynabrade will show its line of high-quality pneumatic abrasive power tools for grinding, sanding, deburring, filing, and polishing for the needs of numerous markets.

Dynaflux Inc. **15080**
241 Brown Farm Rd. SW, Cartersville, GA 30120-6327
(770) 382-8843; (770) 382-9034
www.dynaflux.com

Dynatorch, Inc. 10130
3530 Starnes Dr., Paducah, KY 42003-3505
(270) 442-0560; FAX (270) 442-1722
www.dynatorch.com

The Dynatorch booth will highlight its industrial grade plasma and flame cutting CNC machines and related systems and software. Shown will be how the machines can benefit job shops, metal artists, as well as high-production manufacturing facilities.

Easom Automation Systems, Inc. 10232
32471 Industrial Dr., Madison Heights, MI 48071-1528
(248) 307-0650; FAX (248) 307-0701
www.easomeng.com

The Easom Automation booth will feature its engineering and design services and products that assist in automation and production processes. Products to be featured include weld positioners, precision fixtures, welding cells, cymonic drives, Digi-Dog programmable limit switches, transfer systems, tool shuttles, conveyors, lifters, robot slides, indexing devices, and programmable turntables.

ECKA Granules of America LP 11266
130 N. Evergreen Rd., Ste. 100, Louisville, KY 40243
(502) 253-4550; FAX (502) 253-4563
www.ecka-granules.com

The ECKA booth will display its complete line of dispersion hardened copper alloys and nonferrous metal powders, including thermal spray powders.

Econco/CPI 4102
1318 Commerce Ave., Woodland, CA 95776-5908
(800) 532-6626; FAX (530) 666-7760
www.cpii.com

The company's booth will detail its cost-effective technology for rebuilding the large vacuum oscillator tubes used with the Thermatool radio-frequency welding machines used in tube and pipe manufacturing, and the smaller oscillator tubes used in Trumpf CO_2 lasers.

Edison Welding Institute (EWI) 10067
1250 Arthur E. Adams Dr., Columbus, OH 43221-3585
(614) 688-5000; FAX (614) 688-5001
www.ewi.org

EWI will display at its booth a sampling of the materials-joining innovations and solutions it has developed for its customers and federal agencies. Staff will be on hand to discuss your technical concerns for increasing product quality, productivity, and profitability.

Edwards Manufacturing Co. 1167
PO Box 166, Albert Lea, MN 56007-0166
(507) 373-8206; FAX (507) 373-9433
www.edwardsironworkers.com

Edwards Manufacturing will be demonstrating its full line of ironworking machinery. Featured will be its Jaws ironworkers with Whisper Quiet hydraulic systems and electric foot pedals.

EFD Induction, Inc. 8225
31511 Dequindre Rd., Madison Heights, MI 48071-1537
(248) 658-0700; FAX (248) 658-0701
www.efd-induction.com

New this year, EFD will offer demonstrations of the Minac 18/25-kW mobile induction heater for brazing and other heating operations. Also to be displayed will be its solid-state Weldac high-frequency welding machines for tube and pipe manufacturing.

E. H. Wachs Co. 11128
600 Knightsbridge Pkwy., Lincolnshire, IL 60069-3617
(847) 537-8800; FAX (847) 520-1147
www.wachsco.com

The company will feature its portable pipe construction and maintenance tools including a diverse line of products for cutting, squaring, beveling, facing pipe, tube, and vessels of all sizes and schedules under all conditions and environments.

Elco Enterprises 14025
5750 Marathon Dr., Ste. B, Jackson, MI 49201-7711
(517) 782-8040; FAX (517) 787-6458
www.wire-wizard.com

Elco will display its weld wire dispensing and weld cell support equipment. To be shown are the Wire Wizard® wire-dispensing equipment and conduit, Torch Wizard™ nozzle cleaning stations, the Wire Pilot™ wire-feed assist, Wizard Shield™ antispatters, and Wizard View™ data acquisition systems.

Electric Heating Systems, Inc./AFTEK 14211
2960 E. State St., Ext., Trenton, NJ 08619-4504
(609) 259-4116; FAX (609) 259-4119
www.hotfoilehs.com

Electric Heating Systems will showcase its heat treating equipment for welding applications. Announcing its recent acquisition of AFTEK Welders, the demonstrations will include a unique heat treating unit that allows the operator to weld and PWHT at the same time.

Electron Beam Engineering, Inc. 12132

1425 S. Allec St., Anaheim, CA 92805-6306
(800) 329-3537; FAX (714) 758-0690
www.ebeinc.com

The Electron Beam Engineering booth will introduce its new Beamer 512, a 60-kV, 5-kW 12-in. cubed chamber EBW machine. Its special features include highly repeatable welding, weld schedule storage with touch screen and knob controls, fast pump down, and low maintenance for use in the aerospace and medical industries.

Electron Beam Technologies, Inc. 11118

1275 Harvard Dr., Kankakee, IL 60901-9471
(815) 935-2211; FAX (815) 935-8605
www.electronbeam.com

The company's booth will display samples of POLY-XL jacketed gas metal arc welding and plasma arc cutting composite/coaxial cables. Also on display will be its complete line of FAST 'N EASY bulk electrode handling equipment. Application engineers will be at the booth to discuss your needs.

Enco 13291

PO Box 357, Farmingdale, NY 11735-0357
(800) 873-3626; FAX (800) 965-5857
www.use-enco.com

The Enco booth will feature some of the 60,000 items displayed in its master catalog of machines, tools, and shop supplies.

Encur, Inc. 5193

200 Division St., Keyport, NJ 07735-1604
(732) 264-2098; FAX (732) 264-0126
www.encur.com

Encur will exhibit at its booth a new and innovative bright annealing system for the stainless steel tube and pipe producing industry.

Environmental Air Solutions 14055

2220 Jessica Ln., Coralville, IA 52241-2890
(319) 358-7794; FAX (319) 248-0345
www.keeptheheat.com

The company's booth will feature its Keep The Heat™ air-to-air heat exchanger that provides shop ventilation without losing heat.

ERW Inc. 10198

PO Box 431, 91 Highland Dr., Putnam, CT 06260-0431
(860) 928-1199; FAX (860) 928-9499
www.erwinc.com

The ERW booth will feature its metal masking products for all thermal spray processes as well as some blasting applications.

ESAB Welding & Cutting Products 15001

411 S. Ebenezer Rd., Florence, SC 29501-7916
(843) 669-4411; FAX (843) 664-4459
www.esabna.com

ESAB will exhibit its new PowerCut™ lightweight 1300 and 1600 manual cutting packages featuring simplified operation and reduced setup time. Also to be shown will be its Dual Shield X Series of filler metals, automation equipment, subarc welding machines, and its latest technology in mechanized plasma arc cutting.

ESCO Tool Co. 7198

50 Park St., Medfield, MA 02052-2518
(800) 343-6926; FAX (508) 359-4145
www.escotool.com

The ESCO Tool booth will feature product demonstrations. Some of its tools include boiler tube rolling motors and expanders, Millhog end-prep tools, and Panel Hog saws for cutting tube, panels, and pipe made from all types of alloys including superduplex.

ESTA Corp. 14191

2321-A Distribution St., Charlotte, NC 28203-5370
(704) 971-6960; FAX (704) 971-6966
www.esta.com

The ESTA booth will provide a staff of trained technicians to discuss visitors' options for solving fume and dust extraction concerns.

EST Group 4218

2701 Township Line Rd., Hatfield, PA 19440-1770
(800) 355-7044; FAX (215) 721-1101
www.estgroup.com

The company will display its line of tools that permit fast, safe, high-pressure testing of tubes. A new item to be introduced at the show will be the double block and bleed line Isolation plug.

Exel Orbital Systems, Inc. 13172
1052 Clear Sky Pl., Simi Valley, CA 93065
(310) 449-0054; FAX (310) 449-1154
www.exelorbital.com

Exel Orbital will demonstrate its integrated software solution known as IM, which uses the Internet to track and leverage all quality associated with any manufacturing operation to bring about mass customization of process to reduce manufacturing costs while increasing quality and productivity.

Factory Cat 5243
PO Box 368, Racine, WI 53401-0368
(262) 681-3583-104; FAX (262) 681-3753
www.factorycat.com

The company will display its line of industrial walk-behind and rider sweepers, scrubbers, and burnishers at the show.

FANUC Robotics America, Inc. 10012
3900 W. Hamlin Rd., Rochester Hills, MI 48309-3253
(800) 477-6268; FAX (866) 743-2511
www.fanucrobotics.com

FANUC Robotics America will introduce its new six-axis, ARC Mate 120iC intelligent welding robot featuring compact design, high efficiency, speed, and load capacity to provide enhanced performance for welding parts of all shapes and sizes.

Farley Laserlab USA Inc. 4101
4635 Colt Rd., Rockford, IL 61109-2609
(815) 874-1400; FAX (815) 874-1700
www.farleylaserlab.com

The company's booth will feature its new Fabricator XRP, a combination drilling and cutting machine; and a Profile Plus laser for the plate processing industry. The machines are designed for use by steel service centers, OEMs, bridge builders, structural steel fabricators, and job shops.

FastCut CNC, Inc. 1057
2841 Bowers Pl., Kamloops, BC V1S 1W5, Canada
(250) 314-0580; FAX (250) 314-0590
www.fastcutcnc.com

The booth will showcase the company's low-cost, entry-level industrial CNC plasma arc cutting machine.

Fein Power Tools, Inc. 15119
1030 Alcon St., Pittsburgh, PA 15220-3436
(800) 441-9878; FAX (412) 922-8767
www.feinus.com

The Fein Power Tools booth will display its nibblers up to 6 gauge, shears up to 9 gauge, magnetic annular cutting machines, grinders, hacksaws, and polishing systems for stainless steel.

Flame Technologies Inc. 14119
703 Cypress Creek Rd., Cedar Park, TX 78613-4414
(512) 219-8481; FAX (512) 219-8477
www.flametechnologies.com

The Flame Tech booth will feature its new point-of-purchase packaging, including welding/cutting/brazing outfits packaged in heavy-duty canvas tool bags. To be displayed is a new exothermic product line of burning bars, lance pipes, and holders, as well as a carbon arc gouging torch, hollow-core gouging rods, lightweight Scorpion series heavy-duty tip-mix hand-held cutting torches, direct replacement cutting tips, heating/brazing apparatus, regulators, flash arrestors, flowmeters, balloon fillers, and other products.

Flex-North American, Inc. 11193
13057 W. Center Rd., Ste. 6., Omaha, NE 68144-3723
(402) 933-7759; FAX (402) 933-7729
www.flexna.com

The company will display its line of metal surface treatment products including its LRP 1503 VR "BOA" and LBR 1506 VR pipe sanders, LBS 1105 VE finger belt sander, and the LP 1503 VR finishing machine, and an array of metal grinders.

Flexovit USA, Inc. 11180
1305 Eden Evans Center Rd., Angola, NY 14006-9734
(800) 689-3539; FAX (888) 321-8800
www.flexovitabrasives.com

The company's booth will showcase its lines of high-quality abrasive products including grinding wheels, coated abrasives, wire brushes, and diamond products.

Flowdrill, Inc. 5276
2820A Breckenridge Ind. Ct., St. Louis, MO 63144-2811
(314) 968-1134; FAX (314) 968-1510
www.flowdrill.com

The booth will display the company's Flowdrill process for mounting a bushing in aluminum, brass, copper, steel, stainless steel, and titanium that can be tapped. The process uses friction to generate heat that displaces the base metal to form a hole that can accept a bushing that is about three times the base metal thickness. This bushing can be tapped and used instead of welded, pressed, or inserted nut or clip.

Freedom Special Technologies, Inc. **12214**
2709 E. Ash St., Ste. B, Springfield, IL 62703
(217) 525-0815; FAX (217) 525-0446
www.weldfst.com

Freedom Special Technologies will introduce at its booth the Freedom Pedal, a wireless gas tungsten arc welding pedal engineered to function with any GTA welding machine. It features a plug-and-play, 100-ft-multidirectional range capability, elevation positioning system, steer tab technology, ergonomic shaping, onboard diagnostics, and multichannel adjustability for greater efficiency.

Frommelt Safety Products **11211**
4343 Chavenelle Dr., Milwaukee, WI 53223-2451
(800) 553-5560; FAX (563) 589-2776
www.frommeltsafety.com

Frommelt will display its line of welding screens, curtains, retractable guards, and area wall partitions. Its machine-guarding products include high-speed barrier doors and Robo Guard perimeter fencing. Also to be featured are fume-extraction equipment.

Fusion, Inc. **12014**
4658 E. 355th St., Willoughby, OH 44094-4630
(440) 946-3300; FAX (440) 942-9083
www.fusion-inc.com

The Fusion booth will display the company's lines of brazing and soldering alloys, dispensers, and automatic machines, including fixed-station and rotary indexing machines.

FV Hayek & Co. **11237**
1102 N. Springbrook Rd., Ste. 127, Newberg, OR 97132
(503) 330-6867; FAX (503) 554-9468

F. W. Gartner **10187**
25 Southbelt Industrial Dr., Houston, TX 77047-7011
(713) 225-0010; FAX (713) 229-9841
www.fwgts.com

The F. W. Gartner booth will highlight its services in thermal spraying, machining, grinding, CNC, laser cladding, heat treating, and fabrication operations.

GBC-America Inc. **14233**
2519 E. Southmore Ave., Pasadena, TX 77502-1451
(713) 472-8122; FAX (713) 472-6804
www.gbcamerica.com

The GBC-America booth will feature its portable tube end prep machines, and the Mini Auto machine for the manufacture and repair of heat exchangers and condensers, designed for facing heat exchanger tubes and removing tube-to-tube sheet seal welds.

Gedik Welding, Inc. **14129**
Ankara Cad No. 306 Seyhli, Seyhli-Pendik
Istanbul 34913, Turkey
90-21-63785000; FAX 90-21-63787936
www.gedik.com.tr

Genie Products, Inc. **10191**
PO Box 1028, Rosman, NC 28772-1028
(828) 862-4772; FAX (828) 877-3480
www.genieproducts.com

Genie Products will display its full line of consumable precision replacement parts for all OEM plasma and HVOF thermal spray torches. Also on display will be the GTV line of innovative thermal spray systems.

Genstar Technologies Co., Inc. (GENTEC) **14163**
4525 Edison Ave., Chino, CA 91710-5706
(909) 606-2726; FAX (909) 606-6485
www.genstartech.com

Genstar will display its line of cutting and welding machines, pressure regulators, fittings, valves, welding apparatus, and various gas control and handling devices.

GE Sensing & Inspection Technologies **13214**
50 Industrial Park Rd., Lewistown, PA 17044-9312
(717) 242-0327; FAX (717) 242-2606
www.GEInspectionTechnologies.com

GE Inspection Technologies will showcase its nondestructive testing inspection products using radiographic, ultrasonic, remote visual inspection, and eddy current technologies for applications in the aerospace, power generation, oil and gas, and automotive industries.

Goff's Enterprises **15010**
1228 Hickory St., Pewaukee, WI 53218
(800) 234-0337; FAX (262) 691-3255
www.industrialcurtains.com

The company's booth will feature its portable welding screens that block 100% of UV rays, featuring frames that hinge together to make a stable one-piece barrier to protect passers-

by from arc welding, grinding sparks, and flame cutting operations.

Goodtime Industry Ltd. **10097**
10/F Unit 1012 L Trade Center, No. 78 Tonghu St.
Tongzhou Dist., Beijing 101101, China
86-10-89525972; FAX 86-10-89525970
www.goodtime.com

Goss, Inc. **12119**
1511 Rte. 8, Glenshaw, PA 15116-2301
(412) 486-6100; FAX (412) 486-6844
www.gossonline.com

Goss will display its complete line of cutting, welding, brazing, soldering, and heating tools designed for use in a variety of applications.

Gudel, Inc. **15162**
4881 Runway Blvd., Ann Arbor, MI 48108-9558
(734) 214-0000; FAX (734) 214-9000
www.gudel.com

The Gudel booth will feature its line of linear motion gantry robot modules in single and multiaxis configurations, and its bearings, racks, pinion, gears, and gearboxes used worldwide for factory and process automation, and OEM machinery.

Gullco International **12241**
21568 Alexander Rd., Cleveland, OH 44146-5586
(440) 439-8333; FAX (440) 439-3634
www.gullco.com

Gullco International will feature its automated welding and cutting equipment for heavy industrial use. Featured will be its new Pipe Kat orbital pipe welding system, with all-position, variable-speed travel carriages ideal for vertical and horizontal multipass welding. Also to be displayed will be Moggy single and dual torches, magnetic trackless fillet weld carriages; the KBM-18 and KBM-28 high-speed, portable, plate edge-beveling machines; seam tracking systems, positioners, turning rolls, semiautomatic gouging systems, and Katbak ceramic weld backing.

Häberle/Ken Bergman & Assoc. **5195**
10533 Lorel Ave., Oak Lawn, IL 60453-5154
(800) 956-1313; FAX (708) 422-3604
www.haberleusa.com

The company will display the German-made Häberle line of ferrous and nonferrous cut-off machines, HSS and CBT cold saw blades, and tube deburring machines.

Haco-Atlantic, Inc. **8015**
11629 N. Houston Rosslyn Rd., Houston, TX 77086-3601
(281) 445-3985; FAX (281) 445-3989
www.hacoatlantic.com

Haco-Atlantic will provide continuous demonstrations of its Synchromaster Model SRM 150-10-8, CNC press brake with FastBend graphics 2-D controller, European style tooling, high-speed back gauge, R-axis, and automatic antideflection table. Also to be demonstrated will be the company's new off-line Hacobend 2-D software.

HAI Advanced Material Specialists **10175**
1688 Sierra Madre Cir., Placentia, CA 92870
(714) 414-0575; FAX (714) 414-0574
www.haiams.com

The company's booth will showcase its lines of thermal spray and welding wires, powders, and equipment for twin-wire arc, HVOF, combustion, and plasma spraying.

Harbert's Products Inc./ Allied Flux Reclaiming Ltd. **15034**
PO Box 418, 501 S. Cedar Ln., Greencastle, PA 17225
(800) 377-3103; FAX (717) 597-1748
www.recycleflux.com

The Harbert's Products and Allied Flux booth will present details on their cost-effective closed-loop submerged arc welding flux and slag crushing/reprocessing program that offers third-party testing to meet all welding code applications.

Harris Products Group **14043**
2345 Murphy Blvd., Gainesville, GA 30504-6001
(800) 733-4043; FAX (513) 754-8778
www.harriscal.com

Haynes Wire Co. **10133**
PO Box 677, 158 N. Egerton Rd.
Mountain Home, NC 28758-0677
(828) 692-5791; FAX (828) 697-9818
www.haynesintl.com

The Haynes Wire Co. booth will display its high-performance nickel- and cobalt-based alloys, including HAYNES® and HASTEL-

LOY® thermal spray alloy wires and high-performance stainless steel products.

H. C. Starck, Inc. 10180
45 Industrial Pl., Newton, MA 02461-1951
(617) 630-5800; FAX (617) 630-5879
www.hcstarck.com

The company will showcase its powders, including nitrides, for structural, electronic, and engineered ceramics including Si_3N_4, AlN, BN, borides (LaB_6, TiB_2, ZrB_2, etc.), carbides (B_4C, SiC, TiC, etc.), silicides ($MoSi_2$, etc.), and oxides (Y_2O_3, Spinal, etc.); plus advanced materials for electronics and optics including Nb_2O_5, $NbCl_5$, Ta_2O_5, and $TaCl_5$, and niobium and tantalum ethoxides for specialized applications.

Heck Industries, Inc. 5107
PO Box 425, Hartland, MI 48353-0425
(810) 632-5400; FAX (810) 632-6640
www.heckind.net

The Heck Industries booth will display its line of bevel-mill and plate bevelers, Trace-A-Punch nibblers, Turbo-Burr® deburring tools, hydraulic angle notchers, and pipe notchers.

Heinz Soyer GmbH 12224
Inninger Str. 14, 82237 Woerthsee, Etterschlag
Bavaria, Germany
49-81-5-3885134; FAX 49-81-53885221
www.soyer.com

Heinz Soyer Studwelding will present at the show its complete line of stud welding equipment, ranging from small capacitive discharge systems to high-power inverter, drawn arc systems.

HE & M Saw, Inc. 4207
PO Box 1148, Pryor, OK 74362
(918) 825-4821; FAX (918) 825-4824
www.hemsaw.com

The company's booth will feature its line of metal working fluids and production band saws including vertical, horizontal, plate, and double column saws with capacities ranging from 10 x 10 in. to 80 x 80 in.

Henkel Corp. (Acheson) 11264
1001 Trout Brook Crossing, Rocky Hill, CT 06067-3582
(860) 571-5100; FAX (860) 571-5430
www.henkelna.com

Heron Machine & Electric Industrial Ltd. 10125
#9 Fengying Rd., Taiping Econ & Tech, Changhuang
Guangzhou, Guangdong 510880, China
86-020-87813325; FAX 86-020-87813346
www.heronwelder.com

HI TecMetal Group, Inc. 13190
1101 E. 55th St., Cleveland OH 44024
(216) 881-8100; FAX (216) 426-6690
www.htg.com

Hi TecMetal will feature its services for most aspects of metal joining, thermal and heat treatment, as well as engineering, lab, and assembly capabilities.

H&M Pipe Beveling Machine Co., Inc. 11186
311 E. 3rd St., Tulsa, OK 74120-2401
(918) 582-9984; FAX (918) 582-9989
www.hmpipe.com

H&M will display its pipe cutting and beveling equipment, pipe alignment clamps, flange pins, and accessories to aid in the cutting, fitup, and welding of pipes from 2 to 96 in.

Hobart Brothers Co 13081
101 Trade Square East, Troy, OH 45373-2488
(937) 332-4000; FAX (937) 332-5224
www.hobartbrothers.com

Hobart Brothers will exhibit its full line of filler metal products from the brands Hobart, Tri-mark, McKay, and Corex. Products will include mild steel and low-alloy electrodes, flux-cored and metal-cored tubular wires, solid wire, as well as stainless and hardsurfacing products. Staff will be on hand to assist visitors in welding solutions and product recommendations.

Hobart Institute of Welding Technology 11191
400 Trade Square East, Troy, OH 45373-2463
(800) 332-9448; FAX (937) 332-5200
www.welding.org

Booth personnel will offer literature and complete information about the Institute's numerous welding-related classes and training programs.

Hougen Manufacturing, Inc. 5089
3001 Hougen Dr., Swartz Creek, MI 48473-7935
(800) 426-7818; FAX (810) 635-8277
www.hougen.com

The Hougen booth will display the latest innovations in portable magnetic drills and other hole-making equipment designed to make maintenance, repairs, and installations easier, faster, and safer. Featured will be the new

For info go to www.aws.org/ad-index SEE US AT THE FABTECH/AWS SHOW BOOTH #14201

HMD904S swivel base magnetic drill, patented Rotabroach annular cutting tools for fast hole production, Punch-Pro electrohydraulic hole punchers, and a variety of convenient kits and accessories.

Hugong Welding and Cutting 15179
7177 Waiqingsong Rd., Qingpu Dist.
Shanghai, 201700, China
86-21-69729166; FAX 86-21-69715399
www.hugongwelds.com

Hugong will present its welding and cutting products designed to meet the ISO9001:2000 quality control system.

Hyd-Mech Group Ltd. 3213
PO Box 1659, 1079 Parkinson Rd.
Woodstock, ON N4S 0A9, Canada
(519) 537-2103; FAX (519) 539-5126
www.hydmech.com

Hyd-Mech Group will showcase its extensive metal cut-off bandsaws that feature both straight cutting, double-miter, and single miter cutting to 45 and 60 deg. Also to be shown are dual post horizontal saws designed for straight heavy cut-off and vertical band saws that miter up to 45 degrees in both directions.

Hydratight/DL Ricci Corp. 5239
5001 Moundview Dr., Red Wing, MN 55066-1138
(651) 388-8661; FAX (651) 388-0002
www.hydratight.com

Hydratight/DL Ricci will present its full range of bolting and machining solutions for a variety of in-place situations; portable tools for end squaring, beveling, and cutting of tube and pipe; hydraulic torque and tension tools; and heat treating, flange facing, portable milling, drills, line boring, and grinding equipment.

Hypertherm Inc. 14077
PO Box 5010, Hanover, NH 03755-5010
(603) 643-3441; FAX (603) 643-5352
www.hypertherm.com

Hypertherm will unveil and offer hands-on demonstrations of its latest and most versatile single-gas air plasma cutting system. The company will also give show attendees a sneak peak at the future of HyPerformance plasma with a special system preview.

Hyundai Welding Products 15143
215 Satellite Blvd. NE, Ste. 300, Suwanee, GA 30024
(770) 614-7577; FAX (770) 614-6636
www.hdweld.co.kr

IBEDA/Superflash Compressed Gas Equipment, Inc. 10210
28825 Ranney Pkwy., Westlake, OH 44145-1173
(888) 327-7306; FAX (440) 871-9964
www.oxyfuelsafety.com

IBEDA Superflash will announce its new thermal spray line at the show. To be presented are flame spraying guns for thermal spraying with powder using oxyfuel gas flame employing a safer gas mixture system using the injector principle with acetylene, propane, or hydrogen in combination with oxygen.

II-VI Infrared 5055
375 Saxonburg Blvd., Saxonburg, PA 16056-9499
(724) 352-1504; FAX (724) 352-4980
www.iiviinfrared.com

II-VI Infrared will showcase its CO_2 laser optics for laser OEMs and end users in metals fabrication and other industries. Products include lenses, mirrors, nozzles, windows, partial reflectors, beam splitters, phase retarders, rhombs, beam expanders, polarizers, wave plates, and modulators. Its IR materials include ZnSe, ZnS, and ZnS MultiSpectral.

IMPACT 13106
1750 New York Ave. NW, Lobby
Washington, DC 20006-5301
(202) 393-1147; FAX (202) 393-1507
www.impact-net.org

The IMPACT booth will provide literature and information about its activities as a labor management Taft Hartley Trust with the primary mission to expand opportunities for Union Ironworkers and their signatory contractors through progressive and innovative labor management programs.

IMPACT Engineering, Inc. 12217
500 E. Biddle St., Jackson, MI 49203-3990
(517) 789-0098; FAX (517) 789-1038
www.impactwelding.com

IMPACT Engineering will feature 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 software products will be introduced at the show: IMPACT pcOI Gen 4, a welding cell operator PC interface; and ARClient v. 4.00 for weld monitoring.

IMR Test Labs **10177**
131 Woodsedge Dr., Lansing, NY 14882-8940
(607) 533-7000; FAX (607) 533-9210
www.imrtest.com

IMR Test Labs will offer literature and information on its full service laboratory offering welder and weld procedure qualifications, thermal spray coating evaluation, mechanical testing failure analysis, and material analysis services.

Indura SA **14115**
18020 Brenridge Dr., Brandy Station, VA 22714-1946
(866) 328-3171; FAX (562) 539-3444
www.indura.net

Industrial Maid LLC **10019**
351 S. 12th Rd., Cortland, NE 68331-8144
(402) 798-7116; FAX (402) 798-7117
www.industrial-maid.com

Industrial Maid will present its "green" air-filtration products that use recycled high-density polyethylene plastic panels that are lightweight, quiet, and noncorrosive and use a fraction of the electrical power required for cartridge style dust collectors.

Industrial Solutions & Innovations LLC **11166**
4425 Mustang Rd., Alvin, TX 77511-5366
(281) 824-0356; FAX (281) 824-0357
www.industrialsolutions-llc.com

In-House Solutions, Inc. **11201**
240A Holiday Inn Dr., Cambridge, ON N3C 3X4, Canada
(519) 658-1471; FAX (519) 658-1335
www.inhousesolutions.com

In-House Solutions will introduce the Robotmaster Version 2.1, a CAD/CAM programming software for six- to eight-axis robots. The unit is designed for trimming, deburring, deflashing, dispensing, grinding, and mold machining.

Inman Int'l Corp. **15187**
1802 N. Carson St., Ste. 212-3555
Carson City, NV 89701
(636) 794-0388; FAX (636) 794-0388

Innerspec Technologies **14219**
4004 Murray Pl., Lynchburg, VA 24501-5004
(434) 948-1306; FAX (434) 948-1313
www.innerspec.com

Innerspec Technologies will feature its ultrasonic electromagnetic acoustic transducer (EMAT) technology for nondestructive testing of metallic parts and components, offering some unique capabilities that make it effective for defect detection, thickness measurements, nodularity, anisotropy, grain structure, and for in-service inspections.

Innov-X Systems **4220**
100 Sylvan Rd., Ste. 100, Woburn, MA 01801-1852
(781) 938-5005; FAX (781) 569-0528
www.innov-xsys.com

The company's booth will present its point-and-shoot, hand-held XRF analyzers, featuring Alpha, its smallest and lightest analyzer for nondestructive alloy analysis, grade verification and flow accelerated corrosion (FAC) inspection.

Instrument Technology, Inc. **13218**
PO Box 381, Westfield, MA 01086-0381
(413) 562-3606; FAX (413) 568-9809
www.scopes.com

Instrument Technology will show its borescopes, fiberscopes, videoscopes, and custom remote viewing instruments useful for industrial applications.

Integrated Robotics LLC **14204**
40 Old Dover Rd., Newington, NH 03801-7874
(603) 766-3492; FAX (603) 766-3485
www.integrated-robotics.com

The Integrated Robotics booth will show the company's robot-based manufacturing solutions for most manufacturing processes, including welding, machine tending, grinding and polishing, buffing, deburring, cutting, and material handling.

Integro **11115**
290 Pratt St., Meriden, CT 06450-8602
(203) 235-4424; FAX (203) 630-1093
www.Integro-USA.com

Integro will feature its welding products made with fill-soldered connectors permanently molded to the cable to ensure waterproof and safe welding, and its welding preheat system designed to heat steel to appropriate temperatures to ensure solid and efficient welds.

Interactive Safety Products, Inc. **15190**
9825-A Northcross Center Ct., Huntersville, NC 28078
(704) 664-7377; FAX (704) 664-7316
www.helmetsystems.com

Intercon Enterprises, Inc. **15186**
1125 Fir Ave., Blaine, WA 98230-9702
(800) 665-6655; FAX (604) 946-5340
www.intercononline.com

Intercon Enterprises will show its gas tungsten pipe welding accessories, Jokisch anti-spatters, and Baer hardware.

International Thermal Spray Association **10186**
208 3rd St., Fairport Harbor, OH 44077-5822
(440) 357-5400; FAX (440) 357-5430
www.thermalspray.org

International Titanium Association **14201**
2655 W. Midway Blvd., Ste. 300, Broomfield, CO 80020
(303) 404-2221; FAX (303) 404-9111
www.titanium.org

The International Titanium Association (ITA) booth will offer literature and information on this nonprofit trade association established to foster the development of new applications for titanium, as well as provide a forum for the exchange of ideas within the industry.

International Welding Technologies, Inc. **14205**
276 Pinedge Dr., West Berlin, NJ 08091-9218
(856) 753-8126; FAX (856) 753-8439

The company will present its capacitor-discharge stud welding systems and fasteners in steel, stainless steel, aluminum, brass, and copper.

InterTest, Inc. **5280**
303 Rte. 94, Columbia, NJ 07832-2761
(908) 496-8008; FAX (908) 496-8004
www.intertest.com

The InterTest booth will display the company's line of optical inspection equipment for both in-process weld monitoring and postprocess quality inspections.

Inweld Corp. **15018**
3962 Portland St., Coplay, PA 18037-2224
(610) 261-1900; FAX (610) 261-0744
www.inweldcorporation.com

The company will present its complete line of welding alloys, including stainless and mild steel, aluminum, copper, chrome-moly, nickel, magnesium, titanium, cobalt, silver alloys, and maintenance alloys.

IPEX, Inc. **7178**
2441 Royal Windsor Dr.
Mississauga, ON L5J 4C7, Canada
(800) 463-9572; FAX (905) 403-9195
www.ipexinc.com

IPEX will introduce at its booth its Duratec Airline, a compressed-air and inert-gas piping system that combines the benefits of plastic and metal in one pipe. It is constructed of an inner and outer layer of HDPE sandwiched over an aluminum core, to extend the life of the system, reduce leakage, and save operating costs.

IPG Photonics Corp. **14186**
50 Old Webster Rd., Oxford, MA 01540-2706
(508) 373-1100; FAX (508) 373-1103
www.ipgphotonics.com

IPG Photonics will showcase its high-performance fiber lasers for diverse applications.

IRT ScanMaster Systems, Inc. **15062**
319 Garlington Rd., Ste. B4, Greenville, SC 29615-4621
(864) 288-9813; FAX (864) 288-9799
www.scanmaster-irt.com

IRT ScanMaster Systems will showcase its portable, full-featured USB-driven PC-based ultrasonic instrument that provides operators with a flexible and versatile platform for inspection combined with reporting, networking, and archiving capabilities. Shown will be a single or multichannel instrument configurations offering an unlimited number of setup files for different transducers and inspection practices.

J & S Machine Inc. **8207**
W6009 490th Ave., Ellsworth, WI 54011-5235
(715) 273-3376; FAX (715) 273-5241
www.jsmachine.com

J&S Machine will feature its lines of CNC roll, angle, and profile benders; CNC rotary benders; double head benders; NC rotary benders; tube and pipe benders; and tooling for special projects. The company delivers complete turnkey packages and offers machine capacities up to 8 in. that are electric servo, hydraulic servo, or hydraulically controlled. The company will also feature saws for cutting steel and aluminum shapes.

Jackson Safety **14019**
1859 Bowles Ave, Ste. 200, Fenton, MO 63026-1936
(800) 237-4192; FAX (636) 717-6800
www.jacksonsafety.com

Jackson Safety will feature its complete line of safety products for head, eye, face, and hearing protection. Featured will be the BOSS Big Window EQC with 13 sq. in. of viewing area and the Arctic, an autodarkening filter for use in extreme weather conditions. Showcased will be the company's quality personal and welding safety products for today's welder

Jancy Engineering Inc. **4009**
2735 Hickory Grove Rd., Davenport, IA 52804-1240
(563) 391-1300; FAX (563) 391-2323
www.jancy.com

Jancy Engineering will feature its diverse product line, which is anchored by its Slugger annular cutting machines, magnetic-based drills, and metal cutting saws used in fabrication, construction, and MRO. The company's product line also includes weld preparation equipment such as notchers, bevelers, and positioners. In addition, it offers grinding machines, centerless grinding machines, and pipe and tube benders.

Janda Co., Inc. **14223**
1275 Railroad St., Corona, CA 92882-1838
(951) 734-1935; FAX (951) 734-0649
www.jandawelders.com

Jayesh Industries Ltd. **10131**
605-9 Krushal Commercial Complex
GM Road Amar Mahal Chembur(W)
Mumbai Maharashtra 400 089, India
91-22 6703 9991; FAX 91-22 2526 0986
www.jayeshgroup.com

Jayesh Industries, which is part of Jayesh Group, India, will feature various raw materials such as ferro alloys, metals, and minerals from which welding electrodes are manufactured.

JAZ USA, Inc., & Bullard Abrasives Inc. **11198**
6 Carol Dr., PO Box 861, Lincoln, RI 02865
(877) 529-8721; FAX (877) 529-3291
www.jazusa.com

JAZ has been providing wire brushes since

1924. The comany will highlight its wide range of wire brushes including those with Protective Guard, which provides safety before, during, and after work. Personnel will demonstrate the company's wire brushes and how they can improve your current processes.

Jetline Engineering 12089
15 Goodyear, Irvine, CA 92618-1812
(949) 951-1515; FAX (949) 951-9237
www.jetline.com

ITW Jetline Engineering will showcase its weld automation solutions. It manufactures engineered weld systems and controls, including cold and hot wire feed, tactile and laser joint tracking, arc length/voltage controls, oscillation controls, vision systems, and motion/travel controls. Personnel will demonstrate the company's new process control — the 9900, which works on a seamer and a circumferential and has no limits to the number of parameters or weld processes it can deal with.

Jingyu Welding & Cutting Co. Ltd. 10083
No. 145 Hedong St. Mahang
Chaingzhou Jiangsu 213162, China
86-519-6706120; FAX 86-519-6701045
www.jingyuwelding.com

Jinhua Seleno Brazing Alloys Mfg. Co. Ltd. 13259
No. 588 Binhong Xilu
Jinhua Zhejiang 321016, China
86-579-8227-5178; FAX 86-579-8227-5128
www.brazing-alloys.com

John Tillman Co. 13113
1300 W. Artesia Blvd., Compton, CA 90220-5307
(310) 764-0110; FAX (310) 764-2700
www.jtillman.com

John Tillman will display its line of protective welding gloves, clothing, blankets, curtains, and screens. The company offers more than 2000 items.

Joysun Abrasives Co. Ltd. 11111
No. 129 5th Ave. E. Hanghai Rd.
Economy & Tech Develop Zone
Zhengzhou, Henan Province, China 450016
86-371-676-22388; FAX 86-371-676-22389
www.joysunabrasives.com

Joysun will feature its abrasive products, mainly standard and high-density zirconia, alumina, ceramic, and SiC products. Products include its conventional, professional, and Special SG line of flap discs.

J.P. Nissen Co. 15000
PO Box 339, 2544 Fairhill Ave.
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 felt-tip 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.

Kawasaki Robotics (USA) Inc. 14180
28140 Lakeview Dr., Wixom, MI 48393-3157
(248) 446-4100; FAX (248) 446-4200
www.kawasakirobotics.com

Kawasaki will showcase a new light alloy joining process, friction spot joining (FSJ), as well as heavy deposition arc welding, ultrasonic plastic welding, and other robotic fabricating applications.

Kemper America Inc. 15229
1005 Alderman Dr., Ste. 114, Alpharetta, GA 30005-3825
(770) 416-7070; FAX (770) 828-0643
www.kemperamerica.com

Keystone Fastening Technologies Inc. 8107
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 capable of welding studs through 1-in.-diameter. It will also feature its stud welding accessories for all makes and models, and a complete range of studs in mild steel, stainless steel, aluminum, and other alloys. Stud welding systems from portable handgun models to fully automated production machines will be displayed.

Kinetic Cutting Systems 3223
PO Box 2043, 304 W. Prospect Rd., Ste. F
Fort Collins, CO 80522-2043
(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 with automated bevel heads. The company's machines are suited for bridges, structural steel buildings, heavy machinery, service centers, and large manufacturing facilities.

Klingspor Abrasives Inc. 15222
PO Box 2367, Hickory, NC 28603-2367
(800) 645-5555; FAX (800) 524-6758
www.klingspor.com

Klingspor will showcase its wide variety of coated and bonded abrasives including belts, sheets, discs, and specialty items for the woodworking, metal, solid surface, and fiberglass industries.

Kobelco Welding of America 12049
4755 Alpine Dr., 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 ER70S-6 solid wire, will demonstrate its new E70C-6M metal cored formula as well as a variety of stainless flux cored wires.

Koike Aronson Inc./ Ransome 12001
PO Box 307, 635 W. Main St.
Arcade, NY 14009-0307
(800) 252-5232; FAX (585) 457-3517
www.koike.com

Koike Aronson/Ransome will highlight its Lasertex-3540 large gantry-style 4-kW CO_2 laser beam cutting machine. Demonstrations of flat plate cutting and square (or rectangular) tube cutting will be given. The machine of-


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very well.
USED WORLDWIDE FOR
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• Site Construction
• Maintenance
• Fabrication
• Pipeline Construction
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• GMAW
• FCAW
USED FOR :
• Tube, pipe, tubesheet, and vessels
• 3mm (1/8") and larger
• OD and ID welds
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C-HEAD
REDHEAD
E-HEAD
D-HEAD
T-HEAD
TUBESHEET
QUICKCLAMP
PIPELINER
POWER SUPPLIES
PIPELINER
PIPEMASTER 515
TUBEMASTER 514
PIPEMASTER 516
www.magnatech-lp.com
Phone: 860-653-2573
www.magnatech-europe.com
Phone: +31 321 38 6677
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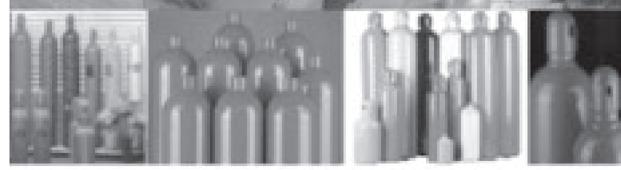


fers unattended (lights out) operation for up to ¾-in. mild steel and SIGMA BOX design for improved beam quality and reduced maintenance costs.

Kokuho Co. Ltd. 13125
1-8-54 Uchikawa, Yokosuka-city
Kanagawa 239-0836, Japan
81-46-835 6404; FAX 81-46-835 2204

Kokuho will feature its lines of land- and marine-purpose products such as attachments and fittings for a variety of vessel types including cargo ships, oil tankers, cruise ships, destroyers, and sailing ships. Information will be provided on the company's innovative plans to improve the welding workshop environment and its wide range of experience and technical expertise backed by years of data gathering and analysis.

Koyo Giken Inc. 4052
4020-4 Tana, Sagamihara city 229-1124, Japan
81-42-760-4306; FAX 81-42-760-4309
www.koyogiken.co.jp

KUKA Robotics Corp. 13233
22500 Key Dr., Clinton Township, MI 48036-1193
(586) 465-8817; FAX (586) 465-8717
www.kukausa.com

Laboratory Testing Inc. 5270
2331 Topaz Dr., Hatfield, PA 19440-1936
(800) 219-9095; FAX (800) 219-9096
www.labtesting.com

Laboratory Testing will showcase its materials testing, calibration, specimen machining, failure analysis, and welder qualification services. Among the company's offerings are mechanical, chemical, metallurgical, and nondestructive testing services as well as dimensional, pressure, force, torque, mass, and vacuum calibration services.

LA-CO Industries/Markal 11143
1201 Pratt Blvd., Elk Grove Village, IL 60007-5708
(800) 621-4025; FAX (800) 448-5436
www.laco.com; www.markal.com

The company will feature its complete line of industrial marking products for all types of metal surfaces, plus glass, plastic, wood, cardboard, and other surfaces. La-Co's products include paint markers in liquid and solid form for marking hot or cold, wet or dry, and rough or smooth surfaces.

Langtec Ltd. 10214
1 Calder Ct.
Accrington, Lancashire BB5 5YB, UK
44-128-2772544; FAX 44-128-2772740
www.langtec.co.uk

Lantek Systems Inc. 7026
2737 S. Broadway Ave., Ste. 104
Tyler, TX 75701-5445
(903) 258-9422; FAX (903) 258-9425
www.lantek-systems.com

The company will feature its CAD/CAM software for punching and oxyfuel, laser, plasma, and waterjet cutting. Its combo systems can handle 2-D and 3-D designs. The systems can interface with CNC press brakes, and offer profile cutting utilizing 5-axis laser and tube cutting machines.

Lapco Mfg. Inc. 12211
98 Glenwood St., Morgan City, LA 70380-2317
(985) 385-5380; FAX (985) 384-5081
www.lapcomfg.com

Lapco will display its line of work clothing and accessories.

LASAG Industrial-Lasers 4118
1615 Barclay Blvd., Buffalo Grove, IL 60089-4544
(847) 483-6300; FAX (847) 483-6333
www.lasag.com

LASAG Industrial-Lasers will feature 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 highly reproducible spot and seam welding applications. The company will also provide information on its dedicated database for optimal process parameter selection, efficient transfer of laser know-how, and excellent worldwide service.

Laser Mechanisms Inc. 4130
24730 Crestview Ct., Farmington Hills, MI 48335-1506
(248) 474-9277; FAX (248) 336-1103
www.lasermech.com

Laser Mechanisms will show its laser beam delivery components and articulated arm systems for high-power CO_2, YAG, and fiber lasers as well as those at other wavelengths that suit all facets of industrial applications. The company will also showcase the PRiMES line of laser beam analysis equipment.

Laserage Technology Corp. **5127**
3021 N. Delaney Rd., Waukegan, IL 60087-1826
(847) 249-5900; FAX (847) 336-1103
www.laserage.com

Laserage Technology will feature its custom laser processing services. The company's capabilities include laser beam welding of most metals, laser machining of stents, and laser machining, cutting, and drilling of a wide variety of materials, including metals, plastics, composites, and ceramics. Finishing operations include electropolishing. Custom cable/wire harness and electromechanical assembly services are also available. Prototype through production services are supported by a complete metallurgical lab, R&D and engineering capabilities, and a company-wide TQM/JIT program.

LaserStar Technologies Corp. **5125**
1 Industrial Ct., Riverside, RI 02915-5218
(401) 438-1500; FAX (401) 434-7260
www.laserstar.net

LENOX **5286**
301 Chestnut St., East Longmeadow, MA 01028-2742
(413) 525-3961; FAX (413) 525-8867
www.lenoxtools.com

Liburdi Automation Inc. **11178**
400 Hwy. 6 N., Dundas, ON L9H 7K4, Canada
(905) 689-0734; FAX (905) 689-0739
www.liburdi.com

Liburdi Automation will feature its precision, vision-based LAWS, Dabber, and Pulsweld power sources; and multiaxis, articulated motion systems and controllers for applications in the turbine, aerospace, nuclear, industrial, and automotive industries. The company will also showcase its extensive range of 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. **15025/10031**
22801 St. Clair Ave., Cleveland, OH 44117-1199
(216) 383-2162; FAX (216) 383-8381
www.lincolnelectric.com

Lincoln Electric wil highlight its lines of arc welding products, robotic arc-welding systems, plasma and oxyfuel cutting equipment, and brazing and soldering alloys. Educational materials will be displayed including welding curriculum, training tools, and reference materials.

Linde Inc. **14029**
575 Mountain Ave., New Providence, NJ 07974-2097
(908) 771-4887; FAX (908) 771-1723
www.linde.com

Linde will exhibit gas technology for welding and cutting applications and cryogenic cooling and cleaning applications. The company has partnered with industrial and welding supply distributors for more than 80 years as a producer of oxygen, nitrogen, argon, helium, liquid helium, hydrogen, carbon dioxide, acetylene, and specialty gases.

Lineage Alloys Inc. **10193**
1901 Ellis School Rd., Baytown, TX 77521-1215
(281) 426-5535; FAX (281) 426-7484
www.lineagealloys.com

Lineage Alloys will exhibit its line of thermal spray powders, which have been produced at the same location for 38 years.

LORD Corp. **11132**
111 Lord Dr., Cary, NC 27511-7923
(919) 468-5981; FAX (919) 859-2739
www.lord.com

LORD will exhibit its line of industrial grade adhesives, which offer practical solutions for material joining. The adhesives can permanently bond dissimilar materials and thin-gauge metals, composites, plastic, wood, rubber, and glass. The company's adhesives provide excellent bonding results as well as a watertight seal at the joint.

Lors Machinery Inc. **12237**
1090 Lousons Rd., Union, NJ 07083-5030
(908) 964-9100; FAX (908) 964-4492
www.lors.com

LS Industries Inc. **3148**
710 E. 17th St. N., Wichita, KS 67214-1312
(800) 835-0218; FAX (316) 265-0013
www.lsindustries.com

LS Industries will show its environmentally safe cleaning, deburring, shot blasting, washing equipment for all metal preparation requirements from the smallest to the largest components. Featured will be pipe blasters, structural blasters, peening, cylinder blasters, aqueous washing systems, and vibratory deburring as well as paint and powder coating systems.

For info go to www.aws.org/ad-index

For info go to www.aws.org/ad-index

Lucas-Milhaupt Inc. 15076
A Handy & Harman Co.

5656 S. Pennsylvania Ave., Cudahy, WI 53110-2453
(414) 769-6000; FAX (414) 769-1093
www.lucasmilhaupt.com

Lucas Milhaupt will feature its complete line of metal joining products and services, such as alloys, fluxes, automated equipment, product design, training and technical assistance. The company supplies brazing and soldering materials to the electrical/electronic, appliance, and transportation markets worldwide.

Luvata Ohio Inc. 11119

1376 Pittsburgh Dr., Delaware, OH 43015-3814
(740) 272-7526; FAX (740) 368-4348
www.nippertcompany.com

Luvata will showcase its metal fabrication, component manufacturing, and related engineering and design services. Its Formed Products unit will highlight resistance welding and projection welding electrodes, and GMAW contact tips and wires. Brands featured will include Nitrode, Cupal, Z-trode, Nitrode Composite, A-trode, C-trode, and Luvaweld.

Magestic Systems Inc. 5009

205 Fairview Ave., Westwood, NJ 07675-2224
(201) 263-0090; FAX (201) 263-0091
www.magestic.com

Magestic Systems will showcase its TruNEST integrated nesting solutions and TruLASER View laser projection solutions. TruNEST provides high material utilization and NC processing for cutting and punching applications. TruLASER is composed of 3-D laser projectors and software, and eliminates the need for hard tooling, templates, and blueprints during fabrication and assembly processes.

Magid Glove and Safety 15166

2060 N. Kolmar Ave., Chicago, IL 60639-3418
(800) 444-8010; FAX (773) 289-9379
www.magidglove.com

Magid will display its lines of work gloves, protective clothing, industrial hygiene, and safety equipment. The company has been manufacturing gloves and personal protective equipment since 1946.

Magnaflux — A Division of ITW 12085

3624 W. Lake Ave., Glenview, IL 60026-1215
(847) 657-5300; FAX (847) 657-5388
www.magnaflux.com

Magnaflux will showcase its lines of liquid penetrant, magnetic particle, and resonant inspection products. Products featured will be SPOTCHECK® visible penetrant, ZYGLO® fluoroscent penetrant, MAGNAGLO® fluorescent magnetic particle, QUASAR® resonant inspection, DARACLEAN® aqueous cleaners, and ultrasonic thickness gauges.

Magnatech Limited Partnership 13013

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. Also featured will be the Pipemaster for multipass welding.

Mannings USA 10059

351 Lowery Ct., Ste. 3, 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.

Marvel Mfg. Co. 1166

3501 Marvel Dr., Oshkosh, WI 54902-7115
(920) 236-7200; FAX (920) 236-7209
www.sawing.com

Marvel will display its Marvel brand tilt frame vertical bandsaws, sawblades, and material handling equipment and systems, as well as its Spartan brand horizontal band saws, automatic carbide circular saws, and ironworkers.

Maryland Brush Co. 15168

3221 Frederick Ave., Baltimore, MD 21229-3807
(800) 654-0774; FAX (888) 278-7440
www.marylandbrush.com

Maryland Brush will exhibit its brush products for weld cleaning and pipeline industries in both carbon and stainless wire constructions. Types include stringer bead, knot and crimp wire cup, end, and wheels.

Master Magnetics Inc. 11087

747 S. Gilbert St., Castle Rock, CO 80104-2262
(888) 293-9399; FAX (800) 874-8268
www.magnetsource.com

Master Magnetics will show its line of magnets and magnetic assemblies for applications requiring lifting, positioning, holding, retrieving or separating, and materials handling. Available are Alnico, ceramic, flexible, and rare earth magnets in a wide range of sizes, grades, and shapes. Also featured will be magnetic floor sweepers, which can pick up scrap metal from aisles and metal manufacturing areas.

Master Weld Products LLC 15014
3962 Portland St., Unit A, Coplay, PA 18037-2224
(610) 261-1000; FAX (610) 261-1555
www.masterweld.net

Master Weld will feature its GMAW and GTAW guns, torches, and consumables.

Matheson Tri-Gas Inc. 12191
1861 Lefthand Cir., Longmont, CO 80501-6740
(303) 678-0700; FAX (480) 626-2751
www.matheson-trigas.com

Matheson Tri-Gas will feature its industrial, medical, specialty, and electronic gases; gas handling equipment; high-performance purification systems; engineering and gas management services; and on-site gas generation services.

Mathey Dearman Inc. 12118
PO Box 472110, 4344 S. Maybelle St.
Tulsa, OK 74147-2110
(918) 447-1288; FAX (918) 447-0188
www.mathey.com

Mathey Dearman will feature its patented cutting and beveling machines including the CGM blade milling machine; numerous accessories for all sizes of pipe diameters and types of pipe; pipe alignment and reforming clamps for welders and pipefitters who need fast, accurate fit-up; welding electrode and flux ovens; and pipe tools for pipe fitting and layout.

M Braun Inc. 10134
14 Marin Way, Stratham, NH 03885-2578
(603) 773-9333; FAX (603) 773-0008
www.mbraunusa.com

M Braun USA will feature its line of inert gas components specially designed for welding applications. The company's glovebox line is comprised of special welding chambers for resistance welding, GTAW, laser beam welding with laser protective vitrification, plasma welding with nitrogen-free argon atmosphere, special feedthroughs for all necessary supply lines, and particle suction units with continuously active separation.

Mecco Marking & Traceability 8088
PO Box 5004, 290 Executive Dr.
Cranberry Township, PA 16066-6436
(888) 369-9190; FAX (724) 779-9556
www.mecco.com

Mecco Marking & Traceability will show its laser and dot peen products for direct part marking for traceability, verification, and part identification. The products feature 2-D data matrix capabilities that meet all AIAG, UID, and SPEC 2000 marking requirements.

Medi-Rub USA 14047
10 Cedar Dr., Mills River, NC 28759-2664
(843) 372-1011; FAX (508) 819-3002
www.medirubusa.com

Medi-Rub will show and demonstrate its U.S.-made massagers designed for the clinical treatment of patients and to aid in the prevention of carpal tunnel, leg cramps, back and neck pain.

MegaFab Whitney/ Piranha/Bertsch 5136/8136
PO Box 457, 3310 E. 4th Ave.
Hutchinson, KS 67504-0457
(620) 663-1127; FAX (620) 662-1719
www.megafab.com

MegaFab will highlight its line of metal fabricating equipment including Piranha ironworkers, press brakes, shears; Bertsch plate bending rolls; Whitney combination plasma/punch fabricating centers, plasma cutting tables, plate laser cutting equipment, portable presses and CNC fabricators. The company's ironworkers feature low-rake flat bar knives to minimize distortion.

Meltric Corp. 10139
4640 W. Ironwood Dr., Franklin, WI 53132-8871
(414) 817-6160; FAX (414) 817-6161
www.meltric.com

Meltric will show its line of switch-rated, heavy-duty plugs, receptacles, and connectors. The products' safety features allow make and break under load and provide significant protection in overload and short circuit conditions and simplifies NFPA 70E code compliance. Ratings from 15 to 400 A.

Mercer Abrasives 14135
300 Suburban Ave., Deer Park, NY 11729-6807
(800) 221-5202; FAX (631) 243-3209
www.mercerabrasives.com

Meta Vision Systems Inc. **12162**
8084 Rt. Transcanadienne
Saint-Laurent, QC H4S 1M5, Canada
(800) 661-0140; FAX (514) 333-8636
www.meta-mvs.ca

Meta Vision Systems will show its welding process control systems utilizing 3-D laser vision hardware and software. The company's products range from low-cost standard systems for robot and welding machine applications to fully customized systems delivering very high performance.

Metabo Corp. **14095**
1231 Wilson Dr., West Chester, PA 19380-4243
(800) 638-2264; FAX (800) 638-2261
www.metabousa.com

Metablo will exhibit its line of industrial electric power tools and abrasives for the professional tradesperson.

Metal Supermarkets **11171**
1675 Tonne Rd., Elk Grove Village, IL 60007-5123
(866) 867-9344; FAX (847) 439-3105
www.metalsupermarkets.com

Metal Supermarkets® will offer its services as a source for a wide variety of metals including steel, stainless, and aluminum, in all standard shapes and sizes. The company will also provide information on its more than 80 locations worldwide that serve the industrial, engineering, maintenance, and other sectors.

Metallisation Ltd. **10217**
Pear Tree Ln., Dudley DY2 0XH, UK
44-138-4252464; 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 **1203**
W141 N9427 Fountain Blvd.
Menomonee Falls, WI 53051-1624
(262) 532-4615; FAX (262) 255-5170
www.mg-systems-welding.com

MG Systems & Welding will feature its CNC gantry cutting machines with plasma and oxyfuel. Machines are available with multiple torches, bevel cutting with oxyfuel and plasma, drills and other options to maximize efficiency. Featured will be the heavy-duty TMC4500ST and Titan II; the precise, quick Metalmaster Plus and MPC; and the smaller EdgeMax, EdgeMaster, and EdgeMate plate-processing machines, as well as the ALFA oxyfuel torch, virtual service, and the Slagger® cutting table.

Micro Air Clean Air Systems **15124**
PO Box 1138, 3025 May Ave., Wichita, KS 67201-1138
(316) 946-5875; FAX (316) 219-2995
www.microaironline.com

Micro Air will highlight its complete line of dust collectors, mist collectors, downdraft tables, clean air booths, and source capture arms for capture of industrial smoke, fumes, dust, and pollutants. The equipment handles welding fumes, grinding, buffing, polishing, coating, plasma, and laser dust and fumes.

Midalloy **12112**
630 Axminister Dr., Fenton, MO 63026-2906
(800) 776-3300; FAX (636) 349-2240
www.midalloy.com

Midalloy will show its high-quality stainless steel, nickel, and low-alloy welding consumables.

Miller Electric Mfg. Co. **13077**
1635 W. Spencer St., PO Box 1079
Appleton, WI 54912-1079
(800) 400-4553; FAX (920) 735-4013
www.millerwelds.com

Miller will showcase its lines of arc welding and plasma cutting equipment and related systems for metalworking, maintenance, and other applications.

M. K. Morse Co., The **5281**
PO Box 8677, Canton, OH 44711-8677
(330) 453-8187; FAX (330) 453-1111
www.mkmorse.com

The company will introduce its Metal Devil Stud Cutter™ at the show, a 14-in. carbide-tipped saw blade for cutting steel studs. The Revolution® and M-Factor by Morse™ carbide blades will also be featured.

MK Products Inc. **13149**
16882 Armstrong Ave., Irvine, CA 92606-4975
(949) 863-1234; FAX (949) 474-1428
www.mkproducts.com

MK Products will feature its Cobramatic® push-pull wire feed technology for aluminum welding, the Aircrafter tabletop rotary positioners, and orbital tube welding systems for sanitary, high-pressure, and ultrahigh-purity applications.

Moldex Metric Inc. **13014**
10111 Jefferson Blvd., Culver City, CA 90232-3509
(310) 837-6500; FAX (310) 837-9563
www.moldex.com

Moldex® will show its lines of hearing and respiratory protection for industrial worker safety. The products are desined for comfort, quality, and value.

Motoman Inc. **13049**
805 Liberty Ln., West Carrollton, OH 45449-2176
(937) 847-6200; FAX (937) 847-6277
www.motoman.com

Motoman will showcase its complete robotic solutions for a wide variety of applications, including arc welding, assembly, coating, dispensing, material cutting (laser, plasma, and waterjet), material handling, material removal, and spot welding. The company's products include more than 175 robot models, with payloads from 3 to 600 kg, as well as 15 families of fully integrated, standardized "World" systems. Its PC-based tools enhance productivity through simulation, calibration, and accurate off-line programming.

MPT Industries **14177**
85 Franklin Rd., 6-B Hamilton Business Park
Dover, NJ 07801-5632
(973) 989-9220; FAX (973) 989-9234
www.mptindustries.com

MPT Industries will display its specialty lubricants that increase equipment life, lower operating costs, and decrease downtime, including chemical-resistant and oxygen-compatible thread sealants; long-lasting multipurpose lubricants and greases; engine oil additive; gear oil additive; air tool oil; and assembly lube.

MultiCam LP **15125**
1025 W. Royal Ln., PO Box 612048
DFW Airport, TX 75261
(972) 929-4070; FAX (972) 929-4071
www.multicam.com

MultiCam will showcase its automated cutting solutions. The company's philosophy is to produce long-lasting, easy-to-maintain CNC machines.

Multiquip Inc. **15118**
18910 Wilmington Ave., Carson, CA 90746-2820
(310) 537-3700; FAX (310) 637-7936
www.multiquip.com

Mutual Industries/ Kromer Cap **15232**
2709 Frederic Ave., Baltimore, MD 21223
(800) 922-9832; FAX (410) 727-3521
www.kromercap.com

The Kromer Cap and Gann Safety divisions of Mutual Industries will feature their fashion welding caps, shop beanies, in-stock and custom-made safety vests, and other safety accessories.

Nation Coating Systems Inc. **10167**
501 Shotwell Dr., Franklin, OH 45005-4663
(937) 746-7632; FAX (937) 746-7658
www.nationcoatingsystems.com

Nation Coating Systems personnel will highlight the company's new coatings for all types of industrial applications, and discuss ways to improve products with thermal spraying.

Nation Wide Products/ Pipe-Pro Cutting Guides **12221**
1301 S. Treadaway Blvd., Abilene, TX 79602-3942
(325) 675-5062; FAX (325) 675-5053
www.nationwideproduct.com

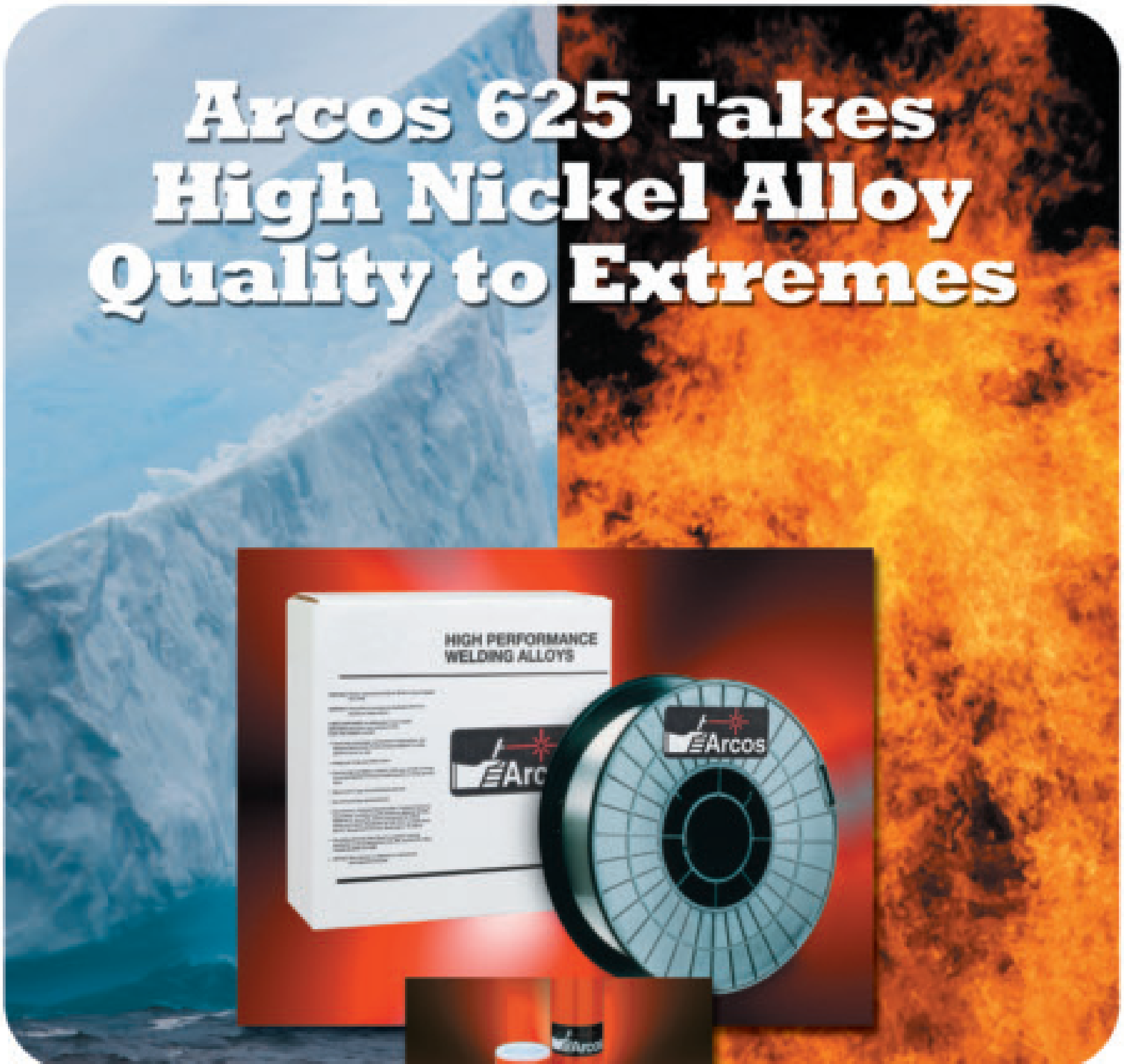
Nation Wide Products will display its line of Pipe Pro cutting guides used to mark angles and saddles for pipe and tube cutting. All products come with a storage container, and private labeling is available.

National Bronze & Metals, Inc. **8050**
PO Box 800818, Houston, TX 77280-0818
(713) 869-9600; FAX (713) 869-9124
www.nbmmetals.com

National Bronze & Metals will exhibit its line of brass, bronze, and copper alloys. The company stocks more than 100 alloys and many others can be special ordered.

National Center for Advanced Manufacturing (NCAM) **10009**
13800 Old Gentilly Rd., Bldg. 420, Rm. 200
New Orleans, LA 70129-2218
(504) 257-0969; FAX (504) 257-5456
www.ncamlp.org

NCAM (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



Arcos, ***The Standard of Excellence in Covered Electrodes and Bare Wire***, offers two outstanding welding products designed to withstand critical temperature extremes.

Arcos 625 and Arcos 1N12 (625) are nickel-chromium-molybdenum products which are designed to be virtually immune to chloride-ion stress-cracking. They feature moderate strength, good fabricability and excellent oxidation resistance. Each is military-approved and provides superior corrosion resistance, over a range of temperatures from cryogenic to extremely elevated (up to 1,800°F).

Arcos 625 is ideal for welding alloys 625, 601, 802 and 9% nickel. This wire is well suited for welding piping systems and reactor components in the power generation industry and for high temperature service in a wide variety of other engineering applications.

Arcos 1N12 (625) is utilized for welding alloys such as 625, 800, 801, 825 and 600. This covered electrode is the smart choice for applications including petrochemical plants, reactor components, furnace equipment, heat exchangers and offshore marine environments.

To learn about the many advantages of specifying Arcos 625 and Arcos 1N12, call us today at **800-233-8460** or visit our website at **www.arcos.us.**

Arcos Industries, LLC
One Arcos Drive • Mt. Carmel, PA 17851
Phone: (570) 339-5200 • Fax: (570) 339-5206

Arcos

technologies and research for industrial applications. NCAM's equipment includes a large-scale friction stir welding system with 6 axes of motion weld head and self-reacting pin tool technology, a high-speed gantry machining system, a nondestructive evaluation system, and two fiber placement (composites) machines.

National Standard LLC 13005
1631 Lake St., Niles, MI 49120-1270
(800) 777-1618; FAX (269) 683-6249
www.nationalstandard.com

National Standard will display its Satin Glide stainless steel welding wire, CopperFree welding wires, inert gas control, and bulk packages for precise arc placement.

Nelson Stud Welding 12124
7900 W. Ridge Rd., Elyria, OH 44035-1952
(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. 15112
Rm. 101, No. 88, Branch Lane 2, Lane 1028
XiuYan Rd., Pudong, Shanghai 201315, China
86-216-8197031; FAX 86-216-8197211
www.newfire.biz

New Fire will highlights its industrial thermal insulating, welding and cutting protection, and safety equipment.

Ningbo East Machinery & Equipment Import & Export Corp. 10093
Rm. 305, No. 107, Xiao Wen St.
Ningbo, Zhe Jiang Province 315101, China
86-574-8734 8251; FAX 86-574-8734 5492
www.eastwelding.com

Ningbo Powerway Group Co. Ltd. 12195
Yunlong Town, Yinzhou District
Ningbobe Zhejiang Province, Ninbo, 315135, China
86-574-83004660; FAX 86-574-88349958
www.pwalloy.com

Ningbo Powerway Group will feature its copper-based alloys, which include welding electrodes, welding wire, and resistance welding materials. Products offered include C656, C681, C773, ErCuAl-A1, ErCuAl-A2, ErCuSi-A, ErCuSn-A, ErCuSnC, RBCuZn-A, RBCuZn-B, RBCuZn-C, RBCuZn-D, C182, C18150, and C150.

Nitto Kohki U.S.A., Inc. 5015
4525 Turnberry Dr., Hanover Park, IL 60133-5492
(630) 924-9393; FAX (630) 924-0303
www.nittokohki.com

Nitto Kohki will exhibit its automatic feed magnetic base drills that use self-regulated feed systems to optimize cutting performance with a number of safety features. Used with Jet-Broach tungsten carbide-tipped annular cutting tools, it can increase production while reducing labor hours and hazards. The company will also feature its other steel working tools including portable hydraulic punches, bevelers, pneumatic, and electric power tools.

Noise Barriers LLC 10215
1207 Remington Rd., Ste. E
Schaumburg, IL 60173-4829
(847) 843-0500; FAX (847) 843-0501
www.noisebarriers.com

Nordfab Ducting 13114
150 Transit Ave., Thomasville, NC 27360-8927
(800) 532-0830; FAX (336) 889-7873
www.nordfab.com

Nordfab will display its 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 other items. Thanks to the product's patented design, straight pipes, elbows, branches, and custom pieces snap together in seconds, and can be taken apart and reconfigured without tools.

North Carolinas Southeast 14109
707 W. Broad St., Elizabethtown, NC 28337
(910) 862-8511; FAX (910) 862-1482
www.ncse.org

The organization will provide information on how coastal southeastern North Carolina is a great location for globally oriented boat manufacturing and marine products businesses interested in expanding or relocating all or part of their operations. The eleven counties of Southeastern North Carolina can assist companies to access and compete in the global marketplace. North Carolinas Southeast provides free, confidential relocation services as the convenient point of access to all resources needed for your site search.

North Safety Products 10242
2000 Plainfield Pike, Cranston, RI 02921-2019
(401) 275-2440; FAX (401) 275-7560
www.northsafety.com

Northwest Mettech Corp. 10204
467 Mountain Hwy.
North Vancouver, BC V7J 2L3, Canada
(604) 987-1668; FAX (604) 987-1669
www.mettech.com

Norton Abrasives 11217
1 New Bond St., Worcester, MA 01606-2614
(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 solutions for production runs on all types of materials.

Nova-Tech Engineering LLC 10011
20818 44th Ave. W., Ste. 201
Lynnwood, WA 98036-7709
(425) 245-7000; FAX (425) 245-7099
www.stirwelding.com

Nova-Tech Engineering will feature its services as a designer and builder of complete friction stir welding (FSW) systems and aerospace tooling. The company 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. The company also has more than 30 years of aerospace tooling experience, with an emphasis on moving line equipment, laser alignment positioners, and other assembly tooling equipment.

NSRW 11205
701 Thames Ct., Pelham, AL 35124-1926
(205) 663-1500; FAX (205) 663-3221
www.nsrw.com

NSRW will showcase its expanded services to ensure weld process integrity and cost containment, engineering services, weld process verification, installation, and production support.

Nutron Nameplate Inc. 15060
PO Box 487, 31269 Lorain Rd.
North Olmsted, OH 44070-0487
(888) 737-5052; FAX (440) 777-6664
www.nutronnameplate.com

The company will introduce its FMA standarized, graphic, ANSI/ISO safety signage for fabricating, welding, and other related equipment.

Ohio Nut & Bolt Co., The 11269
33 Lou Groza Blvd., Berea, OH 44017-1293
(800) 362-0291; 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 low-carbon steel, stainless steel, and 1022 hardened steel will be offered. Also, a standard line of levelers, some with slotted or hex dogpoint terminal ends, will be shown.

Ohio State University 10259
1248 Arthur E. Adams Dr., Columbus, OH 43221-3560
(614) 292-0522; FAX (614) 292-6842
www.iwse.eng.ohio-state.edu/we/

OKI Bering 15086/15095

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 supplies. 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 14229

48 Woerd Ave., Waltham, MA 02453-3824
(781) 419-3900; FAX (781) 419-3980
www.olympusndt.com/en

Olympus will display its portfolio of ultrasonic testing (UT), phased array (PA), eddy current (ET), eddy current array (ECA), remote visual inspection (RVI), and related technologies. The company's brands include R/D Tech, Panametrics-NDT, NDT Engineering, Sonic, and Nortec.

OR Lasertechnology, Inc. 7106

1420 Howard St., Elk Grove Village, IL 60007-2221
(847) 593-5711; FAX (847) 593-5752
www.orlaserwelding.com

OR Lasertechnology will feature its laser welding systems. The company's products include Class IV (open beam) and Class I (enclosed) systems, as well as fully mobile and stationary systems for any laser welding application. The products can perform laser beam welding of chrome-nickel alloys, aluminum, nitrate surfaces, and stainless steel. The company also offers job shop services in Illinois and throughout the U.S. Midwest.

Orbitalum Tools GmbH 12093

Freibuehistr 18, Sirgen, Germany 78224
49-7731 792 735; 49-7731 792 500
www.orbitalum.com

ORS NASCO 15149

2348 E. Shawnee, Muskogee, OK 74403-1423
(918) 781-5300; FAX (918) 682-5936
www.orsnasco.com

ORS Nasco will feature its line of welding, industrial, and safety supplies.

Osborn International 12256

5401 Hamilton Ave., Cleveland, OH 44114-3911
(216) 361-1900; FAX (216) 361-1913
www.osborn.com

Osborn International will feature its complete line of wire and synthetic power brushes including the ATB nylon abrasive brushes and diamond superabrasives, ranging in size from miniature to wide face. Also featured will be the company's Softool honing inserts, maintenance brooms, utility brushes, and a variety of aerosols, abrasives, and buffing wheels.

Oskar Air Products 13133

95 Cypress Dr., Youngsville, NC 27596
(919) 570-2862; FAX (919) 570-2863
www.oskarsales.com

Oskar Air Products will highlight its air filtration and extraction products that include fume arms, portable collectors, dust collectors, robotic cells, downdraft tables, hose reels, blowers/fans, and retrofit systems to extend filter life on most dust collectors. The company's newest products include three new robotic cells and two types of dust collectors.

OTC DAIHEN Inc. 13163

1400 Blauser Dr., Tipp City, OH 45371-2471
(937) 667-0800; FAX (937) 667-0885
www.daihen-usa.com

OTC DAIHEN will provide information on its more than 70 years of experience in advanced arc welding technology, and more than 25 years of experience in advanced welding and robotic systems.

Oxford Alloys Inc. 11177

2632 Tee Dr., Baton Rouge, LA 70814-4913
(225) 273-4800; FAX (225) 273-4814
www.oxfordalloys.com

Oxford Alloys will feature 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. The company also stocks mild and low alloy steel, aluminum bronze, silicon bronze, deox copper and aluminum.

Oxylance Corp. 14187

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.

PAC - Powder Alloy Corp. **10192**
5871 Creek Rd., Cincinnati, OH 45242-4009
www.powderalloy.com
(513) 984-4016; FAX (513) 984-4017

PacMont Inc. **13110**
18855 Chessington Pl.
Rowland Heights, CA 91748-4969
(626) 839-1443; FAX (626) 964-0158

PacMont will display its autodarkening lenses and welding helmets.

Panasonic Factory Solutions Co. **12017**
909 Asbury Dr., Buffalo Grove, IL 60089-4525
(847) 495-6100; FAX (847) 495-6095
www.panasonicfa.com

Panasonic Factory Solutions will exhibit its line of arc welding robots, power sources, and preengineered work cells. Industries served include automotive and its subcontractors, farm and heavy equipment, over-the-road vehicles, general metal fabrication and job shops. The company will provide information on its comprehensive customer support from its Chicago-based Technical Center.

Pandjiris Inc. **14067**
5151 Northrup Ave., St. Louis, MO 63110-2031
(314) 776-6893; FAX (314) 776-8763
www.pandjiris.com

Pandjiris will feature 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. Pandjiris will also offer its engineering expertise for turnkey welding systems designed and manufactured to meet the needs of industry.

Pangborn Corp. **5325**
4630 Coates Dr., Fairburn, GA 30213-2975
(404) 665-5700; FAX (404) 665-5701
www.pangborn.com

Pangborn Corporation will detail its line of surface preparation equipment. The company produces new equipment, retrofits and rebuilds current machines, and provides all levels of service to its customers.

Parker Domnick Hunter **10205**
5900 B Northwoods Pkwy., Charlotte, NC 28269-5747
(800) 345-8462; FAX: (704) 921-1960
www.domnickhunter.com

Parker Domnick Hunter will display its Hyperchill process water chillers and MAXIGAS nitrogen gas generators.

Parker Hannifin Corp. **11295**
6035 Parkland Blvd., Cleveland, OH 44139
(216) 896-2532; FAX (216) 896-5000
www.parker.com

Pat Mooney, Inc. **8151**
502 S. Westgate St., Addison, IL 60101-4525
(630) 543-6222; FAX (630) 543-5584
www.patmooneysaws.com

Pat Mooney will exhibit its friction sawblades for tube mills with a new coating that allows longer use with less cracking. It will also show its FMB direct-drive precision mitre band saws.

Peddinghaus Corp. **4151**
300 N. Washington Ave., Bradley, IL 60915-1600
(815) 937-3800; FAX (815) 937-4003
www.peddinghaus.com

Peddinghaus will unveil four new machines that promote single-operator thermal fabrication of all structural shapes; high-speed drilling, tapping, countersinking, and marking; speed sawing techniques that can improve tonnage up to 25%; and new cutting edge technologies for the structural steel and heavy plate fabrication industries.

Permadur Industries, Inc. **14011**
186 Rte. 206, Hillsborough, NJ 08844-4123
(908) 359-9767; FAX (908) 359-9773
www.permadur.com

Permadur will feature its permanent lifting magnets and custom-built magnet and vacuum systems to support plate loading and multiple part/skeleton offloading and individual cut part handling associated with oxyfuel, plasma, and laser beam cutting systems.

PFERD, Inc. **10094**
30 Jytek Dr., Leominster, MA 01453-5932
(978) 840-6420; FAX (978) 840-6421
www.pferdusa.com

PFERD and PFERD/Advance Brush Co. will highlight its extensive product range, which includes more than 9000 surface finishing, cutting, and power tools.

Phoenix International, Inc. **13124**
8711 W. Port Ave., Milwaukee, WI 53224-3429
(414) 973-3400; FAX (414) 973-3210
www.phx-international.com

Phoenix will feature its line of DryRod® and dryWIRE® ovens for holding, reconditioning, and rebaking welding electrodes. It will also show the Safetube®, a watertight, durable container for maximum protection of electrodes, which offers a carrying strap with cap tether, nonrollaway shape, and safety yellow color.

Plasma Automation, Inc. **14066**
1801 Artic Ave., Bohemia, NY 11716-2413
(631) 563-7234; 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 Monarch I-beam cutting system designed for versatile cutting of precision 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. **10082**
115 Melrich Rd., Ste. 2, Cranbury, NJ 08512-3526
(800) 644-0911; FAX (609) 655-0569
www.plymovent.com

PlymoVent will exhibit its 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. **10163**
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, offers a wide range of iron-, nickel-, cobalt-, aluminum-, and copper-based alloys for the aerospace, automotive, mining, lumber, nuclear, land-based turbines, power generating, cement, and other industries. The company's manufacturing capabilities include hot extruded wire processing, rolling, drawing, and alloy cored wire fabrication.

Port-A-Cool 5330
709 Southview Cir., Center, TX 75935-4341
(800) 695-2942; FAX (936) 598-8901
www.port-a-cool.com

Port-A-Cool will exhibit its portable, evaporative cooling systems for use when standard air-conditioning may be unavailable, impractical, or cost prohibitive. Operating with water and either electricity or compressed air, the units deliver air flow an average of 20 deg cooler than surrounding air.

Praxair, Inc. 13057
39 Old Ridgebury Rd., Danbury, CT 06810-5109
(800) 772-9247; FAX (800) 772-9985
www.praxair.com

Precise Equipment Co. 12216
3311 N. I-35, Ste. 150, Denton, TX 76207-2004
(940) 566-4780; FAX (940) 566-4825
www.precisemanifolds.com

Preco Inc. 13180
500 Laser Dr., Somerset, WI 54025-9774
(715) 247-3285; FAX (715) 247-5650
www.precoinc.com

Preco will highlight 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 12k), robotics, automation, and fully staffed metallurgical and quality labs.

Preston-Eastin Inc. 11101
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, turntables, 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./ Caiman Gloves 15198
9078 Rosecrans Ave., Bellflower, CA 90706-2038
(562) 272-2762; FAX (562) 272-2761
www.caimangloves.com

Primax/Caiman Gloves will exhibit its new glove designs, Revolution™ and Kontour™, which combine fine materials, style, dexterity, comfort, and safety never seen in conventional welding gloves. A new line of premium Boarhide™ welding apparel will also be shown.

Pro Weld Stud Welding 13186
12200 Alameda Dr., Strongsville, OH 44149-3021
(800) 874-7860; FAX (440) 783-3178
www.studwelding.com

Pro Weld Stud Welding will showcase its complete range of threaded, nonthreaded, tapped, and special arc and capacitor discharge studs, stud welding systems, and accessories. Demonstrations will be given to show the advantages of this fast, reliable end welding process that offers a superior strength, distortion- and blemish-free, no drilling and tapping fastening alternative.

Profax/Lenco 13101
PO Box 898, Pearland, TX 77588-0898
(281) 485-6258; FAX (281) 485-8030
www.profax-lenco.com

Profax will feature its GMA, flux core, and submerged arc welding equipment, guns, and consumables; arc gouging torches and carbons; GTAW 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. 15054
701 Mayde Rd., Berea, KY 40403-9723
(859) 985-1776; FAX (859) 986-7423
www.prorobots.com

Progressive Systems will show its PROSYSTEM robot welding, fixturing, and material handling systems. The company is a full-service systems integrator. It can develop application-specific welding solutions for general industry, automotive, and military.

Project Tool & Die Inc. 2005
6955 Danyeur Rd., Redding, CA 96001-5390
(530) 243-8903: FAX (530) 243-8914
www.projecttoolanddie.com

ProMotion Controls, Inc. 11216
1484 Medina Rd., Ste. 118, Medina, OH 44256-5378
(330) 721-1464; FAX (330) 239-1531
www.promotioncontrols.com

ProMotion Controls will exhibit its shape-cutting controls and associated products with advanced intelligence for processes including oxyfuel, plasma, waterjet, and routers. Its PC-based shape-cutting control solutions for new machinery or retrofit include new iControl innovations and software options, a new iDrive and torch lifter, and an iCNC upgrade kit that updates older controls with the latest in advanced capabilities.

PTR-Precision Technologies Inc. 12234
120 Post Rd., Enfield, CT 06082-5690
(860) 741-9311; FAX (860) 745-7932
www.ptreb.com

PTR-Precision Technologies will feature its electron beam welding systems for a wide range of applications. The company also provides parts, service, and retrofits for the systems built by its predecessors: Hamilton Stan-

dard and Leybold. In addition, it offers contract EB welding at its job shops in Enfield, Conn., and Spartanburg, S.C.

Quality Welding Products, Inc. **15006**
118 N. Mill St., King of Prussia, PA 19508
(610) 331-1607; FAX (610) 783-0446
www.qwpinc.net

QWP will introduce several new pickling products for stainless steel and aluminum, and will display a stainless gas tungsten arc welding wire that will eliminate the need for backing/purging, and a new flux that can be used in place of purging that works at its optimum when mixed with water. The company will also introduce a fast pickling process for stainless.

Radyne Corp. **15094**
211 W. Boden St., Milwaukee, WI 53207-6277
(414) 481-8360; FAX (414) 481-8303
www.radyne.com

Radyne will feature its induction power integrated and segregated heating systems for heat treating, brazing, soldering, shrink fitting, wire and pipe heating, and coating, systems. Also featured will be its complete system design, build, and service capabilities for power supplies, material handling, and tooling. Demonstrations of induction heating will be given.

Rasco Mfg. **14133**
13112 Morolaix Ct., Baton Rouge, LA 70815-2823
(225) 273-3163; FAX (225) 273-3176
www.rascodist.com

Rasco will show its line of work, welding, and fire-retardant clothing.

Ratermann Mfg., Inc. **15224**
601 Pinnacle Pl., Livermore, CA 94550-9705
(925) 344-0230; FAX (925) 724-2487
www.rmimfg.com

Ready Welder **14113**
4769 E. Wesley Dr., Anaheim, CA 92807-1941
(800) 465-9184; FAX (714) 970-0800
www.weldstone.net

Ready Welder will highlight its portable and versatile GMAW machine that is designed for use with a typical car battery to generate 350 A and penetrate 1/2-in. steel. An integrated gas line enables the welding of stainless steel and aluminum, and a patented wire feed technology allows use as a spoolgun.

Reis Robotics USA, Inc. **15191**
1320 Holmes Rd., Elgin, IL 60123-1202
(847) 741-9500; FAX (847) 888-2762
www.reisroboticsusa.com

Reis Robotics will promote its expertise in robot and system integration. The company will offer a broad product line of robots and standard peripheral modules and services for automation systems in all major applications fields.

Resistance Welding Manufacturing Alliance – RWMA **10251**
550 NW LeJeune 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.

Retro Systems LLC **13187**
430 W. Clay St., Valley Center, KS 67147-2247
(316) 755-3683; FAX (316) 755-1675
www.retroplasma.com

Retro Systems will demonstrate its MEGA HORNET cutting unit with a full auto process Hypertherm HPR high-definition plasma system. The company integrates the full suite of Hypertherm automation products into its machine design.

Revco Industries, Inc. **12163**
10747 Norwalk Blvd.
Santa Fe Springs, CA 90670-3823
(800) 527-3826; FAX (800) 527-7587
www.blackstallion.com

Revco Industries will feature its Black Stallion protective gloves and apparel, including a full line of welding gloves, leather palm, drivers, fire-retardant and protective clothing, fire blankets, and welding screens.

Rex Cut Products Co. **11173**
PO Box 2109, 960 Airport Rd.
Fall River, MA 02722-2109
(800) 225-8182; FAX (800) 638-8501
www.rexcut.com

Rex Cut will display its cotton fiber and specialty abrasive products for use on stainless steel, aluminum, mild steel, and exotic alloys and materials, as well as unique products designed for grinding, cutting, and blending.

Rhino Welders 12174

2228 Sea Ridge Dr., Signal Hill, CA 90755
(951) 283-8888; FAX (562) 961-8387
www.rhinowelders.com

Rhino Welders will introduce its Mag 251 and 211, which feature powerful, user-friendly, up-to-date technology, with universal parts and economical cost.

RoMan Manufacturing, Inc. 11163

861 47th St. SW, Grand Rapids, MI 49509-5103
(616) 530-8641; FAX (616) 530-8953
www.romanmfg.com

RoMan Manufacturing will display its line of improved resistance welding transformers as well as MFDC power supplies. Company representatives will be available to discuss products and services, including a state-of-the art metallurgical laboratory, in plant consultants, numerous testing capabilities, and complete welding engineering services.

Romar MEC - Fit Up Gear 15167

218 W. Richey Rd., Houston, TX 77090-5804
(281) 440-1725; FAX (281) 440-1724
www.fitupgear.com

Romar MEC – Fit Up Gear and Magswitch have aligned technologies to offer efficient fitting tools, including No-Mar magnetic fitting tools, which utilize powerful compact switchable magnets that will not mar metal.

rose plastic USA LP 10037

PO Box 698, California, PA 15419-0698
(724) 938-8530; FAX (724) 938-8532
www.rose-plastic.us

The company will highlight its more than 3000 types and sizes of packaging, designed and manufactured to be sturdy, versatile, and ecomomical. Custom and standard products made of durable, recyclable polyethylene, polyproplylene, and PVC provide protection from dampness and physical impact during shipment and storage.

Saf T Cart 11100

PO Box 1869,1322 Industrial Park Dr.
Clarksdale, MS 38614-7869
(662) 624-6492; FAX (662) 627-1640
www.saftcart.com

Saf T Cart will display and demonstrate its cylinder handling products, from e cylinders to cylinder trailers; and carts for welding machines, including trailers for gas drives.

Saint Louis Metallizing 10170

4123 Sarpy Ave., St, Louis, MO 63110-1796
(314) 531-5253; FAX (314) 531-4706
www.stlmetallizing.com

Saint-Gobain Coating Solutions 10174

1 New Bond St., Worcester, MA 01606-2614
(508) 795-2351; FAX (508) 795-5751
www.coatingsolutions.saint-gobain.com

Sakura of America 10233

30780 San Clemente St.
Hayward, CA 94544-7131
(800) 776-6257; FAX (510) 475-0973
www.sakuraofamerica.com

Sakura of America will spolight its markers and writing instruments, and feature the Solid Marker™ that marks through grease, oil, rust, dirt, water and underwater, in a variety of colors and with a glow-in-the-dark version.

Sandvik Materials Technology 14007

982 Griffin Pond Rd.
S. Abington Twp., PA 18411-9214
(570) 587-7691; FAX (800) 438-3365
www.smt.sandvik.com

Sandvik will promote its stainless steels and high-nickel alloys for GMAW, GTAW, FCAW, SMAW, SAW strip and fluxes, and electroslag welding consumables and base metals. The focus will be an extensive assortment of duplex, superduplex, super austenitic alloys, and filler metals designed for them.

Sciaky, Inc. 15180

4915 W. 67th St., Chicago, IL 60638-6408
(708) 594-3800; FAX (708) 594-9213
www.sciaky.com

Sciaky will exhibit the very latest in free form fabrication technology, as well as its new, next-generation EB welding machine, the NG1 EVO.

Scotchman Industries, Inc. 4165

PO Box 850, Philip, SD 57567-0850
(605) 859-2542; FAX (605) 859-2499
www.scotchman.com


Visit Us At Fabtech
Booth: #11094
Auto-Darkening Welding Helmet
Python
By
ArcOne®
Don't Follow,
Lead.
Be Unique™
Spirit
Silver/Grey
UpTown
Blue Fusion
Red Fusion
Green Fusion
Silver Fusion
Fighting Tiger
Large
Xtra-Large
Xtreme
4000V
5000V
6000V
Auto-Darkening Filters
Comfagear Headgear
www.arc1weldsafe.com
800-223-4685
For Info go to www.aws.org/ad-index

Scotchman will highlight its hydraulic ironworkers, circular cold saws for manual or automatic operation, manual or automatic band saws, and advanced measuring and programmable feed systems.

Sellstrom Manufacturing Co. 12048
1 Sellstrom Dr., Palatine, IL 60067-6260
(847) 358-2000; FAX (847) 358-8564
www.sellstrom.com

Sellstrom will feature its full line of safety and personal protective equipment, including welding helmets, filters, goggles, eyewear, fall protection, and more.

Shanghai Gonglue Machinery & Elect. Tech. Co. Ltd. 10089
Rm. 1302, No. 14, Lane 1673
Zhangyang Rd., Shanghai, 200135, China
86-21-5821-1886; FAX 86-21-5821-6371
www.xunweld.com

The company will promote its agglomerated flux, and wire and strip, which can be used for cladding stainless steel and nickel alloys.

Shanghai Zhengtai Welding Equipment Co. Ltd. 10083
No.1025 Huajiang Rd., Shanghai, 201803, China
86-216-9111712; FAX 86-215-9142591
www.shzt.com

The company will display its AC and DC inverter technology for GTAW and specialty welding.

Sheet Metal Accessories 12192
2640 N. Powerline Rd.
Pompano Beach, FL 33069-1006
(954) 975-7992; FAX (954) 975-7994
www.sma-inc.net

The company will introduce its new electronic weld cleaner the BOSS, an electro-chemical device for removing scorch/burn marks to eliminate the need for abrasive materials or caustic chemicals.

Shengzhou Xinrui Welding Technology Co. Ltd 10111
Shuiqing Wang, Shanjie Town Industrial Compex
Shengzhou Zhejiang, 312452, China
86-575-83342667; FAX 86-575-83369812
www.xinruigroup.com

Shenzhen Huayilong Development Co. Ltd 10119
Bldg. 3, Section 5, Honghualing Industrial Zone
S. Nanshan Dist., Shenzhen, 518055, China
86-755-86000858; FAX 86-755-86176158
www.szhuayilong.com

The company will feature its line of welding machines.

Shenzhen Tiptop Industrial Development Co. Ltd. 15110
Bldg. 15, East Zone of Baishixia
Fuyong Town BaoAn Dist., Shenzhen, 518103, China
86-755-27386910; FAX 86-755-27386930
www.tiptoptt

Sherwin, Inc. 14107
5530 Borwick Ave., South Gate, CA 90280-7402
(562) 861-6324; FAX (562) 923-8370
www.sherwininc.com

Sherwin will highlight its full line of penetrant materials that are used in weld inspection. The company has the ability to meet penetrant weld inspection needs, and representatives will be available to help solve weld inspection problems.

Shop Data Systems 15128
712 E. Walnut St., Garland, TX 75040-6608
(972) 494-2719; FAX (972) 272-7062
www.shopdata.com

Shop Data Sytems will offer its family of fully integrated CAD/CAM software products that support plasma cutting and etching, oxyfuel cutting, waterjet cutting, and combinations of those processes on a single machine tool.

sia Abrasives 10241
1626 Walker Rd., Scott, LA 70583
(800) 624-4582; FAX (800) 292-9032
www.sia-abrasives.com

The sia Group will feature its new product siastar® with a quick release adapter that fits any conventional angle and straight grinder. The company develops, manufactures, and markets complete abrasive systems, tailored to specific requirements and applications, for the surface treatment of every type of workpiece.

SigmaTEK Systems LLC 3008
1445 Kemper Meadow Dr.
Cincinnati, OH 45240-1637
(513) 674-0005; FAX (513) 674-0009
www.sigmanest.com

SigmaTEK will highlight SigmaNEST, an advanced, automatic nesting NC profile cutting software that supports part marking, chain and common line cutting, multiaxis bevel contouring, automatic true-shape nesting, multitorch nesting and more on plasma, oxyfuel, laser, router, waterjet, punch, and punch combination machines.

SKM Industries Inc. **12137**
PO Box 278, 1012 Underwood Rd.
Olyphant, PA 18447-0278
(570) 383-3062; FAX (570) 383-9482
www.skmproducts.com

SKM Industries will introduce its new Metal-Pro Creamsicle fabrication marker, for steel marking prior to galvanizing. Marks stay on completely during the fabrication process, are weather and UV resistant, and come off completely in the galvanizer's tank without inhibiting the galvanizing process.

SLT USA **7075**
41 New York Tower-A
SG Hwy. Thaltej X Rd., Thaltej
Ahmedabad 380054, India
91-79-2685 4537; FAX 91-79-2685 4539
www.sahajanandlaser.com

SmartTCP, Inc. **12025**
26602 Haggerty Rd.,
Farmington Hills, MI 48331-3406
(248) 994-1041; FAX (248) 994-1042
www.smarttcp.com

SmartTCP will feature its robotic welding solution for complex fabrications in small batch production. The company will also highlight its turnkey gantry welding system that includes hardware, software, installation, training, and support during and after implementation, making it possible for job shops and manufacturers to optimize the fabrication of high-mix, low-volume parts.

SOLAR FLUX **15196**
PO Box 2129, Morehead City, NC 28557-2129
(252) 808-3511; FAX (252) 808-3711
www.solarflux.com

Solar Flux will feature live stainless steel welding demonstrations, using Solar Flux Type B instead of gas purging, and the new Lincoln Electric V-310 GTA machine.

Soutec Soudronic **11181**
46956 Liberty Dr., Wixom, MI 48393-3693
(248) 896-9401; FAX (248) 896-9433
www.soutec.com

Soutec Soudronic will feature its welding equipment, which includes laser, arc, and resistance welding machines.

Southern Copper & Supply Co. **12229**
875 Yeager Pkwy., Pelham, AL 35124-1846
(205) 664-9440; FAX (205) 664-1365
www.southerncopper.com

Southern Copper & Supply will promote its expertise as a copper alloys distributor, offering immediate availability of products listed on its Web site, technical information, a broad range of sizes, and just-in-time delivery.

Spanco, Inc. **3242**
604 Hemlock Rd., Ste. 2, Morgantown, PA 19543-9711
(610) 286-7200; FAX (610) 286-0085
www.spanco.com

Spanco will showcase its ergonomic enclosed track workstation cranes, workstation and I-beam jib cranes, portable and motorized gantry cranes, articulating jib cranes, and fall arrest track systems.

Special Metals Welding Products Co. **13062**
1401 Burris Rd., Newton, NC 28658-1754
(800) 624-3411; FAX (828) 464-8993
www.specialmetalswelding.com

Special Metals will exhibit its nickel-based welding consumables for joining nickel alloys, high-performance steels, cast irons, and dissimilar metals as well as cladding on steel for corrosion or erosion protection, sold under the internationally recognized brand names INCONEL®, MONEL®, INCO-FLUX®, and INCO-WELD®.

Sperian Protection **15172**
900 Douglas Pike, Smithfield, RI 02917-1879
(800) 343-3411; FAX (401) 233-7641
www.sperianprotection.com

The company will feature its personal protective equipment including autodarkening welding helmet technology, safety eyewear, hearing, and respiratory protection.

Stanco Manufacturing, Inc. **11187**
PO Box 1148, 2004 W. Main St., Atlanta, TX 75551-1148
(800) 348-1148; FAX (903) 796-9237
www.stancomfg.com

Stanco Manufacturing will spotlight its complete 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 products are made from materials such as leather, Kevlar®, Nomex®, fiberglass, and other flame-resistant fabrics.

SteelTailor **10228**
Cannes Industrial Park
No. 18 Shuangqiao East Rd.
Chaoyang Dist., Beijing 100121, China
86-10 5166 2600; FAX 86-10 5129-0845
www.steeltailor.com

SteelTailor will focus on its innovative and re-

liable CNC cutting solutions, and introduce its portable CNC cutting machine that cuts software-designed profiles and supports both oxygen and plasma processes. The company will offer opportunities to distributors.

Steiner Industries **11079**
5801 N. Tripp Ave., Chicago, IL 60646-6013
(773) 588-3444; FAX (773) 588-3450
www.steinerindustries.com

Steiner Industries will spotlight its full line of welding/industrial safety products, incuding gloves for welding, work, driver and mechanic, flame-retardant cotton clothing, welding blankets, screens, and curtains.

Strong Hand Tools **11125**
7141 Paramount Blvd., Pico Rivera, CA 90660-3769
(562) 949-8625; FAX (562) 949-4875
www.stronghandtools.com

Strong Hand Tools will exhibit its welding clamps, magnets, and pliers including Adjust-O Magnets, magnets with an on/off switch; the Ground Hog, the grounding clamp that uses high clamping pressure to deliver a complete electrical transfer; the Pipe Plier with V-pads to hold pipe/tube for welding; and the NOMAD˙welding table with fully adjustable height, tilting, and slotted tabletop to accept a wide variety of clamps.

Stud Welding Products **14216**
9459 Washburn Rd., Downey, CA 90242-2912
(800) 252-1919; FAX: (562) 862-3022
www.studweldprod.com

Suhner Industrial Products **11252**
100 Anderson Rd. SW, Rome, GA 30161-9538
(706) 235-8046; FAX (706) 235-8045
www.su-matic.com

Suhner will promote its wide range of flexible shaft, electric, and pneumatic tools and abrasives for material grinding and finishing. Personnel will offer problem solving for all grinding, polishing, and material finishing applications.

Sulzer Metco (US) Inc. **10162**
1101 Prospect Ave., Westbury, NY 11590-2724
(516) 338-2422; FAX (516) 338-2414
www.sulzermetco.com

Sulzer Metco will spotlight its thermal spray materials, integrated systems, and equipment for all thermal spray processes, as well as specialized coating and surfacing services, and global customer support services.

Sumner Manufacturing Co., Inc. **14125**
7414 Alabonson Rd., Houston, TX 77088
(281) 999-6900; (281) 999-6966
www.sumner.com

Sumner will feature its pipe handling equipment, as well as its line of material lifts, wire and storage carts, work tables, and electrician equipment, all produced with the concept of providing safe, priced right, common sense tools.

Superheat FGH Services, Inc. **10025**
680 Industrial Park Rd., Evans, GA 30809-3684
(888) 508-3226; FAX (706) 790-3383
www.superheatfgh.com

Superior Abrasives, Inc. **12173**
4800 Wadsworth Rd., Dayton, OH 45414-4224
(800) 235-9123; FAX (800) 841-3441
www.superiorabrasives.com

Superior Abrasives will highlight its line of coated and nonwoven abrasives.

Superior Products, Inc. **12125**
3786 Ridge Rd., Cleveland, OH 44144-1127
(216) 651-9400; FAX (216) 651-4071
www.superiorprod.com

Superior Products will promote its complete line of compressed gas fittings, assemblies, and manifold systems for the welding, medical, and specialty gas markets throughout the world. Technical assistance will be available to work with you to develop a manifold system to improve compressed gas delivery.

Swagelok Co. **15163**
31400 Aurora Rd., Solon, OH 44139-2764
(440) 349-5934; FAX (440) 349-5806
www.swagelok.com

Swagelok will premier its M200 power supply that offers 200-A capability, ease of use, and portability, and includes features such as high-resolution, color industrial touch screen; automatic shield gas control; multilanguage capability; and a universal voltage input.

Sweetwater Economic Development Assoc. **15214**
1400 Dewar Dr., Ste. 205A
Rock Springs, WY 82901-5850
(307) 352-6874; FAX (307) 352-6876
www.sweda.net


"AlcoTec wire gives me the quality I need for my aluminum welding."
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.
AlcoTec
Quality, Technology, Support — Simply the best
2750 Aero Park Drive, Traverse City, MI 49686-9263
Phone: 1-800-228-0750
www.alcotec.com
A member of the ESAB Group, Inc.
For Info go to www.aws.org/ad-index
SEE US AT THE FABTECH/AWS SHOW BOOTH #14003

The Sweetwater Economic Development Association assists local businesses (southwest Wyoming) and industries with business retention and expansion, including workforce recruitment. Sweetwater County, Wyoming, has a variety of high-paid jobs for skilled workers due to increased energy production. Available jobs include electricians, welders, fabricators, machinists, mechanics, and laborers along with other related skill sets.

Synetik Design 11233
14b rue Lepine,
Saint-Jacques QC J0K 2R0, Canada
(450) 839-2400; FAX (450) 839-1032
www.synetik-di.com

Synetik will display Stag4, a new welding chair for a more comfortable, productive, and safer welding session. The chair offers effective ergonomic support during welding in tight and restricted positions.

TAFA, Inc. 10211
A Praxair Surface Technologies Co.
146 Pembroke Rd., Concord, NH 03301
(800) 224-9585; FAX (603) 225-4342
www.praxair.com/thermalspray

TAFA will offer its complete line of thermal spray materials and equipment, including carbide, metallic, and ceramic powders, wires, and spare parts complemented with plasma, HVOF, and arc spray equipment.

TEAM Industrial Services 15146
200 Hermann Dr., Alvin, TX 77511-5596
(800) 662-8326; FAX (281) 331-4107
www.teamindustrialservices.com

TEAM Industrial Services will promote its expertise in on-site specialized industrial services, including turnaround, shutdown, outage services, on-stream leak repairs, emissions control, hot taps, line stops, valve repairs, field machining, new project construction, pipe repair, field heat treating, NDE inspections, and more.

Team Industries, Inc. 8212
PO Box 350, Kaukauna, WI 54130-0350
(920) 766-7977; FAX (920) 766-0486
www.teamind.com

Team Industries will feature its welding positioners, argon through-hole purge systems, variable rotational torque systems, hydraulically elevated self-leveling positioner, programmable AC motor drives, and serrated and carbide gripper jaws.

TEC Torch Co., Inc. 12141
PO Box 1870, San Marcos, CA 92079-1870
(760) 747-3700; FAX (760) 747-2121
www.tectorch.com

Tec Torch will promote its GTAW torches, including the original TEC brand torches, the WeldTec brand torches, the high-performance Speedway brand torches, the I-head interchangeable head flex, ball joint, and roto head torches. The company will also show its compact stainless steel water coolers and a unique GTAW spot gun.

Techalloy Welding Products 11112
2310 Chesapeake Ave., Baltimore, MD 21222-4012
(410) 633-9300; FAX (410) 633-2033
www.techalloy.com

Techalloy Welding Products will feature its product line of stainless steel and nickel alloys in solid wire forms and covered electrodes.

Technogenia, Inc. 12205
708 Old Montgomery Rd., Conroe, TX 77301-2740
(936) 441-4770; FAX (936) 539-4760
www.technogenia.com

Technogenia will exhibit its special hardfacing products with spherical cast tungsten carbide that, when deposited on the tool's surface, provides antiabrasion solutions for various applications.

Techsouth, Inc. 11229
3238 Robinson Circle, Charlotte, NC 28229
(704) 334-1100; FAX (704) 342-0998
www.techsouthinc.com

TECMEN Electronics Co. Ltd 10085
Bldg D-B, No. 21, N. Liuzhou Rd.
XiaoLiu Indusry Park, Nanjing 210031, China
86-25-8555-1955; FAX 86-25-8555-1933
www.tecmen.cn

TECMEN will showcase its autodarkening welding helmets designed to protect the eye and face from sparks, spatter, and harmful radiation under normal welding conditions. Products conform to applicable ANSI Z87.1 standards, and also meet CSA and CE standards for use in Canada and Europe.

Tempil — an ITW Co. 12087

2901 Hamilton Blvd.
South Plainfield, NJ 07080-2517
(908) 757-8300; FAX (908) 757-9273
www.tempil.com

Tempil will display its high-quality temperature-indicating products, including the well-known TEMPILSTIK.

Tensile Testing Metallurgical Laboratory 13261

4520 Willow Pkwy., Cleveland, OH 44125-1042
(216) 641-3290; FAX (216) 641-1223
www.tensile.com

Tensile Testing Metallurgical Laboratory will feature its services as an independent laboratory that specializes in mechanical, chemical, corrosion, and metallurgical testing, and welding procedures (PQRs).

Termmei Industry and Commerce Co. 15088

No. 1017 Eco Int'l. Digital Plaza
No. 38 Guanhe Changzhou, Jiangsu 213003, China
86-519-86801833; FAX 86-519-86801366
www.termmei.com

Termmei Industry and Commerce will feature its manufacturing and development of GMAW guns, GTAW torches, and spare parts.

Texas State Technical College 10257

3801 Campus Dr., Waco, TX 76705-1696
(254) 867-4884; FAX (254) 867-3550
www.waco.tstc.edu

Thermacut, Inc. 15059

PO Box 1197, 153 Charlestown Rd.
Claremong, NH 03743-1197
(603) 543-0585; FAX (603) 542-5745
www.thermacut.com

Thermacut will highlight its advanced plasma cutting and welding consumables, accessories, and replacement torches.

Thermadyne Industries Inc. 13025/13043

16052 Swingley Ridge Rd., Ste. 30
Chesterfield, MO 63017-2079
(636) 728-3181; (636) 728-3021
www.thermadyne.com

Thermadyne wiil feature its metal cutting, welding products, and accessories under a variety of leading premium brand names including Victor®, Tweco®, Arcair®, Thermal Dynamics®, Thermal Arc®, Stoody®, Turbo Torch®, Firepower® and Cigweld®.

Thermion 10195

PO Box 780, Silverdale, WA 98383-0780
(360) 492-6469; FAX (360) 447-8314
www.thermioninc.com

Thermo Scientific NITON 5257

900 Middlesex Tpke., Bldg. 8
Billerica, MA 01821-3929
(978) 670-7460; FAX (978) 670-7430
www.thermofisher.com/niton

Thermo Scientific Niton will spotlight its leading handheld, nondestructive elemental analysis instruments, which provide positive grade identification and composition analysis of materials that have lost traceability, such as stainless steels, nickel- and cobalt-based alloys, titanium alloys, and more.

3M Abrasive Systems Div. **10199**
3M Center Bldg. 223-6N-02
Saint Paul, MN 55144-0001
(651) 737-1786; FAX (800) 852-4668
www.3M.com/abrasives

3M Occupational Health & ESD **15101**
Bldg 235-2W-70, Saint Paul, MN 55144-0001
(651) 736-1751; FAX (651) 736-6677
www.3M.com/occsafety

ThyssenKrupp **12187**
306 Columbia Tpke.
Florham Park, NJ 07932-1217
(973) 236-1664; FAX (973) 236-1960
www.thyssenkrupp.com

ThyssenKrupp will premier its nickel-based alloys for heat- and corrosion-resistant applications in wire, cut lengths, spools, and covered electrode products for cladding and joint welding.

Tianjin Jinlong Welding Material Co. Ltd. **10105**
Yuantian Rd., Changsheng St.
Gegu Town Jinnan District, Tianjin 300352 China
86-22-286-95656; FAX 86-22-286-86879
www.jinlongweld.com

Tianjin Jinlong will feature its copper and copper alloy welding materials.

Tianjin Xinsen Welding Materials Co. Ltd. **10109**
Huyuan Town, Shuangjie Zhen Beichen District
Tianjin 300400, China
86-22-26972630; FAX 86-22-26972720
www.xinsenwelding.com

Tianjin Xinsen will feature its expertise in the production of copper and copper alloy welding materials.

TJ Snow Co. **13054**
PO Box 22847, Chattanooga, TN 37422-2847
(423) 894-6234; FAX (423) 308-3187
www.tjsnow.com

TJ Snow will highlight its automatic and manually operated resistance welding machinery and consumable supplies, spot welding and arc welding robots, welding seminars, weld controls/transformers, and repairs.

Toolmen Corp. **8102**
878 Westinghouse Rd.
Georgetown, TX 78626-7532
(888) 771-1166; (888) 866-4910
www.toolmen1.com

Toolmen will highlight its advanced CNC welding and cutting machines, which feature dynamic force and pressure control and have the ability to utilize vision systems to provide real-time adaptive feedback to the machine control.

Top Cat Air Tools **12210**
38285 Pelton Rd., Willoughby, OH 44094-7740
(440) 954-7500; FAX (440) 954-7118
www.tcservice.com

Torch Wear **11108**
2374 Edison Blvd., Twinsburg, OH 44087-2376
(330) 425-2738; FAX (330) 425-2739
www.torchwear.com

Torch Wear will showcase its safety and welding apparel for protection and comfort, including a unique product line of reengineered garments made exclusively from CarbonX material.

Torchmate **15205**
280 S. Rock Blvd., Ste. 150
Reno, NV 89502-4160
(775) 673-2200; FAX (775) 673-2206
www.torchmate.com

Torchmate will offer a wide array of CNC cutting systems with options for the home hobbyist up to advanced machine and fabrication shops.

TRAutomation **15233**
106 Spring St., Chattanooga, TN 37405-2020
(423) 875-8862; FAX (423) 875-4902
www.trauto.com

Tennessee Rand Automation (TRA) will feature its expertise in the design and manufacture of automated machinery including custom machines; robotic systems for handling, arc/resistance welding, tube bending; full production tube bending systems; industrial HMI; pneumatic clamps; and weld monitoring equipment.

Tregaskiss **12079**
2570 North Talbot Rd.
Windsor, ON N0R 1L0, Canada
(877) 737-3111; FAX (877) 737-2111
www.tregaskiss.com

Tregaskiss will feature its development and manufacture of GMAW guns, peripherals, and consumables, including its brand-name products TOUGH GUN®, TGX®, TOUGH LOCK®, and TOUGH GARD® .

Trendex Information Systems, Inc. 14111
2367 Rue Guenette
Saint-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. Demonstrations will show how to control accounts receivable, accounts payable, general ledger, and inventory.

Tri Tool, Inc. 10118
3041 Sunrise Blvd., Rancho Cordova, CA 95742-6502
(800) 345-5015; FAX (916) 288-6160
www.tritool.com

Tri Tool will feature its ID mounting, beveling, and flange facing tools, and OD mounting, cutting/beveling tools, along with company services that include field machining, training, technical support and custom designs.

Trion, Inc. 14217
101 McNeill Rd., Sanford, NC 27330-9451
(919) 777-6341; FAX (919) 777-6399
www.trioninc.com

Trion will premeir its air purification products designed to meet stringent indoor air quality demands of industrial manufacturing with a variety of filtration technologies that ensure high-efficiency removal of mist, smoke, and fumes.

Triple Crown Products 7122
814 Ela Ave., Waterford, WI 53185-4237
(800) 619-1110; FAX (262) 534-7879
www.crownquality.com

Triple Crown will feature its caps, uniform, and ad specialty products with service that personalizes products by silkscreening, direct embroidery, and embroidered emblems.

Trumpf, Inc. 7005/7015
111 Hyde Rd. Farmington, CT 06032-2851
(860) 255-6000; FAX (860) 255-6421
www.us-trumpf.com

The latest TRUMPF fabricating and laser technology will be on display.

Tuff Toe, Inc. 12242
1442 W. Collins Ave., Ste. G
Orange, CA 92867-5443
(714) 997-9585; FAX (714) 997-9594
www.tufftoe.com

Tuff Toe will showcase its two-part liquid polyurethane adhesive that is applied to work boots and is slag, abrasion, chemical, and water resistant for longer boot life.

TWI North America LLC 11261
400 Georgia Ave., Bldg. C
Deer Park, TX 77536-2508
(281) 680-2000; FAX (281) 680-2004
www.twinorthamerica.com

TWI will feature its core business of technology transfer. Through local and international networks, TWI continually infuses and then diffuses the results of research and development activities on a broad range of Inspection and nondestructive examination technologies. Products offered include training and certification, welding and joining consultancy, design and materials consultancy, structural integrity services, corrosion assessment and protection, failure investigation, and litigation engineering software

U-Mark, Inc. **5296**
102 Iowa Ave., Belleville, IL 62220-3940
(618) 235-7500; FAX (425) 962-9840
www.umarkers.com

U-Mark will introduce the green label series of xylene-free markers, which are designed to withstand industrial applications. A variety of specialty markers is also available.

Uniarc Limited **12176**
Jinan Export Processing Zone
East End of Jing Shi Dong Rd., Jinan 250102 China
86-531-8823 9393; FAX 86-531-8823 9398
www.uniarc.com.cn

Uniarc will feature its capabilities to provide OEM customers (and volume buyers) with a single-source manufacturing solution for GMAW guns and GTAW torches from Chinese-based manufacturing facilities.

Unibraze **13111**
1050 Penner Crest St., Houston, TX 77055-7317
(800) 364-6900; FAX (713) 869-5600
www.unibraze.com

Unibraze will showcase its single source line of welding alloys and consumables, featuring aluminum, cobalt, hardfacing, stainless steel, nickel, mild and low-alloy steels, titanium, and copper-based alloys produced by the industry's leading manufacturers. Keen rod storage ovens will be on display, and representatives will be available to discuss the full line of storage ovens.

United Abrasives, Inc./SAIT **10049**
PO Box 75, 185 Boston Post Rd.
Willimantic, CT 06226-0075
(860) 456-7131; (860) 456-8341
www.unitedabrasives.com

The company will exhibit its high-quality and consistently manufacturered abrasive products.

United Air Specialists **11190**
4440 Creek Rd., Cincinnati, OH 45242-2832
(800) 252-4647; FAX (513) 891-4171
www.uasinc.com

United Air Specialists will highlight its air pollution control systems, featuring its advanced nanofiber cartridge filter technology for the collection of welding fume and smoke.

Universal Drilling & Cutting **3002**
974 N. Du Page Ave., Lombard, IL 60148-1244
(630) 495-9940; FAX (630) 495-9941
www.unibor.com

Universal Drilling & Cutting Equipment will spotlight its Unibor line of annular cutting equipment and magnetic drills.

Uniweld Products, Inc. **12149**
2850 Ravenswood Rd.
Ft. Lauderdale, FL 33312-4920
(954) 584-2000; FAX (954) 334-2882
www.uniweld.com

Uniweld will premier its line of flame tools, gas control equipment, and accessories for gas welding, and cutting/brazing/soldering applications. Senior corporate managers will be on hand to answer questions.

US Hose Corp. **15218**
815 Forestwood Dr., Romeoville, IL 60446-1167
(800) 473-0474; FAX (815) 886-4550
www.ushosecorp.com

US Hose will offer a new high-pressure cylinder filling hose to improve the safety of gas transfer to cylinders. The inert fluoropolymer innercore is specially formulated for reliability and the unique braid reinforcement offers working pressure capability in excess of 5000 lb/in.^{2}.

Vanguard Machinery International LLC **12067**
14309 Sommermeyer St., Houston, TX 77041-6204
(713) 462-5800; FAX (713) 462-8222
www.vanguardmachinery.com

Vanguard Machinery's welding division offers a complete line of welding and fabricating equipment, including manipulators, positioners, turning rolls, plasma and oxyfuel cutting tables, ironworkers, press brakes, pipe intersection machines, and bandsaws.

Viking Blast and Wash Systems **5095**
3810 N. Toben St., Wichita, KS 67226-2903
(316) 634-6699; FAX (316) 634-6658
www.vikingcorporation.com

The company will feature its full line of blast cleaning equipment, from tumble belt blasters and table blasters to pass-through washers.

Vitronic Machine Vision **15211**
11900 Plantside Dr., Ste. G
Louisville KY 40299-6367
(502) 266-2699; FAX (502) 266-2695
www.vitronic.com

Vitronic Machine Vision will highlight its vision solutions developed for both standard and custom applications. The company will continuously demonstrate its VIRO weld joint inspection system for the objective verification of high-volume welding integrity.

Walker Magnetics **5305**
20 Rockdale St., Worcester, MA 01606-1922
(508) 853-3232; FAX (508) 852-8649
www.walkermagnet.com

Magnets and magnet systems for plate, tubing, and bundle handling, permanent, electro and electro-permanent magnets, and cutting table magnet systems will be featured.

Walter Surface Technologies **13251**
810 Day Hill Rd., Windsor, CT 06095-1790
(860) 298-1100; FAX (860) 298-1113
www.walter.com

Walter Surface Technologies will premier its capabilities to provide solutions ranging from surface conditioning, shaping, and preparation to surface finishing, cleaning, and protection with technologies that use abrasive systems, chemical cleaners, lubricants, and biotechnology solutions.

Washington Alloy Co. **10013**
7010 Reames Rd., Ste. G
Charlotte, NC 28216-2230
(888) 522-8296; FAX (704) 598-6672
www.weldingwire.com

Washington Alloy will feature its variety of filler metals and other welding accessories.

Watts Specialties, Inc. **12251**
800 Fife Way, Milton, WA 98354-8838
(253) 922-1414; FAX (253) 922-6808
www.watts-specialties.com

Watts Specialties will highlight the CL124 computerized pipe cutting machine, short pipe bevelers, and straight pipe cut-off machines.

Weartech International, Inc. **12233**
13032 Park St., Santa Fe Spgs, CA 90670-4006
(562) 698-7847; FAX (562) 945-7847
www.weartech.net

Weartech will display its complete line of cobalt- and nickel-based hardfacing rods and electrodes of different alloys, and cobalt-based GMAW wires, as well as PTA and 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 at the booth.

Weil Engineering North America LLC **8174**
1180 E. Big Beaver Rd., Troy, MI 48083-1907
(248) 743-1200; FAX (248) 743-1201
www.weilengineering.com

Weil Engineering will offer complete laser welding systems for tubing in the automotive industry, heavy-duty trucking industry, and general industries. The company will also feture its roll-forming and tube cutting machines.

Weiler Corp. **15048**
1 Weiler Dr., Cresco, PA 18326-9804
(570) 595-7495; FAX (570) 595-2002
www.weilercorp.com

Weiler will exhibit its power brushes and abrasives for the welding industry, including a wide selection of wheel, cup, end and tube brushes in addition to the popular Roughneck® weld cleaning products.

Weiss North America **11131**
3860 Ben Hur Ave., Bldg. 3
Willoughby, OH 44094-6370
(440) 269-8031; FAX (440) 269-8036
www.weissna.com

Weiss will launch a new line of rotary positioners capable of carrying loads of up to 50 tons.

Weld-Aid Products **11162**
14650 Dequindre St., Detroit, MI 48212-1504
(313) 883-6977; FAX (313) 883-4930
www.weldaid.com

Weld-Aid will show its line of antispatter products.

Weld Engineering Co., Inc. **15038**
34 Fruit St., Shrewsbury, MA 01545-3200
(508) 842-2224; FAX (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, the company's advanced pressure feed and recovery systems and flux rebake and holding ovens will be exhibited. Live demonstrations of flux recovery will be taking place continuously.

Weldas Co. **12199**
128 Seaboard Ln., Franklin, TN 37067-8219
(800) 524-0162; FAX (615) 377-3635
www.weldas.com

Weldas will exhibit its premium quality leather gloves and clothing, flame-retardant clothing, and accessories.

Weldcoa **12140**
335 E. Sullivan Rd., Aurora, IL 60505-9762
(630) 806-2000; (630) 806-2001
www.weldcoa.com

Weldcoa will premier its gas cylinder handling and filling equipment, much of it patented and developed through close association with customers.

Weldcraft **13085**
2741 N. Roemer Rd., Appleton, WI 54911-8629
(800) 752-7620; FAX (920) 882-6840
www.weldcraft.com

Weldcraft will exhibit its broad line of GTAW torches and accessories, including the Crafter Series, Legacy Series, MicroTig, Quick Connect System, and WP Series.

Weld-Ed National Center **12198**
1005 N. Abbe Rd., Elyria, OH 44035-1613
(440) 366-7027; FAX (440) 366-4624
www.weld-ed.org

The mission of the National Center for Welding Education and Training is to improve the quality and availability of welding technicians in the

U.S. To accomplish the mission the Center's staff and partners work collaboratively on the development of new and improved curricula as well as providing continuing education opportunities for welding instructors.

Welding Alloys USA, Inc. 10078
8535 Dixie Hwy., Florence, KY 41042-3298
(859) 525-0165; FAX (859) 525-9094
www.welding-alloys.com

Welding Alloys will highlight its welding consumables and equipment, and the specialized services it provides in automated welding equipment, hardfacing and rebuilding of industrial parts, and the manufacture of composite wear plates.

Welding Equipment Manufacturers Committee (WEMCO) 10253
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. The committee also provides value-added information and services to end users, distributors, and manufacturers in the welding industry, as well as promotes coalitions between AWS and manufacturers of welding, cutting, and related welding-industry equipment. WEMCO also hosts one of the welding industry's most effective and valuable annual events, which is filled with unparalleled networking opportunities for you and your organization.

Welding Expert 12194
PO Box 178930, San Diego, CA 92117-1042
(858) 483-9451; FAX (858) 483-4740
www.weldingexpert.net

The company will feature its Welding Expert, a bench-top tool that provides a solution for weld bead measurement. Welding Expert provides digital images, measurements and report generation while eliminating the need for separate microscope, illumination source, camera, and software.

Welding Technology Corp. 12115
150 E. Saint Charles Rd.
Carol Stream, IL 60188-2075
(630) 462-8250; FAX (630) 462-8259
www.weldtechcorp.com

Weldmetals India Pvt. Ltd 10029
36-B, Udyog Vihar- Phase-5
Gurgaon, Haryana, 122016, India
91-124-4003391; FAX 91-124-4003393
www.weldmetals.com

Weldmetals will feature its resistance welding electrodes in copper chromium zirconium (RWMA CLASS 2), cobalt beryllium copper (RWMA CLASS 3), cobalt copper with beryllium (RWMA CLASS 4), brass, tungsten copper, molybdenum, and pure tungsten for spot, projection, seam, and groove welding applications.

Weldmotion LLC 15134
N1091 Midway Rd., Hortonville, WI 54944-9661
(920) 716-9241; FAX (920) 748-3518

Weldsale Co. LLC 12101
2151 Dreer St., Philadelphia, PA 19125-1918
(215) 739-7474; FAX (215) 426-1260
www.weldsale.com

Weldsale will highlight its platens, stands, and tooling.

Weldship Corp. 15150
225 W. 2nd St., Unit 1
Bethlehem, PA 18015-1274
(610) 861-7330 ; FAX (610) 861-5175
www.weldship.com

Weldship and Texas Trailer will feature supply tube trailers, gas and liquid ISO containers, ground storage assemblies, and CO_2 transports to industrial gas manufacturers, independent distributors, and specialty chemical producers.

Wendt USA LLC 12105
3730 California Rd., Orchard Park, NY 14127-1747
(866) 335-3527; FAX (866) 336-3527
www.wendtusa.com

Wendt will exhibit its abrasive products for metalworking, finishing and polishing applications, including flap wheels, flap discs, and flap rolls in abrasive, nonwoven, and felt polishing versions.

WESCAN Systems LTD-Linatrol Profile Cutting Div. 13128
777 Walkers Line
Burlington, ON L7N 2G1, Canada
(905) 333-6000; FAX (905) 333-6005
www.linatrol.com

Wescan will promote its Linatrol family of industrial CNC controls specifically designed for profile and shape cutting to optimize oxyfuel and plasma cutting, waterjet, router, foam, and other profile cutting applications. The new Infinity CNC and digital Warp Drive servo system will be the company's special feature.

West Cryogenics, Inc. 14181
17301 E. Fm 1097 Rd., Willis, TX 77378-3959
(936) 856-6549; FAX (936) 856-0432
www.westcryogenics.com

Western Enterprises 14149
875 Bassett Rd., Westlake, OH 44145-1142
(800) 783-7890; FAX (440) 835-8283
www.westernenterprises.com

Western will feature its products for the control, storage, and transmission of high-pressure gases to the industrial, medical, specialty, and helium gas markets.

Williams Metals and Welding Alloys, Inc. 13136
125 Strafford Ave., Ste. 108, Wayne, PA 19087-3335
(610) 225-0105 FAX (610) 225-0208
www.wmwa.net

Williams Metals & Welding Alloys will feature its full line of welding consumables and nonferrous metal products.The company will have customer service reps from its Ohio, Alabama, North Carolina, and Texas locations available to discuss productivity and cost advantages.

Wire Crafters, Inc. 13196
6208 Strawberry Ln., Louisville, KY 40214-2900
(800) 626-1816; FAX (502) 361-3857
www.wirecrafters.com

Wire Crafters, a leading supplier of physical barriers to the manufacturing and process industries, will display the latest in machine perimeter guarding systems, including its 840 and new RapidWire systems.

Wisconsin Wire Works, Inc. 10035
PO Box 385, 319 Universal St.
Wales, WI 53183-0385
(262) 968-6982; FAX (262) 968-6985
www.wisconsinwireworks.com

Wisconsin Wire Works will highlight its copper and bronze wires for the welding and thermal spraying industries, including deoxidized copper, silicon bronze, phosphor bronze, low fuming bronze, nickel-aluminum bronze, manganese-nickel aluminum bronze, and aluminum bronze.

Wolf Robotics **12043**
4600 Innovation Dr., Fort Collins, CO 80525-3437
(970) 225-7600; FAX (970) 225-7700
www.wolfrobotics.com

Wolf Robotics will exhibit a custom-engineered welding system featuring its new SkyHookLift 5000-kg positioner. Also, RobotStudio offline programming and simulation software will be demonstrated.

Worldwide Labor Support of IL, Inc. **14173**
PO Box 2067, Pascagoula, MS 39569-2067
(800) 748-1395; FAX (228) 762-3428
www.worldwidelabor.com

Worldwide Labor Support will promote its services as a contract labor company that provides skilled craftsmen nationwide to industrial and marine companies. Its services include employee screening, certification, printing and delivery of payroll, W-2 distribution, payroll taxes, providing workers' compensation and liability coverages, and handling all workers' compensation and unemployment claims.

Xycorp, Inc. **14208**
1258 Montalvo Way, Palm Springs, CA 92262-5441
(760) 323-0333; FAX (760) 323-2229
www.xcsplasma.com

York Portable Machine Tools **14013**
1641 17th Ave.,Campbell River
BC V9W 4L5, Canada
(250) 287-7716; FAX (250) 287-8362
www.yorkmachine.com

The company will feature its portable, powerful, easy to use, York bore welding machines and boring bars designed for on-site or in-shop repairs to worn pin and bearing fits.

Zhejiang Yuguang Aluminum Material Co. Ltd. **11223**
22 Hehua Rd., Economic Development Zone,
Wuyi Zhejiang 321200, China
86 579-792-1164; FAX 86 579-792-1166
www.zjyuguang.com

Zhejiang Yuguang Aluminum will promote its manufacturing services and on-time delivery.

Zhengzhou Anxin Abrasives Co. **12135**
No. 68 Kexuedadao, Zhengzhou 450002, China
86 371-6375-1616; FAX 86 371-6782-6977

Whether your requirements are for portable machine tools for industry such as our heavy-duty PIPEMaster™ pipeline equipment, our BEVELMaster™ ID mounted beveling machines, our 600 Series OD mounted portable lathes, to our 300 and 500 Series tools for severing and end-prep for high-purity welding, TRI TOOL has a solution for you. Call today to find out how our quality, dependable machinery can save you time and money with in-place machining.

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Unit C F1 14th Yuanzheng Plaza
No. 106 Chengdong Rd., Zhengzhou 450004, China
86 371-663-11492; FAX 86 371-663-64729
www.zzstc.com.cn

Zibo TAA Welding Co. Ltd. 14220
No. 2 Mengshui, Industrial Development Zone
Zibo Shandong 255318, China
86 533-688-0559; FAX 86 533-6889-358
www.taa.net.cn

Zibo TAA will exhibit its welding wire for the GMAW, SAW, and FCAW processes, including stainless steel welding.

ZJ Industries, Inc. 13204
125 W. Factory Rd., Addison, IL 60101-5103
(630) 543-6655; FAX (630) 543-6644
www.zjindustriesinc.com

ZJ Industries will feature its resistance welding products, including welding electrodes, tips, adapters, holders, shunts, cables, welding machine arms, seam welding wheels, resistance welding controls, tip dressers, copper alloys, and accessories.

ZRID Pty. Ltd. 14105
Unit 1, 77 Motivation Dr.
Wangara WA 6065, Australia
61-89-302-2120; FAX 61-89-302-2120
www.zrid.com.au

ZRID will introduce its unique safety device for welders that provides 0 volts between earth and electrode when not welding, has automatic cut-off when arc is broken, gives the operator full control of arc initiation with no false starts, and can be used on all arc welding equipment.

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

Int'l Congress of Sheet Metal Presswork Associations (ICOSPA 2008). Sept. 14–17, Grand Rapids, Mich. Contact Precision Metalforming Assn., (216) 901-8800, or visit *www.icospa.com.*

4th Annual MarineLog Global Greenship Conf. and Expo. Sept. 16, 17, Washington Marriott Hotel, Washington, D.C. Visit *www.marinelog.com.*

♦Welding in Aircraft and Aerospace Conf. Sept. 16, 17, The Broadview, Wichita, Kan. Contact American Welding Society (800/305) 443-9353, ext. 455; visit *www.aws.org/conferences.*

Friction Stir Technologies and Applications for Defense Applications Workshop. Sept. 17, 18. Living/Learning Center, University of Pittsburgh at Johnstown, Pa. Organized jointly by Navy Metalworking Center and Navy Joining Center. Visit *www.nmc.ctc.com/index.cfm?fuseaction=eventinfo&eventid=50.*

Weld Expo — Canadian Mfg. Week — Metal Finishing Expo. Sept. 23–25. Int'l Centre, Toronto, Canada. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org.*

Guangzhou Int'l Trade Fair for Moldmaking and Tooling, Design, and Application Development. Sept. 24–26, Guangzhou Int'l Convention & Exhibition Center, Guangzhou, China. Visit *www.asiamold-china.com.*

Tooling for Composites. Sept. 29–Oct. 1. Doubletree Hotel, Seattle, Wash. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org.*

Making Lean Work for the Job Shop and Small Manufacturer. Oct. 1, 2. Doubletree Hotel, Oak Brook, Ill. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/leanjobshop.*

♦FABTECH International & AWS Welding Show. Oct. 6–8, Las Vegas Convention Center, Las Vegas, Nev. 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. 455; *www.aws.org.*

♦New Technologies in Thermal Cutting. Oct. 6, Las Vegas Convention Center, Las Vegas, Nev. In conjunction with the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; *www.aws.org.*

♦New Nondestructive Testing Technologies Conf. Oct. 7, Las Vegas Convention Center, Las Vegas, Nev. In conjunction with the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; *www.aws.org.*

♦Friction Stir Welding Conf. Oct. 8, Las Vegas Convention Center, Las Vegas, Nev. In conjunction with the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; *www.aws.org.*

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For Info go to www.aws.org/ad-index

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ISR ’08, 39th Int’l Symposium on Robotics. Oct. 15–17, COEX Convention Center, Seoul, Korea. Visit *www.isr08.org.*

2nd Int’l Railroad Symposium and Trade Exposition. Oct. 15–17, Haydarpasa Train Station, Istanbul, Turkey. Visit *www.irsturkey.org.*

ICALEO® 2008, 27th Int’l Congress on Applications of Lasers & Electro-Optics. Oct. 20–23. Pechanga Resort & Casino, Temecula, Calif. Contact Laser Institute of America, (800) 345-2737, (407) 380-1553, *www.icaleo.org.*

Lean to Green Manufacturing. Oct. 27–29. Doubletree Hotel & Executive Meeting Center, Portland, Ore. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/leantogreen.*

CNC Machining Clinic. Nov. 4–6. Doubletree Hotel, Oak Brook, Ill. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org.*

5th METALFORM Mexico Expo. Nov. 11–13. Centro Banamex, Mexico City, Mexico. Sponsored by Precision Metalforming Assn. Visit *www.metalform.com/mexico.*

♦**Welding of Engineering Plastics and Composites Conf.** Nov. 11, 12. Contact American Welding Society, (800/305) 443-9353, ext. 455; *www.aws.org/conferences.*

8th Int’l Symposium of the Japan Welding Society. Nov. 16–18, Kyoto, Japan. Visit *www.nta-aps.jp/8WS/.*

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Aerospace Measurement, Inspection & Analysis Conf. Nov. 18, 19. Ft. Worth Convention Center, Ft. Worth, Tex. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/aerotest.*

PACE 2009, The Power of Paint & Coatings. Feb. 15–18, 2009. New Orleans Convention Center, New Orleans, La. Visit *www.pace2009.com.*

HOUSTEX, 2009. Feb. 24–26, 2009. George R. Brown Convention Center, Houston, Tex. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/houstex.*

♦**Joining Dissimilar Metals Conf.** March 3, 4, 2009. Orlando, Fla. Contact American Welding Society, (800/305) 443-9353, ext. 455; visit *www.aws.org.*

Lean for the Supply Chain. March 3–5, 2009. Crown Plaza Hotel, San Jose, Calif. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org.*

WESTEC. March 30–April 2, 2009. Los Angeles Convention Center, Los Angeles, Calif. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/westec.*

MicroManufacturing and NanoManufacturing Conf. & Exhibits. March 31–April 1, 2009. Sheraton Bloomington Hotel, Minneapolis, Minn. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/micro, www.sme.org/nano.*

♦**IBSC, 4th Int'l Brazing and Soldering Conf.** April 26–29, 2009, Hilton Hotel in the Walt Disney World Resort, Orlando, Fla. Cosponsored by AWS and ASM International. Contact American Welding Society, (800/305) 443-9353, ext. 229; visit *www.aws.org.*

JOM-15, 15th Int'l Conf. on the Joining of Materials, and **6th Int'l Conf. on Education in Welding.** May 3–6, 2009, Helsingør, Denmark. Contact JOM Institute, *jom_aws@post10.tele.dk.*

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

Advanced Manuf. Expo. and Plant Maintenance & Design Engineering Show. May 19–21, 2009. Place Bonaventure, Montreal, Que., Canada. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org.*

EASTEC. May 19–21, 2009. Eastern States Exposition Grounds, W. Springfield, Mass. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/eastec.*

♦**Weld Cracking Heat-Affected Zone Conf.** June 9, 10, 2009, Columbus, Ohio. Contact American Welding Society, (800/305) 443-9353, ext. 229; *www.aws.org.*

First Int'l Conf. on Welding Technologies. June 11–13, 2009. Gazi University, Ankara, Turkey. Visit *www.icwet09.org.*

Western Mfg. Technology Show. June 16–18, 2009. Northlands Park-AgriCom, Edmonton, Alb., Canada. Contact Society of Mfg. Engineers, (800) 733-4763, *www.sme.org/eastec.*

♦**Welding Corrosion-Resistant Alloys Conf.** Sept. 22, 23, 2009, New Orleans, La. Contact American Welding Society, (800/305) 443-9353, ext. 229; *www.aws.org.*

AWS Certification Schedule

Certification Seminars, Code Clinics and Examinations

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

Certified Welding Inspector (CWI)

Location	Seminar Dates	Exam Date
Miami, FL	Oct. 19-24	Oct. 25
New Orleans, LA	Oct. 19-24	Oct. 25
Tulsa, OK	Oct. 19-24	Oct. 25
Long Beach, CA	Oct. 26-31	Nov. 1
Newark, NJ	Oct. 26-31	Nov. 1
Portland, OR	Oct. 26-31	Nov. 1
Cleveland, OH	Nov. 2-7	Nov. 8
Atlanta, GA	Nov. 16-21	Nov. 22
Dallas, TX	Nov. 16-21	Nov. 22
Roanoke, VA	Nov. 16-21	Nov. 22
Corpus Christi, TX	EXAM ONLY	Nov. 22
Sacramento, CA	Nov. 30-Dec. 5	Dec. 6
Spokane, WA	Nov. 30-Dec. 5	Dec. 6
Syracuse, NY	Nov. 30-Dec. 5	Dec. 6
St. Louis, MO	EXAM ONLY	Dec. 6
Miami, FL	Dec. 7-12	Dec. 13
Reno, NV	Dec. 7-12	Dec. 13
Fresno, CA	Jan. 11-16, 2009	Jan. 17, 2009
Beaumont, TX	Jan. 11-16	Jan. 17
Miami, FL	Jan. 25-30	Jan. 31
Albuquerque, NM	Jan. 25-30	Jan. 31
Pittsburgh, PA	Feb. 1-6	Feb. 7
Denver, CO	Feb. 1-6	Feb. 7
Seattle, WA	Feb. 1-6	Feb. 7
Milwaukee, WI	Mar. 1-6	Mar. 7
Indianapolis, IN	Mar. 1-6	Mar. 7
Atlanta, GA	Mar. 1-6	Mar. 7
Houston, TX	Mar. 8-13	Mar. 14
San Diego, CA	Mar. 8-13	Mar. 14
Norfolk, VA	Mar. 8-13	Mar. 14
Anchorage, AK	Mar. 22-27	Mar. 28
Portland, OR	Mar. 22-27	Mar. 28
Boston, MA	Mar. 22-27	Mar. 28
Phoenix, AZ	Mar. 22-27	Mar. 28
Miami, FL	Mar. 29-Apr. 3	Apr. 4
Chicago, IL	Mar. 29-Apr. 3	Apr. 4
Dallas, TX	Apr. 19-24	Apr. 25
Springfield, MO	Apr. 19-24	Apr. 25
Baton Rouge, LA	Apr. 19-24	Apr. 25
San Francisco, CA	Apr. 26-May 1	May 2
Portland, ME	Apr. 26-May 1	May 2
Las Vegas, NV	Apr. 26-May 1	May 2
Nashville, TN	May 10-15	May 16
Jacksonville, FL	May 10-15	May 16
Baltimore, MD	May 10-15	May 16
Detroit, MI	May 31-Jun. 5	Jun. 6
Miami, FL	May 31-Jun. 5	Jun. 6
Albuquerque, NM	May 31-Jun. 5	Jun. 6
Spokane, WA	Jun. 7-12	Jun. 13
Oklahoma City, OK	Jun. 7-12	Jun. 13
Birmingham, AL	Jun. 7-12	Jun. 13
Hartford, CT	Jun. 14-19	Jun. 20
Pittsburgh, PA	Jun. 14-19	Jun. 20
Beaumont, TX	Jun. 14-19	Jun. 20

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
Dallas, TX	Oct. 20-25	NO EXAM
Miami, FL	Dec. 1-6	NO EXAM
New Orleans, LA	Jan. 12-17, 2009	NO EXAM
Denver, CO	Feb. 23-28	NO EXAM
Dallas, TX	Mar. 30-Apr. 4	NO EXAM
Sacramento, CA	May 4-9	NO EXAM
Pittsburgh, PA	Jun. 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
Tulsa, OK	Oct. 20-24	Oct. 25
Atlanta, GA	Nov. 17-21	Nov. 22
Long Beach, CA	Dec. 8-12	Dec. 13
Atlanta, GA	Jan. 26-30, 2009	Jan. 31
Houston, TX.	Mar. 2-6	Mar. 7
Baton Rouge, LA	Apr. 20-24	Apr. 25
Columbus, OH	Jun. 1-5	Jun. 6

CWS exams are also given at all CWI exam sites.

Certified Radiographic Interpreter (CRI)

Location	Seminar Dates	Exam Date
Philadelphia, PA	Oct. 20-24	Oct. 25
Seattle, WA	Nov. 17-21	Nov. 22
Jacksonville, FL	Dec. 8-12	Dec. 13
Long Beach, CA	Feb. 2-6, 2009	Feb. 7
Miami, FL	Mar. 9-13	Mar. 14
Indianapolis, IN	Apr. 20-24	Apr. 25
Miami, FL	Jun. 22-26	Jun. 27

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.

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.

International CWI Courses and Exams

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

American Welding Society®

Know the Welding and Joining Processes

The stated 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." If you've ever wondered how many processes that covers, the following figure shows all of the welding and joining processes and gives the official AWS letter designations for them. The allied processes will be featured in next month's Welding Workbook.

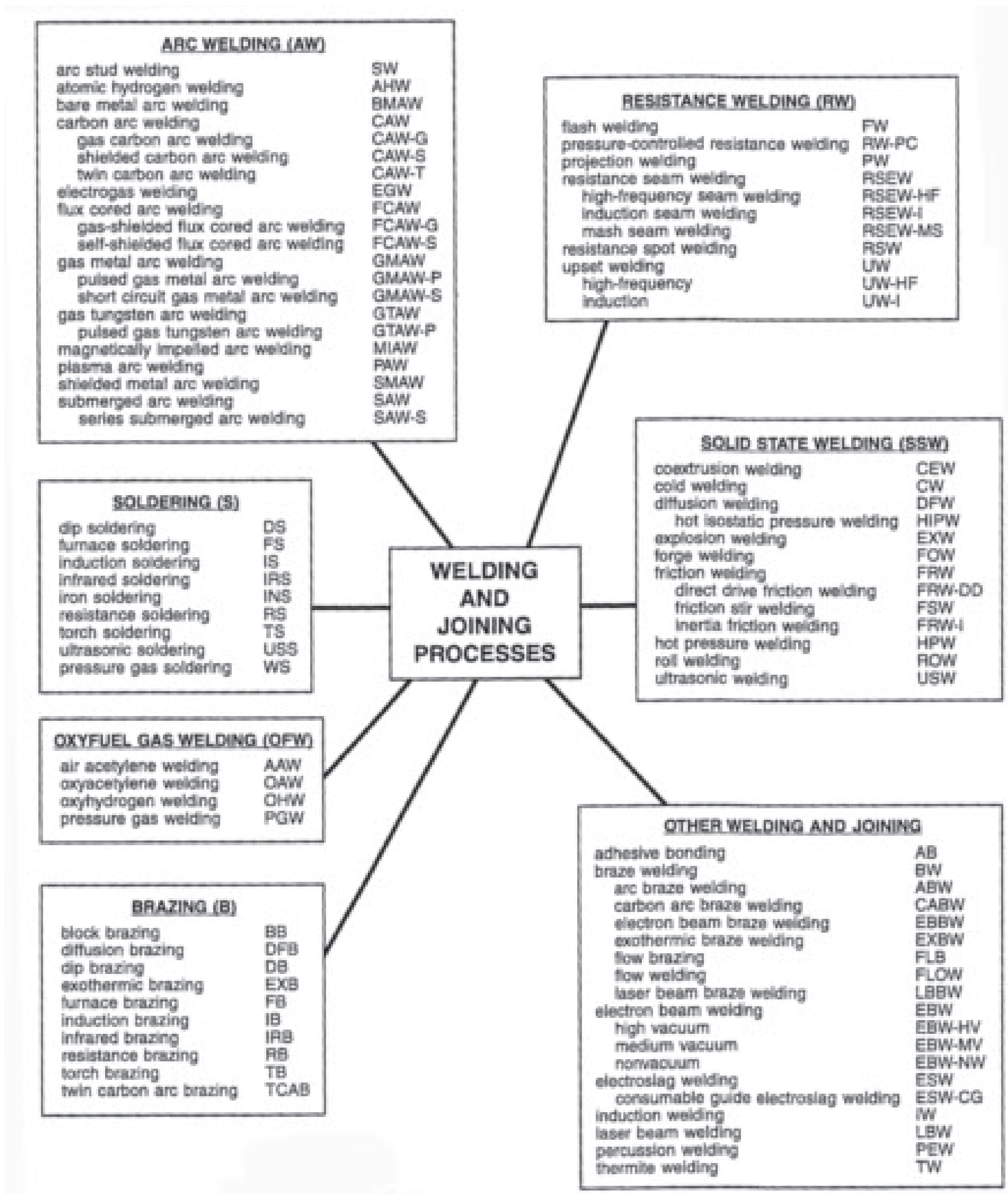

Fig. 1 — Master chart of welding and joining processes.

Excerpted from AWS A3.0:2001, *Standard Welding Terms and Definitions*.

SOCIETY NEWS

BY HOWARD M. WOODWARD

It's Welding Show Time in Las Vegas

A rooftop view looking down on Las Vegas Boulevard, a.k.a. The Strip, a.k.a. Glitter Gulch. Photo courtesy of the Las Vegas News Bureau.

You'll discover a lot of wonderful things to see and do in Las Vegas while you are not busy attending the FABTECH International & AWS Welding Show Oct. 6–8. The area's colorful history and unique attractions make spending an extra day or two for a mini vacation a good idea.

Las Vegas (The Meadows in Spanish) was discovered in 1829 by a Mexican scout who stumbled upon the oasis-like valley in the middle of the Mojave Desert. The abundant artesian spring water shortened the Spanish Trail to Los Angeles, and hastened the rush west for California gold. In 1844, John C. Fremont, leading an expedition, camped at the site. Today, the main downtown thoroughfare, **Fremont St.,** bears his name, as does the **Fremont Hotel & Casino**.

In 1904, the tent town called Las Vegas sprouted saloons, stores, and boarding houses as work began on the first railroad grade into the area. The San Pedro, Los Angeles, and Salt Lake Railroad, later absorbed by its parent, Union Pacific, made its inaugural run from California to points east on Jan. 20, 1905. The city of Las Vegas was officially founded four months later on May 15.

Today, the **Plaza Hotel,** located at Main and Fremont Streets, stands on the site of the original Union Pacific Railroad depot. Freight and passenger trains still use the depot site at the hotel as a terminal — the only railroad station in the world located inside a hotel-casino.

The **Las Vegas Convention Center,** where the welding show will be held, is a 1.6-million-sq-ft facility with 1.3-million sq ft of exhibit space. Supported mainly by room tax revenues, it is one of the larger exhibition facilities in the world.

Among Vegas's myriad entertainment offerings, first-time visitors must see the **Bellagio Fountains** waltz and strut to music. The free shows, barring high winds, are scheduled frequently day and evening.

Take one of the numerous, reasonably priced bus and air tours with hotel pickup to **Hoover Dam, Grand Canyon, Las Vegas Strip, Lake Meade, Colorado River, Bryce Canyon, Zion National Park, Death Valley,** and many other locations.

The top show picks currently include ***Blue Man Group*** playing at the Venetian. It's a multimedia, audience-involved, sensory experience that is described as a mix of art, music, thought, sight, touch, words, and sounds led by three blue men.

Technology is the star of ***KÀ Cirque du Soleil*** where a floating stage appears and disappears, becoming at different times a mountain, a beach, a palace, a battleground, or a wheel of death, with a delightful cast of puppets (actually humans in suits that turn them into crabs, turtles, snakes, and other creatures).

Phantom, playing at Venetian, is a 95-minute spectacular restaging of *The Phantom of the Opera* musical production.

Jersey Boys playing at Palazzo is the story of Frankie Valli and the Four Seasons.

The ***Stomp Out Loud*** production unfolds inside a $28-million environment specifically built for this show.

Mamma Mia!, playing at Mandalay Bay, has become a musical sensation around the world. This production incorporates songs from the hit pop group, Abba, into a delightful story.

Visit *www.lasvegas.com* for complete listings of hotels, shows, tours, headliners, and comedy shows. Review the descriptions then make your reservations or buy tickets online, or call (877) 847-4858.

Enjoy your visit to Las Vegas and the 2008 FABTECH International & AWS Welding Show. ♦

Tech Topics

Errata D1.3/D1.3M:2008
Structural Welding Code — Sheet Steel

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

Page 25. Subclause 4.6.1.1. Incorrect reference. Correct reference from "3.2" to "Clause 3".

Page 26. Subclause 4.6.2.1. Incorrect reference. Correct reference from "3.3" to "Clause 3".

Page 26. Subclause 4.6.3.1. Incorrect reference. Correct reference from "3.4" to "Clause 3".

Standards Approved by ANSI

The following revised standards were approved by ANSI on the dates shown.

D1.1/D1.1M:2008, *Structural Welding Code — Steel.* Approved 7/02/08.

D1.2/D1.2M:2008, *Structural Welding Code — Aluminum.* Approved 6/23/08.

D8.14M:2008, *Specification for Automotive Weld Quality — Arc Welding of Aluminum*. Approved 6/23/08.

Standards for Public Review

AWS was approved as an accredited standards-preparing organization by the American National Standards Institute (ANSI) in 1979. AWS rules, as approved by ANSI, require that all standards be open to public review for comment during the approval process. The following revised and new standards are submitted for public review; the review expiration date is shown. Draft copies may be obtained from R. O'Neill *roneill@aws.org;* (800/305) 443-9353, ext. 451.

D1.8/D1.8M:200X, *Structural Welding Code — Seismic Supplement.* Revised — $56.50. 8/11/08.

D14.8M:200X (ISO 17844:2004 IDT), *Welding — Comparison of Standardized Methods for the Avoidance of Cold Cracks.* New — $25.00. 9/01/08.

D17.3/D17.3M:200X, *Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Hardware.* New — $29.50. 8/25/08.

ISO Standards for Public Review

Copies of the following draft International Standard 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. Any comments regarding ISO documents should be sent to your national standards body. In the United States, if you wish to participate in the development of International Standards for welding, contact A. Davis *adavis@aws.org;* (800/305) 443-9353, ext. 466.

ISO/DIS 14343, *Welding consumables — Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat-resisting steels — Classification.*

New Standards Projects

Development work has begun on the following two revised standards. Directly and materially affected individuals are invited to contribute to their development. Participation on all AWS Technical Committees and Subcommittees is open to all persons. Those wanting to participate should contact the AWS Staff Engineer listed with the document.

C7.3M/C7.3:200X, *Process Specification for Electron Beam Welding.* This specification discusses applicable specifications, safety, requirements, fabrication, quality examination, equipment calibration and maintenance, approval of work, and delivery of work. It addresses processing and quality control requirements for electron beam welding with both high- and low-voltage welding equipment in high- and medium-vacuum variations. Stakeholders: ANSI, AWS, manufacturers using electron beam welding, welding engineers, machine operators, general public (confidence in soundness of electron beam welds). Reino Starks, ext. 304.

D1.3/D1.3M:200X, *Structural Welding Code — Sheet Steel.* This code contains the requirements for arc welding of structural sheet/strip steels, including cold formed members, hereafter collectively referred to as "sheet steel," which are equal to or less than 3⁄16 in. (0.188 in./4.8 mm) in nominal thickness. When this code is stipulated in contract documents, conformance with all its provisions shall be required, except for those provisions that the Engineer or contract documents specifically modifies or exempts. Stakeholders: Manufacturers, welders, engineers, fabricators, designers. Selvis Morales, ext. 313.

Technical Committee Meetings

All AWS technical committee meetings are open to the public. Persons wishing to attend a meeting should dial (305) 443-9353 and the extention of the staff secretary of the committee listed below.

Sept. 11, D8 Committee on Automotive Welding. Detroit, Mich. Contact A. Alonso, ext. 299.

Sept. 16–19, D1 Committee on Structural Welding. Milwaukee, Wis. Call S. Morales, ext. 313.

Sept. 26, C1 Committee on Resistance Welding. Ontario, Canada. Call A. Alonso, ext. 299.

Sept. 23–25, B2 Committee on Procedure and Performance Qualifications. Pittsburgh, Pa. Call S. Morales, ext. 313.

Sept. 24, SH4 Subcommittee on Labeling and Safe Practices. Pittsburgh, Pa. Call S. Hedrick, ext. 305.

Oct. 6, A5K Subcommittee on Titanium and Zirconium Filler Metals. Las Vegas, Nev. Call S. Borrero, ext. 334.

Oct. 6, G2D Subcommittee on Reactive Alloys. Las Vegas, Nev. Call S. Borrero, ext. 334.

Oct. 7, D9 Committee on the Welding, Brazing, and Soldering of Sheet Metal. Las Vegas, Nev. Call A. Alonso, ext. 299.

Oct. 7, 8, C3 Committee on Brazing and Soldering and Subcommittees. Las Vegas, Nev. Call S. Borrero, ext. 334.

Oct. 8, A5H Subcommittee on Filler Metals and Fluxes for Brazing. Las Vegas, Nev. Call S. Borrero, ext. 334.

Oct. 15, SH1 Subcommittee on Fumes and Gases. Columbus, Ohio. Call S. Hedrick, ext. 305.

Oct. 20–22, 2008, A2 Committee on Definitions and Symbols. Wheeling, W.Va. Call A. Alonso, ext. 299.

Technical Committees Help Wanted

J1: Resistance Welding

Share your technical 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 resistance welding consumables, components, and machinery. Contact Annette Alonso, (800) 443-9353, ext. 299; *aalonso@aws.org*.

C5: Arc Welding

The C5 Committee on Arc Welding and Cutting seeks volunteers to assist in the preparation of its recommended practices. Much of the content of the *Welding Handbook* chapter on arc welding and cutting processes is taken from these documents. Contact John Gayler, (800) 443-9353, ext. 472; *gayler@aws.org.*

D1I : Reinforcing Bars

Volunteers are sought to serve on the D1I Subcommittee on Reinforcing Bars. Members are currently revising D1.4, *Structural Welding Code — Reinforcing Steel.* To learn more about how you can contribute to this committee's work, contact Selvis Morales, (800) 443-9353, ext. 313; *smorales@aws.org.*

A2 Committees Keep Busy in Ohio

The A2 Committee on Definitions and Symbols met May 5–7 at the GE Learning Centre in Cincinnati, Ohio. The A2B Subcommittee on Definitions wrapped up its work on the next edition of AWS A3.0, *Standard Welding Terms and Definitions.* The A2C Subcommittee on Symbols, having just published A2.4:2007, *Standard Symbols for Welding, Brazing, and Nondestructive Examination,* as well as the A2.1:2007, *AWS Welding Symbol Chart,* began work on the next revisions. **Brian Galliers** from GE Aviation hosted the meeting and **Bill Brundege** from BAE Systems in Fairfield, Ohio, led the members on a tour of the welding facility.

The next A2 meeting is scheduled for Oct. 20–22, 2008, in Wheeling, W.Va. For more information on the A2 Committee on Definitions and Symbols, contact **Annette Alonso,** A2 secretary, (800/305) 443-9353, ext. 299; *aalonso@aws.org.*

Shown during the A2 Committee BAE tour are (from left) Richard Holdren, A2B chair; J. P. Christein, A2 vice chair and A2C chair; Christopher Lander, an applicant; Annette Alonso, A2 Committee secretary; Brian Galliers; Pat Newhouse; David Beneteau; Chuck Ford; Jesse Grantham; and Larry Barley.

Foundation Updates its 2008 Silent Auction

The AWS Foundation requests donations of national company gift cards for the Silent Auction to be held in Las Vegas during the FABTECH International & AWS Welding Show, Oct. 6–8. Gift cards of $200 to $250 may be purchased then donated, or you may send a check to the Foundation to purchase cards from Omaha Steaks, Tony Roma's, Bass Pro Shops, JC Penney, Home Depot, Macy's, etc. With the holidays coming right after the Show, gift cards will be a great way to buy some gifts early. All funds raised will go to scholarships.

To donate a gift card, contact Nazdhia *nprado-pulido@aws.org;* (800) 443-9353, ext. 250.

The first donators include

AWS Cincinnati Section
AWS Mobile Section
AWS Rochester Section
AWS Tulsa Section
AWS Twin Tier Section
Nancy and Barry Carlson
Ray and Sandy Shook
WESCO Gas & Welding Supply, Inc.
Howard Woodward

Foundation Raffle Winner Visits HQ

Just back from "paradise," a sun-tanned Nancy Carlson (second from left) visited AWS headquarters after enjoying the seven-day Caribbean cruise she won in the 2007 AWS Foundation auction. Shown are (from left) Ray Shook, AWS executive director; Carlson; Nazdhia Prado-Pulido, coordinator; Vicki Pinsky, manager; and Sam Gentry, AWS Foundation executive director. Carlson is secretary of the Idaho/Montana Section, and a past District 20 director.

Attend the Qualification Committee Meeting at the Show

The Personnel and Facilities Qualification Committee (PFQC) invites you to attend its next meeting to be held Oct. 8, 2008, 8 A.M. to noon in Rm. S216 at the Las Vegas Convention Center during the FABTECH International & AWS Welding Show. This committee is responsible for creating qualification standards that form the basis for many of AWS's certification programs including the welding inspector, test facilities, welding fabricator, welding educator, and welding supervisor. This committee is actively recruiting new members to work on future revisions to these qualification standards. The PFQC produces all of the AWS B5.X standards such as AWS B5.1 (Welding Inspector). Other PFQC documents published or currently being drafted are radiographic interpreter, welding technician, welding engineer, welding inspector specialist, underwater inspectors, and sales representative. Anyone directly or indirectly affected by the content of these AWS qualification standards are welcome to attend this meeting, and if further interested, urged to apply for membership on the committee or one of its subcommittees.

Life Members Offered Free Registration for Technical Sessions at the Show

AWS Life Members are urged to take advantage of their free registration to the entire Professional Program (a $325 value) plus free admission to the FABTECH International & AWS Welding Show, scheduled for Oct. 6–8, 2008, at Las Vegas Convention and Visitors Authority, Las Vegas, Nev. The free registration allows AWS Life Members to attend any of the technical sessions presented 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. You may also request the form from the Membership Dept. at (800) 443-9353, ext. 260. To obtain your free registration, mark "AWS Life Member: Free Registration" at the top of the Registration Form. Then FAX both sides of the form to (305) 443-7559, Attn: R. Lara, accounting director; or mail the form to Ruben Lara, AWS, 550 NW LeJeune Rd., Miami, FL 33126.

District Director and Student Member Awards Presented

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.

District 2 Director **Ken Stockton** has nominated **Alan Zibitt,** New York.

District 17 Director **J. Jones** has nominated **Carey Reeves,** Oklahoma City, and **Jim Goetz,** Ozark Section.

District 22 Director **Dale Flood** has nominated the following to receive this award for 2007–08:

Jason Roberts — Sacramento Valley
Mark Reese — Sacramento Valley
Randy Naylor — Sierra Nevada
Durella Combs — Santa Clara Valley
Brian Hardin — San Francisco

The **Houston Section,** District 18, has been awarded the Henry C. Neitzel National Membership Award for the greatest net numerical increase in membership for the year 2007–08.

The **Drake Well Section,** District 10, earned the Henry C. Neitzel National Membership Award for the greatest net percentage increase for 2007–08.

The following Sections in each District achieved the greatest percentage increase in membership for the year.

District	Section
1	Maine
2	Philadelphia
3	York-Central Pennsylvania
4	Southwest Virginia
5	North Florida
6	Twin Tiers
7	Johnstown-Altoona
8	Greater Huntsville
9	Pascagoula
10	Drake Well
11	Western Michigan
12	Upper Peninsula
13	Illinois Valley
14	Indiana
15	Arrowhead
16	Siouxland
17	Ozark
18	Cuautitlan Izcalli (Mexico)
19	Northern Alberta
20	Idaho/Montana
21	Arizona
22	Sacramento

Student Chapter Member Awards Presented at District Conferences

During the recent 2008 District conferences, Section representatives selected the following Student Members to receive AWS Student Chapter Member Awards.

Troy Wigfall, Central Piedmont Community College, Charlotte Section, District 4.

Jay Johnson, Central Piedmont Community College, Charlotte Section, District 4.

William Lamperez, Southeastern Louisiana University, Baton Rouge Section, District 9.

Duncan Perkins, Mississippi Gulf Coast Community College, Pascagoula Section, District 9.

Aaron Bailey, Montana Tech, Idaho/Montana Section, District 20.

Jameson Butler, Central New Mexico Community College, Albuquerque Section, District 20.

Brian Harden, Sierra College, Sacramento Section, District 22.

The AWS Board of Directors established the Student Chapter Member Award to recognize AWS Student Members whose Student Chapter activities have produced outstanding school, community, or industry achievements. This award also provides an opportunity for Student Chapter advisors, Section officers, and District directors to recognize outstanding students affiliated with AWS Student Chapters, as well as to enhance the image of welding within their communities.

To qualify for this certificate award, the individual must be an AWS Student Member affiliated with an AWS Student Chapter. The nomination form can be downloaded from *www.aws.org/sections/awards/student_chapter.pdf,* or call the Membership Dept. at (800) 443-9353, ext. 260.

Nominees Solicited for Prof. Masubuchi Award

November 3 is the deadline for submiting nominations for the 2009 Prof. Koichi Masubuchi Award. The award is presented each year to one person, 40 years old or younger, who has made significant contributions to the advancement of materials joining through research and development. The award, presented during the FABTECH International & AWS Welding Show, includes a $5000 honorarium. Send a résumé listing background, experience, publications, honors, awards, plus at least three letters of recommendation from researchers to Prof. John DuPont, *jnd@lehigh.edu.* The award is sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology.

Nominees Sought for Robotic Arc Welding Awards

December 31 is the deadline for submitting nominations for the 2009 Robotic and Automatic Arc Welding Award. The award, offering a plaque and a $1500 honorarium, is presented during the FABTECH International & AWS Welding Show to recognize achievements in the area of robotic arc welding. The nomination packet should include a summary of the candidate's accomplishments, experience, publications, and awards. Remit to Wendy Sue Reeve, 550 NW LeJeune Rd., Miami, FL 33126. Contact Reeve at *wreeve@aws.org;* (800/305) 443-9353, ext. 293. The award was established in 2004 by the AWS D16 Robotic and Automatic Arc Welding Committee, with the approval of the AWS board of directors.

SECTION NEWS

F. T. Siradakis (left), District 11 director, presents Roy Bailiff the District CWI of the Year Award at the Central Michigan Section event.

F. T. Siradakis (left), District 11 director, presents Bill Eggleston the District Educator Award at the Central Michigan Section program.

Shown (from left) are Mobile Section Scholarship Chair Jerry Betts with students Matt Murphy, Kelly Wilson, and Eric Schoen.

The Quiz the Experts winners heft their hard-won trophy. Shown (from left) are Roy Bailiff, Jim Farmer, and Bill Eggleston, with contest chair Jeff Carney. The event was hosted by the Central Michigan Section in April.

District 9

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

MOBILE

May 8

Activity: The Section members met for their last meeting before summer break. The events included recognition of past chairmen, and presentation of scholarships and other awards. **Jerry Betts,** scholarship chairman, presented scholarships to **Matt Murphy, Kelly Wilson,** and **Eric Schoen.** The meeting was held at Saucy Q Restaurant in Mobile, Ala., for 30 attendees.

District 11

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

CENTRAL MICHIGAN

April 14

Activity: **Jeff Carney,** advisor to the Ferris State Student Chapter, hosted the annual Quiz the Experts competition featuring attendees from the Detroit, Saginaw Valley, Central Michigan, Western Michigan, and Toledo Sections, and the Ferris State University Student Chapter. The Central Michigan Section team, **Roy Bailiff, Jim Farmer,** and **Bill Eggleston,** took top honors. District 11 Director **F. T. Siradakis** presented the District Educator of the Year Award to Chairman **Bill Eggleston,** and the District Dalton E. Hamilton Memorial CWI of the Year Award to **Roy Bailiff.** The event was held at Tony M's Restaurant in Lansing, Mich.

DETROIT

June 14

Activity: The Section held its Spouses' Night and Past Chairmen's Night along with a brief executive board meeting at The Inn at St. Johns in Livonia, Mich. The past chairs in attendance included **Dave Beneteau, Chuck Padden, Marty Keasal,**

An historic gathering of 17 Detroit Section past chairmen. Shown are (from left) Dave Beneteau, Chuck Padden, Marty Keasal, Bernie Bastian, Amos Winsand, Bob Wilcox, Ray Roberts, Carl Hildebrand, Jim Gooda, Don DeCorte, Tom Sparschu, John McKenzie, Richard DuCharme, Fred Ellicott, Carl Occhailini, Jim Dolfi, and Jim Osborne.

AWS President Gene Lawson addressed the Kansas City Section in June.

Shown at the Western Michigan Section program are (from left) Chairman Matt Post; Ferris State students Nate Miller, Tim Mikel, and Rory O'Hern; speaker and District 11 Director F. T. Siradakis; and past Chairman Kevin Fleming.

Shown at the Nebraska Section and Linweld open house program are (from left) Pat Neuhalfen, Debbie Finn, Jeff Hagemann, and Sean McKown.

Shown at the Western Michigan Section program are (from left) District 11 Director F. T. Siradakis with award winners David Murray (District Educator), Phil Schiffer (District Meritorious), and Scot Reitenour (Section Meritoriuous).

Bernie Bastian, Amos Winsand, Bob Wilcox, Ray Roberts, Carl Hildebrand, Jim Gooda, Don DeCorte, Tom Sparschu, John McKenzie, Richard DuCharme, Fred Ellicott, Carl Occhailini, Jim Dolfi, and **Jim Osborne.**

WESTERN MICHIGAN

MARCH 19

Speaker: **F. T. Siradakis,** District 11 director

Affiliation: Airgas Great Lakes

Topic: The impact of today's students on the future of welding

Activity: Siradakis presented the District Meritorious Award to Treasurer **Phil Schiffer,** District Educator Award to **David Murray,** Section Distinguished Service Award to **Kevin Fleming,** and Section Meritorious Award to **Scot Reitenour.** The program was held at Ferris State University in Big Rapids, Mich.

District 12

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

MILWAUKEE

JULY 16

Activity: The Section held a general board meeting preceded by a tour of Miller Park Stadium. Hosted by Chairman **Jerry Blaski,** others in attendance included **Karen Gilgenbach,** vice chair; **Roger Edge,** certification chair; **John Kozenieki** and **Craig Wentzel,** scholarship chairs; **Bob Bruss,** secretary; and **Roger Warren,** a new board member.

District 13

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

CHICAGO

JUNE 18

Activity: The Chicago Section board members held a meeting at Bohemian Crystal Restaurant in Chicago, Ill. Attending were **Chuck Hubbard, Craig Tichelar, Cliff Iftimie, Vicky Landorf, Marty Vondra, Hank Sima,** and **Eric Krauss.**

Shown are the participants in the Manufacturing Academy sponsored in part by the Yankton Sr. High School Student Chapter and the Siouxland Section.

District 16

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

KANSAS CITY

JUNE 24
Speaker: **Gene Lawson,** AWS president
Affiliation: ESAB Welding & Cutting Products
Topic: AWS future and goals
Activity: The meeting was held at Kansas City Masterpiece Restaurant.

Shown at the Milwaukee Section's board meeting are (from left) Roger Edge, Chairman Jerry Blaski, John Kozenieki, Vice Chair Karen Gilgenbach, Craig Wentzel, Roger Warren, and Secretary Bob Bruss.

NEBRASKA

JUNE 19
Activity: The Section members participated in an open house event held at Linweld's new store in Council Bluffs, Iowa. **Jeff Hagemann,** store manager, hosted the activities. Factory representatives offered hands-on demonstrations of their products. Assisting were Linweld employees **Pat Neuhalfen, Debbie Finn, Jeff Hagemann,** and **Sean McKown.**

Yankton Sr. High School Student Chapter

JUNE 9–20
Activity: The Student Chapter and the Siouxland Section members participated in the second annual Manufacturing Academy held in Yankton, S.Dak. Sponsored by Mitchell Technical Institute and the Regional Technical Education Center, the students spent two weeks learning about manufacturing principles, touring local manufacturing facilities, and

Shown at the June meeting of the Chicago Section board members are (from left) Chuck Hubbard, Craig Tichelar, Cliff Iftimie, Vicky Landorf, Marty Vondra, Hank Sima, and Eric Krauss.

The Charter Members of the Chile Section are (from left to right; top to bottom) Jorge Esponda, Linton Carvajal, Luis Gonzalez, Erwin Manriquez, José Luis Núñez, Juan Donoso, Robert Keller, José Marin, Mauricio Parraguez, Antonio Segura, Vice Chair Jorge Parada Ahumada, Chairman Mauricio Ibarra Echeverria, and Treasurer José Lecea Caro.

Her winning ticket at the AWS Foundation's raffle won Idaho/Montana Secretary Nancy Carlson a week-long Caribbean cruise.

District Directors Contact Information

Dist. 1 — **Russ L. Norris**
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russ.norris@airgas.com

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kenneth.stockton@pseg.com

Dist. 3 — **Alan J. Badeaux Sr.**
(301) 753-1759
abadeaux@ccboe.com

Dist. 4 — **Roy C. Lanier**
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rlanier@email.pittcc.edu

Dist. 5 — **Steve Mattson**
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stevemattson@bellsouth.net

Dist. 6 — **Neal A. Chapman**
(315) 349-6960
weldingengineer@inbox.com

Dist. 7 — **Don C. Howard**
(814) 269-2895
howard@ctc.com

Dist. 8 — **Joe Livesay**
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joe.livesay@ttcc.edu

Dist. 9 — **George D. Fairbanks Jr.**
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Dist. 10 — **Richard A. Harris**
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Dist. 16 — **David Landon**
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Dist. 17 — **J. J. Jones**
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jjones@thermadyne.com

Dist. 18 — **John R. Bray**
(281) 997-7273
sales@affiliatedmachinery.com

Dist. 19 — **Neil S. Shannon**
(503) 419-4546
neilshnn@msn.com

Dist. 20 — **William A. Komlos**
(801) 560-2353
bkoz@arctechllc.com

Dist. 21 — **Jack D. Compton**
(661) 362-3218
jack.compton@canyons.edu

Dist. 22 — **Dale A. Flood**
(916) 288-6100, ext. 172
flashflood@email.com

working internships. Each participant earned half a high school credit, were paid a $100 stipend, and received AWS Student Memberships donated by the Student Chapter. The topics included welding safety, lab orientation, facilities management, precision measuring equipment, welding processes and applications, basic machining processes, and CNC part programming with advanced applications. The graduation ceremony featured keynote speaker **Pam Roberts,** secretary, South Dakota Dept. of Labor.

District 17

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

District 17 Conference

JUNE 13, 14
Activity: The District 17 conference was held at Hilton Inn in Tulsa, Okla., hosted by the Tulsa Section.

District 20

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

IDAHO/MONTANA

APRIL
Activity: Section Secretary **Nancy Carlson's** winning ticket in the AWS Foundation's raffle won Carlson and her daughter, Nicole, a seven-day Caribbean cruise. The raffle was held during the 2007 FABTECH International & AWS Welding Show in Chicago.

Shown are the attendees at the District 17 conference in Tulsa, Okla.

District 22

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

SACRAMENTO

MARCH 26

Activity: About 55 Section members and guests met at Cosumnes River College in Sacramento, Calif., for a pizza dinner followed by a hands-on program featuring the latest inverter power sources. The presenters included **Angela Gomes,** sales manager, and **Brian Johnson** and **Jack Davis,** applications engineers, for ESAB Welding Products. **Dale Flood,** District 22 director, and **Jason Roberts,** Cosumnes River College welding professor, attended the program.

Nebraska Section members and Linweld employees are (from left) Joe Beving, Pat Neuhalfen, Bill Maroney, Mark Smith, Debbie Finn, Sean McKown, Bob Willenkamp, Jeff Hagemann, and Chris Molczyk.

Shown at the Sacramento Section program in March are (from left) Jason Roberts, Angela Gomes, Jack Davis, and Brian Johnson.

International

CHILE

JUNE 20

Activity: This was the first meeting of the board of directors of the Chile Section, chartered May 18, 2008. Chairman **Mauricio Ibarra Echeverria** of Indura S.A. Industria y Comercio conducted the meeting. The officers defined the Section's meeting calendar, and set up the various committees. **Ibarra Echeverria** said, "We are happy to install an AWS International Section in Chile. It will be the first time everyone will be able to get accurate welding information from one source." Other charter members include Vice Chair **Jorge Parada Ahumada,** Secretary **Antonio Segura Guerrero,** Treasurer **José Lecea Caro, Jorge Esponda, Linton Carvajal, Luis Gonzalez, Erwin Manriquez, José Luis Núñez, Juan Donoso, Robert Keller, José Marin,** and **Mauricio Parraguez.** The meeting was held in Santiago de Chile.

Shown at the inaugural Chile Section board meeting are (from left) Chairman Mauricio Ibarra Echeverria, Erwin Manriquez, Luis Gonzalez, Juan Donoso, Antonio Segura Guerrero, José Lecea Caro, and Jorge Parada Ahumada.

Notice of Annual Meeting of the American Welding Society

The Annual Meeting of the members of the American Welding Society will be held on Monday, Oct. 6, 2008, beginning at 9:30 A.M. at Las Vegas Convention and Visitors Authority, Las Vegas, Nev.

The regular business of the Society will be conducted, including election of officers and nine members of the Board of Directors. Any other business properly brought before the membership will be considered.

New AWS Supporters

Affiliate Companies

Blackhawk Marine and Industrial Contractors, LLC
602 Azalea Rd., Ste. C
Mobile, AL 36609

Elvis Welding Service Inc.
3824 Business St.
Myrtle Beach, SC 29579

Glover's Welding LLC
157 W. Harbor Dr.
Littleton, NC 27850

Marina Innovators, LLC
1247 4th Ave., Ste. B
Auburn, GA 30011

Midwest Automation Inc.
PO Box 2582
Ft. Smith, AR 72902

Process Systems Inc. Construction Co.
3732 E. Raines
Memphis, TN 38118

SmartTCP, Inc.
26602 Haggerty Rd.
Farmington Hills, MI 48331

Trumac Engg. Co. Pvt. Ltd.
N.I.D.C. Industrial Estate
near Lambha Village
Post Narol Ahmedabad Gujarat
382405 India

Supporting Companies

Wayne Engineering Div. of Wayne Industrial Holdings, LLC
701 Performance Dr.
Cedar Falls, IA 50613

Educational Institutions

Denver City High School
601 Mustang Ave.
Denver City, TX 79323

Elkhart Area Career Center
2424 California Rd.
Elkhart, IN 46514

Flatwoods CCC Job Corps
2803 Dungannon Rd.
Coeburn, VA 24230

J. F. Drake State Technical College
3421 Meridian Dr. N.
Huntsville, AL 35811

Logan High School
50 North St.
Logan, OH 43138

Whitney M. Young Job Corps Center
8460 Shelbyville Rd.
Simpsonville, KY 40067

Wolf Creek Job Corps
2010 Opportunity Ln.
Glide, OR 97443

Membership Counts

Member Grades	As of 8/01/08
Sustaining	494
Supporting	319
Educational	460
Affiliate	440
Welding distributor	50
Total corporate members	**1,763**
Individual members	48,722
Student + transitional members	4,883
Total members	**53,605**

Member-Get-A-Member Campaign

Shown are the July 18 standings for the 2008–2009 AWS Member-Get-A-Member Campaign. See page 185 of this *Welding Journal* or visit *www.aws.org/mgm* for campaign rules and prize lists. If you have any questions regarding your member proposer points, call the Membership Dept., (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[6]
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 Roundtable

Sponsors of 9–19 new Members.

P. Betts, Mobile — 12

President's Club

Sponsors of 3–8 new Members.

W. Rice, Tri-State — 5
M. Wheat, Western Carolina — 3

President's Honor Roll

M. Boyer, Detroit — 2
B. Donaldson, British Columbia — 2
F. Hendrix, New Jersey — 2
J. Polson, L.A./Inland Empire — 2
A. Stute, Madison-Beloit — 2
D. Wright, Kansas City — 2
M. Yung, Portland — 2

Student Member Sponsors

Sponsors of 5 or more students.

A. Rowe, Philadelphia — 36
T. Moore, New Orleans — 32
D. Berger, New Orleans — 30
B. Benyon, Pittsburgh — 28
E. Norman, Ozark — 26
D. Schnalzer, Lehigh Valley — 22
R. Munns, Utah — 19
D. Pickering, Central Arkansas — 16
R. Rummel, Central Texas — 13
A. Stute, Madison-Beloit — 13
D. Taylor, Kern — 13
R. Evans, Siouxland — 11
R. Norris, Maine — 9
N. Carlson, Idaho/Montana — 7
S. MacKenzie, Northern Michigan — 7
D. Howard, Johnstown-Altoona — 6
J. Boyer, Lancaster — 5
J. Reed, Ozark — 4
M. Rahn, Iowa — 3

Guide to AWS Services

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

AWS PRESIDENT

Gene E. Lawson
glawson@esab.com
ESAB Welding & Cutting Products
25108 Margurite Pkwy., PMB #165
Mission Viejo, CA 92692

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)

Database Administrator
Natalia Swain..*nswain@aws.org* ....(245)

Human Resources

Director, Compensation and Benefits
Luisa Hernandez.. *luisa@aws.org* ....(266)

Manager, Human Resources
Dora A. 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, D.C., (202) 785-9500; FAX (202) 835-0243. Identifies funding sources for welding education, research, and development. Monitors legislative and regulatory issues of importance to the welding 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.. *jkrall@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
Andrew Cullison.. *cullison@aws.org* .....(249)

Editor
Mary Ruth Johnsen.. *mjohnsen@aws.org* (238)

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)

Webmaster
Angela Miller..*amiller@aws.org* ....(456)

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, Certification Operations
John Filippi..jfilippi@aws.org ....(222)

Managing Director, Technical Operations
Peter Howe.. *phowe@aws.org* ....(309)
Manages and oversees the development, integrity, and technical content of all certification programs.

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.

EDUCATION SERVICES

Managing Director
Dennis Marks.. *dmarks@aws.org* ....(449)

Director, Education Services Administration and Convention Operations
John Ospina.. *jospina@aws.org* ....(462)

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

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

Technical Publications
AWS publishes about 200 documents widely used throughout the welding industry.
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, Sheet Metal Welding

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

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

Brian McGrath . *bmcgrath@aws.org* .....(311)
Methods of Inspection, Mechanical Testing of Welds, Welding in Marine Construction, Piping and Tubing, Robotic and Automatic Welding

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

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

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

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

Nominees for National Office

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

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

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

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

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

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

Director-at-large: To be eligible for election as a director-at-large, an individual shall previously have held office as chairman of a Section; as chairman or vice chairman of a standing, technical, or special committee of the Society; or as 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 Gerald D. Uttrachi, chair, National Nominating Committee.

The next meeting of the National Nominating Committee is scheduled for October 2008. The terms of office for candidates nominated at this meeting will commence January 1, 2010.

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.

William Irrgang Memorial Award 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.

This award consists of a $2500 honarium and a certificate. It is presented during the FABTECH International & AWS Welding Show held each fall. The award is administered by the American Welding Society and sponsored by The Lincoln Electric Co. to honor the late William Irrgang.

George E. Willis Award is awarded each year to an individual who promotes the advancement of welding internationally by fostering cooperative participation in areas such as technology transfer, standards rationalization, and promotion of industrial goodwill.

The award consists of a $2500 honarium and a certificate. It is presented during the FABTECH International & AWS Welding Show held each fall. The award is administered by the American Welding Society and sponsored by The Lincoln Electric Co. to honor George E. Willis.

Honorary Membership Award is presented to 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. Honorary Members have full rights of membership.

National Meritorious Certificate 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.

International Meritorious Certificate Award is given in recognition of significant contributions to the welding industry for service to the international welding community in the broadest terms. The awardee is not required to be an AWS member. Multiple awards may be given. The award consists of a certificate and a one-year AWS membership.

AWS Publications Sales

Purchase AWS standards, books, and other publications from
World Engineering Xchange (WEX), Ltd.
orders@awspubs.com; www.awspubs.com
Toll-free (888) 935-3464 (U.S., Canada)
(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
Claudia Stachowiak
Reprint Marketing Manager
866-879-9144, ext. 121
claudia@fostereprints.com

AWS Foundation

AWS Foundation, Inc., is a not-for-profit corporation established to provide support for educational and scientific endeavors of the American Welding Society. Information on gift-giving programs is available upon request.

Chairman, Board of Trustees
Ronald C. Pierce

Executive Director, AWS
Ray Shook, ext. 210, *rshook@aws.org*

Executive Director, Foundation
Sam Gentry, ext. 331, *sgentry@aws.org*

Corporate Director, Solutions Opportunity Squad
Monica Pfarr, ext. 461, *mpfarr@aws.org*

Director, Solutions Opportunity Squad
Connie Bowling, ext. 308, *cbowling@aws.org*

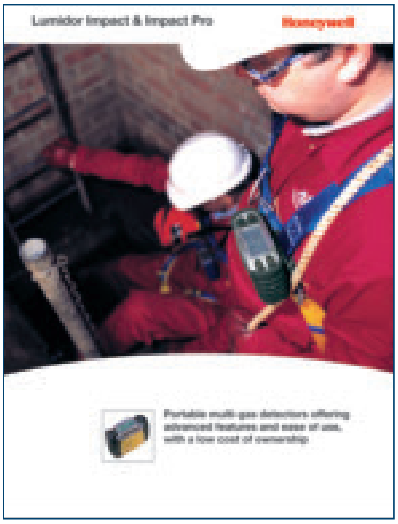
550 NW LeJeune Rd., Miami, FL 33126
(305) 445-6628; (800) 443-9353, ext. 293
General Information:
(800) 443-9353, ext. 689; *vpinsky@aws.org*

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 **Gene E. Lawson,** as listed on the previous page.

Literature Pictures Indoor Air Quality Monitor



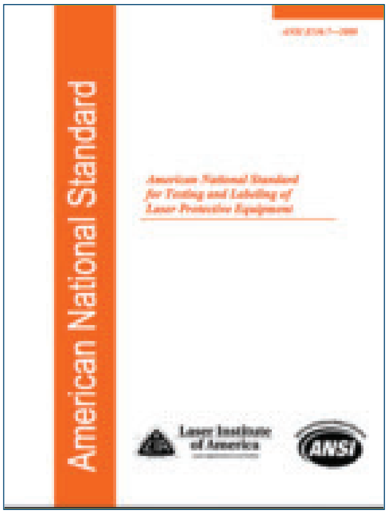
A two-page, full-color brochure details the Honeywell Analytics, Inc., IAQ-Point™, an indoor-air-quality monitor that measures carbon dioxide, temperature, and humidity levels for controlling ventilation in schools and commercial buildings. Outlined are its IR sensing technology that offers better drift and temperature compensation for measuring ambient CO_2 levels that integrates into existing building automation systems through an array of analog and digital outputs. Explained is how the device measures CO_2 levels then, when the level reaches a preset level, triggers the opening of dampers that introduce conditioned fresh air. The brochure can be downloaded from *www.globalspec.com/FeaturedProducts/Detail/HoneywellAnalytics/IAQPoint/61829/0.*

Brochure Pictures Full Line of Industrial Brushes

The 92-page, full color, profusely illustrated *Advance Brush* catalog can be downloaded as a PDF or ordered in hard copy. The brushes illustrated and described include crimped wheel, knot wheel, cup and bevel, end, stem-mounted, miniature, power tube internal cleaning types, abrasive filament, nonwire, conveyor cleaning, strip, scratch, block, platers, and small specialty brushes. Other products include maintenance brooms, squeegees, painter's rollers, and accessories. Complete technical information is provided in chart form, including recommended rev/min for various operations. Detailed is the M-Brad™ nylon monofilament that evenly encapsulates abrasive grit particles to give precisely controlled, consistent gradual cutting action, and the numerous products using the technology.

PFERD Inc.
www.pferdusa.com
(978) 840-6420

Laser Protective Equipment Featured in New Standard

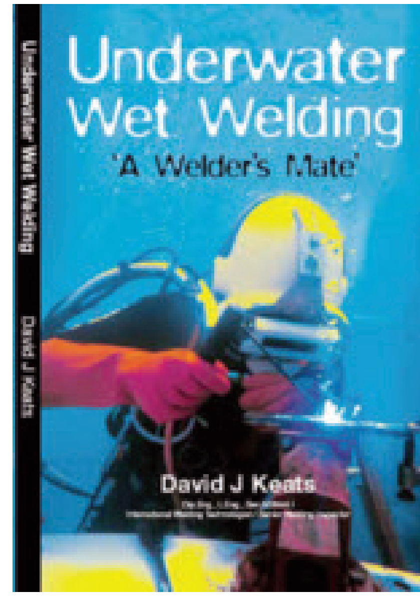


The new code, ANSI Z136.7, *American National Standard for Testing and Labeling of Laser Protective Equipment,* provides guidance on the test methods, protocols, specifications, report format, and labeling for devices used for eye protection from lasers and laser systems that operate at wavelengths between 180 nm and 1 mm. Such protective devices include laser eye protective devices or instrument filters, laser window filters, and laser area protective barriers, screens, and beam-blocking curtains. The test procedures provided ensure that eyewear, windows, and barriers maintain their specified level of protection throughout the useful life of the product. The code also addresses the new reflective coatings and hybrid filters. List price is $145, $125 for LIA members.

Laser Institute of America
www.laserinstitute.org/store/ANSI/115
(407) 380-1553

Underwater Wet Welding Explored in New Manual

The 300-page *Underwater Wet Welding,* subtitled *A Welder's Mate,* authored by David J. Keats, is intended as a reference manual for experienced commercial divers involved with welding, and as a source of technical data for all non-welders. Included are numerous easy-to-follow tips for successful welding and problem solving with more than 200 illustrations and photographs. Topics include equipment, safety, welding parameters, electrodes, terminology, properties of metals, basic metallurgy, heat treatments, quality assurance, practical exercises, and exam questions. The book, about $45 postpaid, may be purchased online. Visit *www.specialwelds.com.*



ABICOR Binzel Fills Two Key Posts

Matt Perkins

Brian Berry

ABICOR Binzel, Frederick, Md., has named **Brian Berry** an account specialist, and **Matt Perkins** district sales manager for accounts in Ohio and most of Indiana. Berry previously worked as a robotics technician for Roy Smith Co., and service engineer at Genesis. With more than 20 years' experience in the welding industry, Perkins worked 28 years with MTD Products as a supervisor for welding and robotics, and for Sarca Manufacturing as a supervisor in its robotic tech department.

Best Glove Names Territory Manager

Best Glove, Menlo, Ga., has appointed **Troy Boeckman** Minnesota territory manager. Boeckman, with 11 years of experience in sales, previously worked as territory manager for Hallmark Building Supplies, and as a district manager for Bosch Tool Corp.

Parlec Appoints President

Parlec, Inc., Fairport, N.Y., a supplier of tooling, work-holding, and presetting solutions, has appointed **Doug Woods** president. Woods previously served as president of Parlec International. He succeeds **Michael Nuccitelli,** formerly president and CEO, who currently serves exclusively as CEO.

Resistance Welding Sales Manager Named at Snow

Robert Hosa

Robert J. Hosa has joined T. J. Snow Co., Chattanooga, Tenn., as district sales manager for resistance welding machinery throughout the Midwest. Based in Columbus, Ohio, Hosa has more than 30 years of experience in the resistance welding industry. He has held positions with McKay Machine, Wean-United, Taylor-Winfield, and A&E Welding Machinery.

IMAGE Names West Coast Sales Manager

Nick Perry

IMAGE Industries, Inc., Huntley, Ill., a supplier of stud weld fasteners and application equipment, has named **Nick Perry** west coast sales manager, a newly created post. Based in Manhattan Beach, Calif., Perry previously was a sales representative for Priority Mailing Systems.

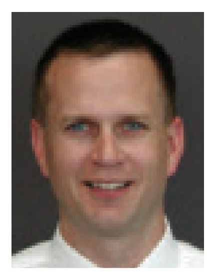
Weldquip Hires Managers for Canada and Mexico

Casey Simpson

Luis Villasante

American Weldquip, Inc., Sharon Center, Ohio, has appointed **Casey Simpson** and **Luis Villasante** district managers for Ontario, Canada, and Mexico, respectively. Simpson previously worked for Black and McDonald, and as a territory manager for Praxair and Air Liquide. Villasante most recently was owner and general manager of Sistemig, S.A., based in Mexico City, Mexico.

TRUMPF Canada Appoints Managing Director



James Rogowski

TRUMPF Inc., Farmington, Conn., has named **James Rogowski** managing director of TRUMPF Canada, based in the Toronto area. Rogowski joined the company in 1998 where he most recently served as product manager of 2D laser machines and automation.

Wagner Companies Fills Two Key Positions

Alexander Harris

Connie Knaak

The Wagner Companies, Milwaukee, Wis., a manufacturer of handrail fittings and metal products for architectural and industrial applications, has appointed **Alexander Harris** an estimator/customer service representative for systems and promoted **Connie Knaak** to manager of employee development and training. Prior to joining the company, Harris was an assistant project manager at Vogel Engineering, Inc., in New Berlin,Wis. Knaak, with the company for 20 years, previously served in production control.

Motoman Names President

Steve Barhorst

Motoman, Inc., Dayton, Ohio, has appointed **Steve Barhorst** president and COO, succeeding **Craig Jennings** who held the post for 11 years. Previously, Barhorst served as senior vice president and CFO and president of Motoman Robotica do Brasil.

General Manager Named at Industrial Metal Supply

Industrial Metal Supply Co., Los Angeles, Calif., has appointed **Martin J. Mechsner** general manager and chief engineer for its Fabrication division. Mechsner is president and CEO of the Small Manufacturers' Institute, president of Schober's Machine and Engineering, and adjunct professor of technology and mechanical engineering at California State University, Los Angeles campus.

Cryoquip Appoints Sales Manager for SE Asia

Joel Maclou

Cryoquip, Murrieta, Calif., has named **Joel Maclou,** with Cryoquip-Australia, to the position of sales manager, ASEAN region (southeast Asia), based in Kuala Lumpur, Malaysia. Maclou joined the company in 1999 following graduation from RMIT University, Melbourne, Australia, as a chemical engineer.

Airgas Appoints Communications VP

Airgas, Inc., Radnor, Pa., has named **Jay Worley** vice president — communications and investor relations. With the company since 1993, Worley has held several positions, most recently as director of investor relations. In addition, the company has named **Andy Cichocki** a division president of Airgas, and promoted **Steve Marinelli** to succeed Cichocki as president of Airgas National Welders. Marinelli, with the company for 28 years, has served since 2000 as vice president of marketing.

Tech Specialist Joins ProMotion Controls

Randy May

ProMotion Controls, Inc., Medina, Ohio, has appointed **Randy T. May** technical service specialist for North, Central, and South America. Prior to joining the company, May was a maintenance technician at TEKFOR, responsible for maintaining CNC machining centers and forging presses.

Orbitform Names President

Orbitform Group, Jackson, Mich., has named **Phil Sponsler** president. Sponsler previously served the company for eight years as general manager.

Think globally. Act pampered.

Focus on global growth and have a world of fun at the 2009 WEMCO Annual Meeting in San Diego.

WEMCO, a Standing Committee of the American Welding Society, is committed to collaborating with fellow industry leaders to stay relevant and dynamic in this the ever-changing global economy. On February 26-28, 2009, WEMCO executives will spend several days at the Rancho Bernardo Inn Golf Resort and Spa, in San Diego, Calif., analyzing:

- Industry globalization and economic potential in emerging markets
- Trends and related issues of private labeling
- Issues surrounding rapid growth and expansion

A world of information on global opportunities

WEMCO understands the importance of networking with fellow industry leaders to promote the welding industry, and encourages its growth and development. Each year, the WEMCO Annual Meeting continues to bring together top-level executives from major welding equipment manufacturers throughout the United States and Canada. In 2009, some of the featured presenters will include Dick Couch, president & CEO of Hypertherm, and Chris Ebeling, VP & general manager of Linde Canada, Ltd. Also joining WEMCO will be the highly-anticipated Alan Beaulieu of the Institute for Trend Research. Beaulieu's delivery of his economic forecast has proven accurate, as well as entertaining.

We cordially invite executives of welding equipment/products manufacturing companies to join WEMCO on February 26-28 to represent their organizations. The networking opportunities are immense, and the information is invaluable. Read some of the feedback from past attendees:

"The best such conference that I have ever attended."

"Great meeting. Excellent speakers."

"Great program. Just the right mix we needed."

"Terrific program content, relevant topics, interesting speakers."

"The program was excellent all the way through. I wish other associations were as good."

How to register

Attendance fees are $720 per attendee, and $225 for spouses and guests. WEMCO has also secured a group rate with the Rancho Bernardo Inn of $250 per room, per night, plus applicable taxes. Go to the WEMCO website (*www.aws.org/wemco*) to download your 2009 Registration Form today. Forms can be submitted via e-mail at *wemco@aws.org*, or via fax to (305) 442-7451. Deadline to register for the 2009 WEMCO Annual Meeting is January 26, 2009.

For further information about the annual meeting, please contact Natalie James-Tapley at (800) 443-9353, ext. 444, or via e-mail at *tapley@aws.org*.

Note: Guests eligible for WEMCO membership may attend only one WEMCO Annual Meeting before joining the committee.

AWS WEMCO

WELDING EQUIPMENT MANUFACTURERS COMMITTEE

3M™ Speedglas™ 9100 Welding Helmet

3M's new Speedglas™ 9100 helmet has been radically re-designed to provide optimal protection, comfort, and performance. This new design not only changes how the welder wears the helmet, but how they experience the helmet's fit, stability and balance. The new 9100 series also offers three new ADF models with normal, large, and extra large viewing areas. Please visit www.speedglas.com.

3M
Building 235-2W-70
St. Paul, MN 55144-1000
(800) 328-1667
Fax: (651) 736-6677

See Us at Fabtech/AWS Booth #15101

Orbiter

See Us at Fabtech/AWS Booth #13181

Tube Welding that's Out of this World!

NEW fusion orbital weldheads from Astro Arc Polysoude utilize a closed chamber inert atmosphere for high pressure and sanitary welds…

Perfect for tubes, short ferrule fittings, elbows and T's. The specific tube sizes are accommodated by the use of Patented TCI's™, Titanium Collet Inserts.

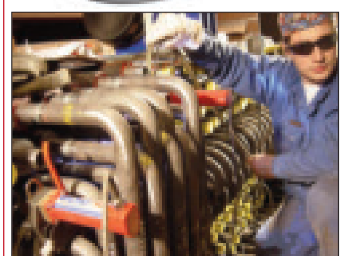
Astro Arc Polysoude, Inc.
24856 Avenue Rockefeller
Valencia, CA 91355
(661) 702-0141
Fax: (661) 702-0632
E-mail: sales@astroarc.com
www.astroarc.com

All-Fab's Tank Turning Rolls

All-Fab's model RD-3-INW tank turning rolls have variable speed, hand-held pendent control, on/off foot control, maximum capacity per set 6600 lbs and both drive rolls are independently powered. The LED readout for speed adjustment, adjustable center distance. Contact us for more information.

All-Fab Corp
1235 Lincoln Road
Allegan, MI 49010
(269) 673-6572
Fax: (269) 673-1644
Website: www.allfabcorp.com
E-mail: sales@allfabcorp.com

Grip It



See Us at Fabtech/AWS Booth #13181

Grip-It Modular Weldhead

Take hold of your next pipe welding job.

Grip-It attaches directly to the pipe

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Python™ Welding Helmets

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High Nickel Alloys Brochure

Arcos Industries, LLC offers a brochure which details the company's comprehensive line of premium bare and covered electrode products for welding high nickel alloys. Electrode classifications, approvals, applications, diameters, typical mechanical properties and chemical compositions are included as well as a comparability chart for convenient reference.

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One Arcos Drive
Mt. Carmel, PA 17851
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www.astroarc.com

See Us at Fabtech/AWS Booth #13302

Handheld Non-Destructive Alloy Analyzer

Bruker AXS Handheld, the technology leader in handheld XRF alloy analyzers, provides a range of analyzers for use in fabrication and welding shops. The S1 TRACER is a lightweight portable alloy analyzer which will provide alloy grade identification and chemistry in 5-10 seconds. This unit can easily measure samples at high temperatures.

Bruker AXS Handheld will introduce the TRACERturboSD. This is the first portable handheld XRF analyzer to incorporate an SDD (silicon drift detector) which provides a new level of performance in a handheld instrument. This instrument can provide alloy identification and complete chemistry in 1-5 seconds and separate very similar alloys such as P91 vs. 9Cr/1Mo or B1900 vs. B1900Hf. This detector enables analysis of light elements such as Mg, Al and Si (without vacuum or He) which are very important in welding, especially in aluminum alloys.

BRUKER

Bruker AXS Handheld
415 North Quay St; Suite 1
Kennewick, WA 99336
(509) 783-9850 or
(800) 466-5323
Sales/Information: Ext 236
www.BrukerHandheld.com
E-mail: sales@brukerhandheld.com

Internal Auditing and Audit Program Design for Steel Fabricators

See Us at Fabtech/AWS Booth #10063

One day Internal Audit training course Tuesday, October 7 in conjunction with Fabtech/AWS Las Vegas!

Ideal for:

- Welding professionals interested in improving their system
- Those responsible for implementing and maintaining industry compliance (AISC, AWS, ISO)
- QA/QC Professionals and Upper Management

Contact us for more information or to register.

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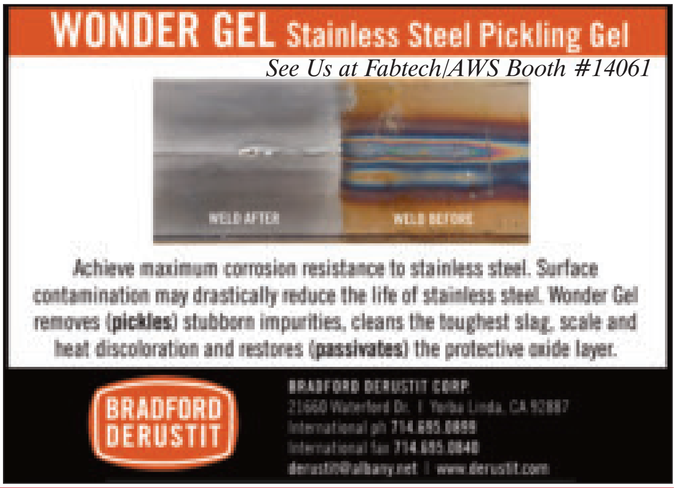
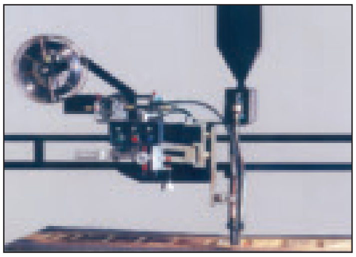


Fixturing Kits for Welding Offer Many Solutions

The Demmeler modular fixturing system for welding comes with a full range of components to fixture virtually any part. Angles, spacer blocks, clamps, positioning and clamping bolts and a complete family of universal stops can be assembled into a ready-to-use welding fixture in a matter of hours. The five-sided table has surfaces that are flat and square to 0.0004 in./ft and bores that are located ± 0.001 in.

Bluco Corporation
3500 Thayer Ct.
Aurora, IL 60504
(866) DR-BLUCO
Website: www.bluco.com

See Us at Fabtech/AWS Booth #10142



NEW MIG Carbide Hardfacing System

Rankin Automation® automatic and semi-automatic multi-axis MIG Carbide hardfacing systems feed all grades of tungsten carbide into a molten matrix providing a rough, tough wear surface. Exceptional turnkey systems that increase service life up to 50 times on parts subject to severe abrasion. Manufactured by Broco, Inc.

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Fax: (909) 483-3233
Email: Sales@brocoinc.com
www.brocoinc.com

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Introducing the BoreClad Welding System for Automated I.D. Cladding.

A complete welding and positioning system for symmetrical, chucked parts. Angled design optimizes bead quality and deposition rate. Ideal for cladding with stainless steel, nickel alloys and other exotic metals. Designed for parts with a max. O.D. of 12" and min. I.D. of 2", 18", 24" and 36" welding stroke models available.

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(888) 265-1202
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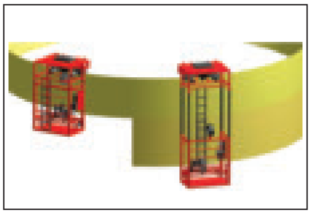
Website: www.bortech.com
E-mail: sales@bortech.com



See Us at Fabtech/AWS Booth #15049

Reduce Field Storage Tank Welding Time

Bug-o offers an Automatic Girth Welder for tank fabrication applications. The self-propelled welding system can reduce field storage tank welding time up to 40%. Weld defects are greatly reduced saving tank erection costs. The Girth Welder is applicable for bottom-up or jack-up constructed single- or double- wall storage tanks inside and outside welding.

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E-mail: jwhite@weld.com

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Our new MPM 165 welder/generator with a four stroke reliable Honda engine is truly portable and goes where others can't. It provides up to 150 amps of DC power to handle steel up to 1/2" thick. Runs 6010 and 7018 electrodes. Lightweight (72 pounds) but powerful, its unique DC chopped auxiliary output allows operation of virtually all standard hand-held power tools. Compactly designed and quiet to operate, it produces superior weld results.

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FAX: (336) 887-6194
Website: www.burco.net
E-mail: burcoweld@aol.com

See Us at Fabtech/AWS
Booth #11204

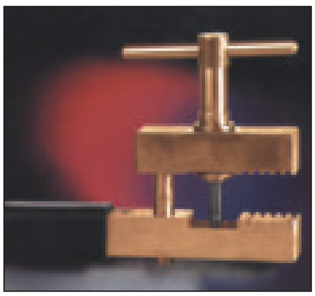
NEW 4140 Alloy Steel Electrode

Applications: The 4140 E14 electrode is typically used to build up all types of dies, forgings, castings, and other machine parts made from medium carbon, low alloy steels. It may also be used for joining thin sections of AISI 4140 materials.

Hardness: 32-40 Rc as welded, Flame hardenable to 58 Rc.

Classification: AISI 4140.

COR-MET INC
12500 Grand River Road
Brighton, Michigan 48116
(810) 227-3251
sales@cor-met.com
www.cor-met.com



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Ground Clamps

Our most popular ground clamp (#108600) features:

- 600 amps
- Protective threads
- Maximum conductivity
- Positive cable connection
- Flat jaw with strong gripping power.
- Maximum jaw opening: 1 5/8" Weight: 3 lbs., 2 ozs.
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Advanced Arc Data Monitoring and testing utilizing Weld Count, Weld Time, Weld Volume Applied, and Accumulated Arc Density to test welds and test parts. WPM-08 PC based HMI and Operator Interface panel alerts operator and displays PASS/FAIL status signals as well as important SPC trend data and user defined Sigma value limits. Connects to plant Ethernet and provides WEB based access to your most remote manufacturing locations.

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See Us at Fabtech/AWS
Booth #11124

Non-Metallic Weld Backings

At Cerbaco we will provide you with the proper weld backings for your applications. Our engineers will be happy to assist you in implementing a backing that will give you a finished quality, full penetration weld from one side. Cerbaco weld backings eliminate the need for arc gouging and heavy grinding. Cerbaco can also develop new backings and formulations for your specific needs. Cerbaco Ltd is the one source for weld backings.

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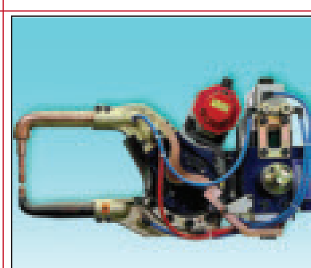

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New Reduction Gear X-Type

This gun uses a patented reduction gear design engineered to provide high force, high rigidity and long life for use in many applications. The main drive unit is fully sealed to prevent spatter infiltration. Because the transformer and drive motor are mounted in the center, the gun is symmetric. No right hand or left hand needed. Parts are standardized increasing flexibility and reducing spare parts inventory.

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Advanced Welding System®

Quickly and easily create fully code-checked WPQRs, PQRs, and WPSs in accordance with the AWS D1.1, in addition to pre-qualified WPSs under Section 3. Full welder management including continuity, inspection, and NDE. A huge materials database and cutting edge report system round out this complete solution from the longest standing provider/author of welding documentation software in the world. Free Demo Available.

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Fume Collectors for Welding & Thermal Spray

Donaldson® Torit® fume collectors with Ultra-Web® & HEPA filters can help you meet OHSA's lowed limits on hexavalent chromium exposure. Our patented Ultra-Web nanofiber filters capture the sub-micron-size particles that typically make up 80% of welding fume. Immediate availability of many portable & stationary models.

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www.donaldsontorit.com

Mobile Welding Fume Extractors

See Us at Fabtech/AWS Booth #14191

ESTA USA is introducing their mobile Welding Fume Extractors SRF K-10 (single arm) and SRF K-15 (double arm unit). The units are extremely mobile and light weight, and yet are strong and durable. These systems comply with the strict regulations of OSHA; it has a patented tilt mechanism so the operator will never have to be in contact with the filtered out debris like Hexavalent Chromium, which is known by OSHA to be very health hazardous. These systems not only exceed OSHA standards but due to their capability of filtering all particles down to size will save money on cooling and heating costs as well.

ESTA Corporation
2321-A Distribution Street
Charlotte, NC 28203
(704) 971-6960 or (800) 968-3782
Fax: (704) 971-6966
www.esta.com

Tungsten Carbide Welding Consumables Provide Exceptional Wear Properties

Durum USA offers one of the most complete lines of Tungsten Carbide coating consumables. The wide choice of tungsten carbide types allows customers to select the most appropriate product for their applications and processes. Our line of Tungsten Carbide products includes metal-cored and arc-spray wires, electrodes, tube rods, HVOF and HVAF powders, PTA powders, flame-spray powders and laser cladding powders.

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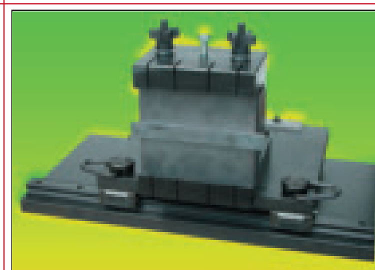

Automated Bend Specimen Cutting System

The Fischer Model BSC Bend Specimen Cutting System can achieve weld bend specimen cutting times of 3 to 5 minutes per bend for plain carbon steel. Bend testing is competitive with radiography with this method. Fixtures are available for removing bend specimens from plate or pipe and for removing backing bars. For more information, visit our website.

Fischer Engineering Company
8220 Expansion Way
Dayton, OH 45424
(937) 754-1750
FAX: (937) 754-1754
Website: www.fischerengr.com

See Us at Fabtech/AWS Booth #10219

New PTA Product Line Offered by DURUM USA

Our line of PTA products now includes PTA systems, torches and powders. The systems can run both hand-held and machine torches, which provides flexibility for various uses in your job shop. Our torches are very sturdy and easy to maintain. The composite Tungsten Carbide powders available from Durum USA are especially suitable for high wear applications.

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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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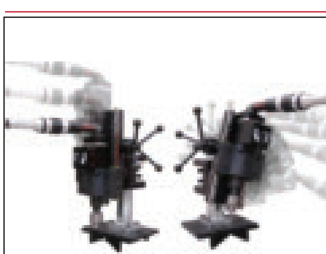
Website: www.fischer-technology.com



See Us at Fabtech/AWS Booth #11128

E.H. Wachs Company Launches New Multi-Axial PowerDrill

The Wachs Multi-Axial PowerDrill is designed for drilling, boring, and tapping pipes of any diameter. The drill features 5" tool diameter, high-torque gearing, long feed travel, and multiple (5 axes) of adjustment for amazing flexibility. The Multi-Axial uses a wide range of standard tooling and tool adapters. (1-1/2" straight bore spindle 38.1 mm / Morse Taper) Available in pneumatic or hydraulic.

E.H. Wachs Company
600 Knightsbridge Parkway
Lincolnshire, IL 60069
www.wachsco.com

See Us at Fabtech/AWS Booth #14163

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.
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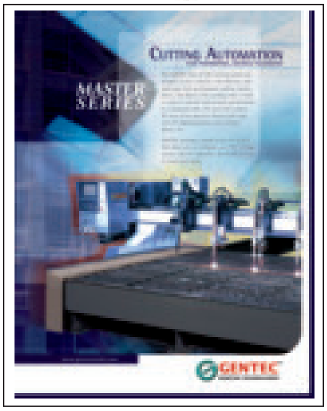
Chino, CA 91710
(909) 606-2726
Website: www.genstartech.com



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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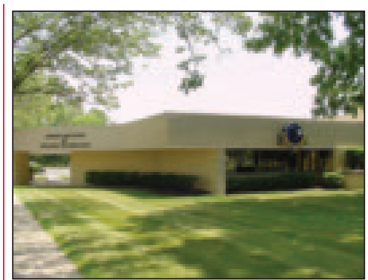

HIWT Virtual Tour

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 2008/2009 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
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www.welding.org

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New Kits from Goss Inc.

- Weldpro UL Listed Torch & Regulators
- Durable Forged Bodies with Stainless Steel Needle Valves
- 20 Ft. Hose, "B" Connections
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Welding Training Curriculum Available

Complete training programs including DVDs, instructor guides, and student workbooks. Newly offered in 2008 is Gas Tungsten Arc Welding Pipe 2-inch and Gas Tungsten Arc Welding Pipe 6-inch. To see a complete line of curriculum offerings including GTAW, SMAW, GMAW, and FCAW, you can shop online at www.welding.org or request a printed training materials catalog.

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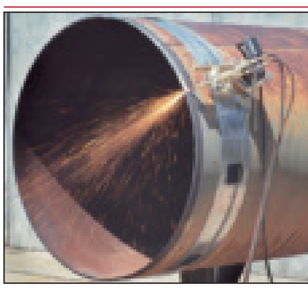

H&M Band-Type Pipe Cutting and Beveling Machine

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 over-sized, 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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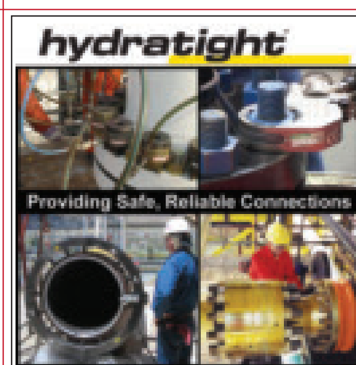

Bolting and Machining Solutions.

That's what Hydratight offers around the globe everyday. Whether its hydraulic tensioning or torque wrenches or DL Ricci machining tools, Hydratight offers sales, rental or on-site technical support of connecting solutions plus (as an OEM) the ability to customize our solutions safely to your exact situation. See video of our solutions in action on our website.

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Booth #5239

Hydratight
(651)388-8661
redwing@hydratight.com
www.hydratight.com

Weld Shaver

Heck Industries has added a new hand held weld shaver to their line of fabricating equipment. The new weld shaver uses standard carbide inserts in a milling cutter to shave weld beads flush to a work piece. Used for cleaning butt welds and corner welds. The weld shaver will remove only the weld and not damage surrounding materials such as conventional grinding of joints. The 2 horsepower Model WS-625 will quickly remove welds at 6-8 feet per minute.For more information and a catalog please contact Heck Industries.

Heck Industries
(800) 886-5418,
Fax: (810) 632-6640,
www.heckind.net

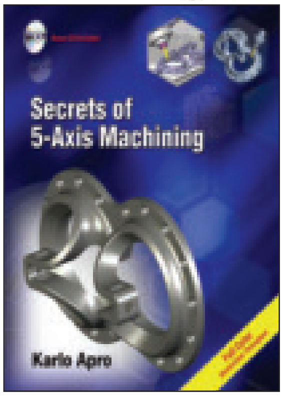
See Us at Fabtech/AWS
Booth #5107

Hypertherm Unveils World's Most Versatile Half-inch Plasma System Powermax45 Offers High Performance in Portable Package

Hypertherm, the world leader in plasma metal cutting technology, introduces the Powermax45®, the world's most versatile and portable 1/2" plasma cutting and gouging system, in booth 14077 at this year's Fabtech/AWS Welding Show. Users will benefit from the system's ease-of-use, excellent cut quality, and long consumable life, which keep productivity high and operating costs low.

See Us at Fabtech/AWS
Booth #14077

Hypertherm, Inc.
Etna Road, PO Box 5010
Hanover, NH 03755
(603) 643-3441
Fax: (603) 643-5352
www.hypertherm.com



See Us at Fabtech/AWS
Booth #34013

All You Need To Know About 5-Axis Machining In One Book!

This unbiased, to-the-point description of 5-axis machining presents information gathered during the author's 30 years of hands-on experience in the manufacturing industry. As a one-of-a-kind resource secrets of 5-Axis machining features full-color illustrations throughout that help explain the theories and principles and includes a CD containing avi files, high quality illustrations, and sample parts. Visit us at our booth in the FABTECH/AWS Welding Show to see this and many more resources!

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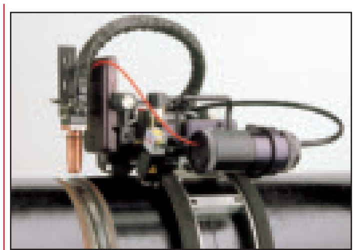

New Digital FCAW Orbital Pipe Welding Systems

A new Pipeliner model from Magnatech utilizes a push-pull system for positive feeding. Using a 30 lb. standard wire spool lowers consumable costs. The Head welds pipes 6 – 60 in. The Pipeliner allows contractors to use standard 30° "V" bevels, eliminating expensive field remachining. The digital model replaces the field-proven analog Pipeliner, with over 20 years of welding pipes to API 1104, ASME, and DNV Standards.

Magnatech Limited Partnership
6 Kripes Road – P O Box 260
East Granby, CT 06026-0260
(860) 653-2573
Fax: (860) 653-0486
Email: info@magnatech-lp.com
Web: www.magnatech-lp.com

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Booth #13013

Hardy Non Sparking Tools – New!

The new Hardy Tools line of non-sparking hand tools made of aluminum bronze is now available. Non-Sparking tools are used in a variety of volatile industrial environments including petroleum and chemical manufacturing, explosive and blasting activities in both underground and open-pit mining and grain elevators. The complete Hardy Tools line through Intercon encompasses metric as well as standard sized tools. Please contact us for more information or view our web site at www.intercononline.com

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Mannings' resistance and induction systems have been proven reliable on projects demanding heat uniformity, accurate control, dependability and safety. Mannings' equipment is designed for manual, programmable, or remote operation. Economical to use and simple to operate, it is robust in construction and easily capable of heavy on-site work loads.

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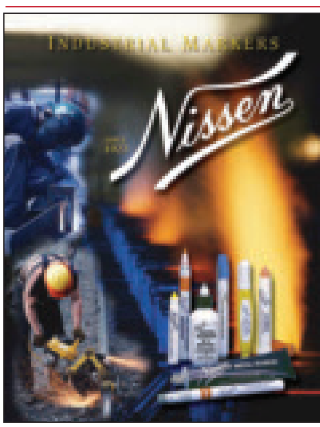

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Booth #15000

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.

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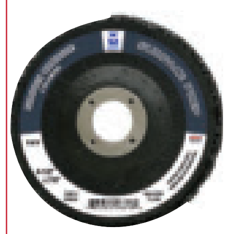

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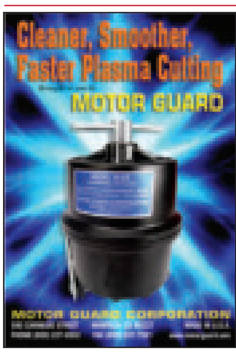

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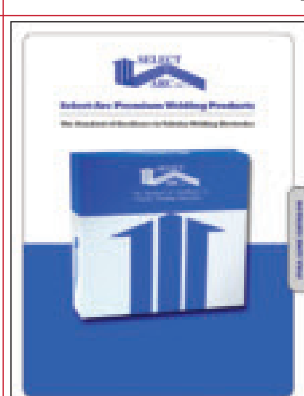

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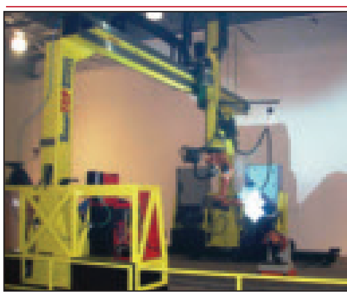

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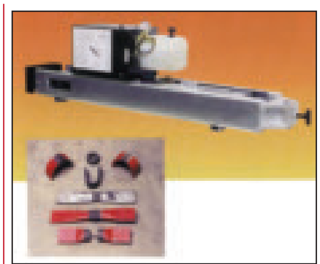

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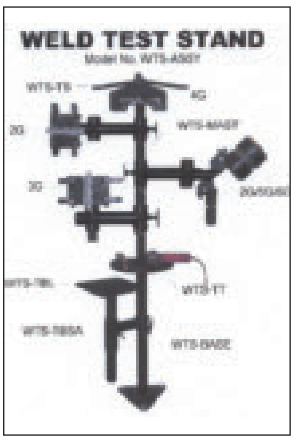

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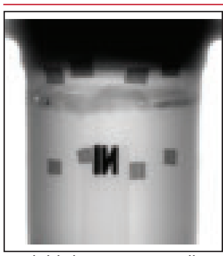

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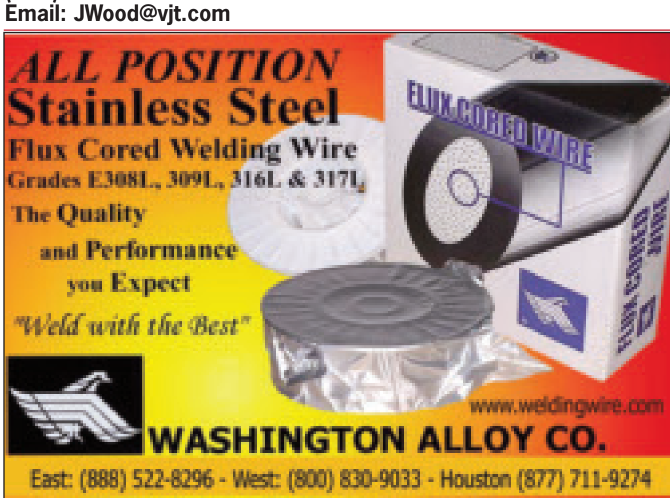

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Automatic Weld Planning by Finite Element Simulation and Iterative Learning

An automatic off-line planning system was developed to predict the optimum control variables in gas metal arc welding

BY P. V. JEBERG, H. HOLM, AND O. MADSEN

ABSTRACT. This paper presents a system for automatic planning of gas metal arc welding (GMAW) operations. The system automatically generates optimal dynamic trajectories of welding control variables (power input, current, and voltage; and travel speed) such that a desired weld quality is obtained despite known changes in process conditions, for example, geometric changes.

The system is based upon a finite element simulation of the GMAW process. The finite element model developed for the purpose consists of two parts: a heat conduction model simulating the temperature distribution within the workpiece and a model simulating the weld pool surface shape. To improve the accuracy of the finite element model, a calibration method has been developed that enables precise simulation with varying welding control variables.

The finite element simulation is coupled to an iterative learning controller, which exploits the capability of simulations to be repeated. The iterative learning controller identifies the best possible dynamic trajectories of the welding control variables in an iterative process.

The results of open loop execution of automatically planned GMA welding on butt joints with constant and varying thermal regions are presented. A comparison with industrially applied data showed that a significant reduction of the heat input and workpiece distortion could be achieved while maintaining a satisfactory weld quality. The results demonstrate the superiority of process performance based on planning by iterative learning control compared to manual execution of welding task and compared to process planning based on traditional methods.

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Introduction

For many years, steel-structure fabrication companies have introduced welding robots in the effort to remain competitive. The robots are capable of improving the arc on time, removing humans from hazardous work environment, and securing a more homogeneous weld quality. To increase the productivity of welding robots, off-line programming is an often used method, but off-line programming has been confined to planning the robot motion. The welding control variables are set based on resource consuming welding experiments, and they are therefore not necessarily optimized with regard to heat input. Instead, the settings of the welding control variables are just usable settings, which result in an acceptable weld quality for the entire weld task. In general, constant values of the welding control variables entail that the variables are set in a conservative manner, such that the process is kept well within the usable process window. However, this can result in too large heat input and in too much added material compared to what will be possible with dynamic trajectories of the welding control variables, which are optimized with regard to minimum heat input. Too high heat input and too much added material have a negative effect on workpiece distortion and consequently on production efficiency. However, obtaining process optimized dynamic welding control variables by use of experiments is also costly, especially if the geometry complexity entails a change in thermal process conditions along the weld joint. This calls for a method for automatic and optimal planning of dynamic trajectories of the welding control variables.

KEYWORDS

Automatic Planning
Finite Element Model
Gas Metal Arc
Iterative Learning
Welding Variables

During the last decades arc welding has been simulated by numerical methods, especially by finite element methods. A comprehensive overview of finite element analysis and simulation of welding has been made by Mackerle (Ref. 1). However, only few references exist to work where numerical models have been used directly for automatic weld planning. Doumanidis (Refs. 2, 3) presents results of off-line planning of trajectories of the plasma arc heat source in scan welding. More recently, Ericsson (Ref. 4) presents a finite element based method to optimize the gas tungsten arc welding (GTAW) process.

This paper focuses on a system for automatic and optimized planning of the GMA welding operations. The system builds upon a concept for automatic weld process planning and online real-time feedback control created at Aalborg University, Denmark (Refs. 5–10). The struc-

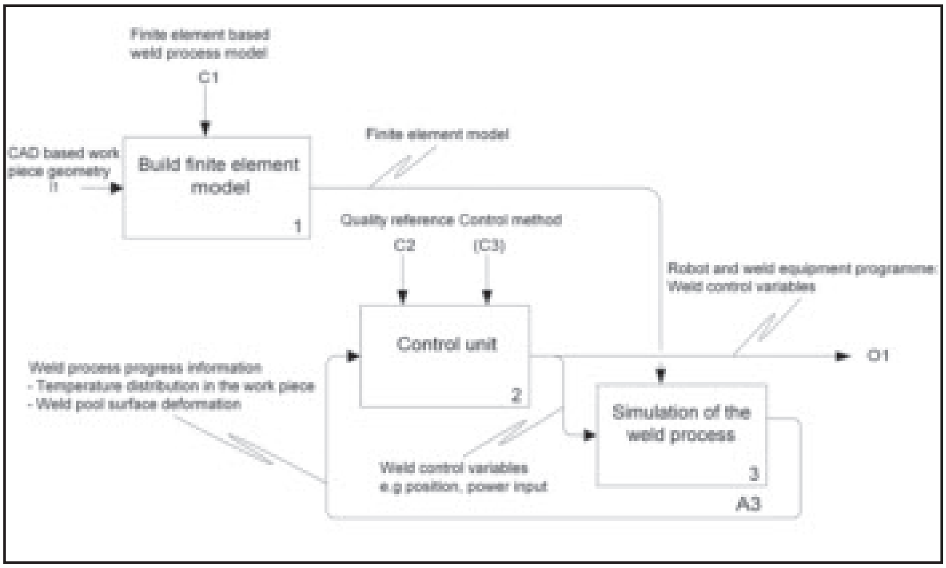

Fig. 1 — The off-line process-optimized weld planning system.

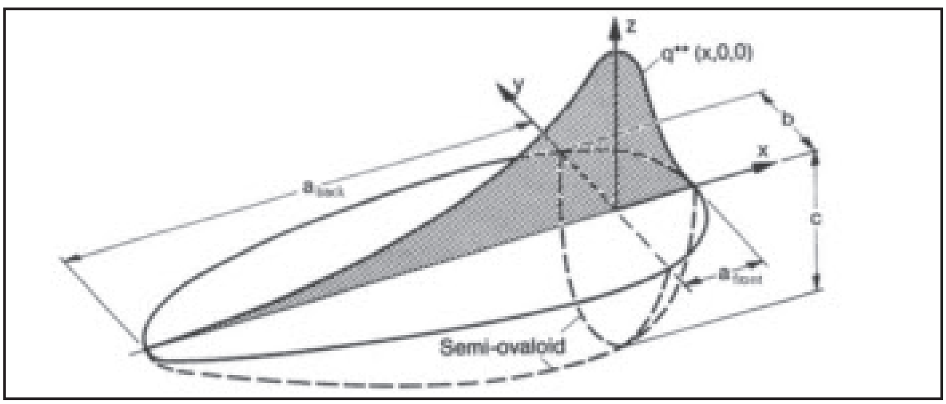

Fig. 2 — Volumetric heat source (Ref. 12).

ture of the system is presented along with the finite element model and the iterative learning algorithm used to perform the process optimization. At present, the system is used to plan butt joint complete penetration single-pass GMA-welding tasks. The results of open-loop execution of planned weld tasks are presented. A more thorough description of the system can be found in Ref. 8.

Off-Line Process Optimized Weld Planning

The automatic off-line planning system consists of two parts. One part is the finite element model, which models the workpiece geometry and the welding process. The other part of the planning system is a control function, which is used to optimize the simulated process. Figure 1 shows a diagram of the off-line process-optimized weld planning system. During simulation, the weld process information is sampled at each time step to identify the weld process progress. Depending on the control method, the information can either be used to adjust the values of the process control variables for the next time step, or the information can be saved and used to update the entire trajectory of the process control variables before a new simulation is performed. The latter is the case with iterative learning control.

The control unit in Fig. 1 takes a quality reference as input, which as an example can be the maximum allowed weld pool surface deformation or the minimum required size of the fusion zone. Based on the comparison of the quality reference and the process progress, the control unit makes rectifying actions on the values of the welding control variables such that the error between the desired quality and the process progress is minimized. In this way the controlled simulation identifies the optimal trajectories of the welding control variables with regard to the desired quality reference. The level of optimality depends on the effectiveness of the control method applied. A primary benefit of using a simulation in search of optimal settings of the welding control variables is removal of costly experiments in search of the optimal settings.

The trajectory of the optimized control variables is saved and used as a basis for a robot program used for the physical execution of the simulated weld task. If the agreement between the simulation and the physical world is good, the physical execution of the planned weld will result in an optimized process with regard to the quality reference. However, if the difference between the simulated and the physical world is not sufficiently small, a real-time feedback control system is needed. A real-time feedback control system based on a temperature-sensitive camera has been developed and presented in Ref. 9. The system compares the weld pool surface temperature profile obtained during execution with the reference weld pool surface temperature profile obtained during simulations. Hence, the off-line process-optimized planning system generates the real-time quality reference.

Finite Element Model

The finite element model for simulating complete joint penetration welding consists of two parts: a heat conduction model to simulate the temperature distribution within the workpieces and a weld pool surface shape model, which simulates the shape of the weld pool surface. The latter is of special interest when simulating complete joint penetration welding and welding on an inclined workpiece because in these cases there is an increased risk of breaking the weld pool surface. The two models are coupled together through the cross-sectional area of the weld pool. The location of the melting isotherm is identified by the heat conduction model, and is set to 1530°C (Ref. 8). The material within the area between the melting isotherms is considered to consist of liquid metal, and the domain of this area is transferred to the weld pool surface shape model as the domain of interest. Further description of the coupling of the models is presented in Refs. 8 and 10.

Heat Conduction Model

The heat conduction model calculates the heat distribution inside the workpiece

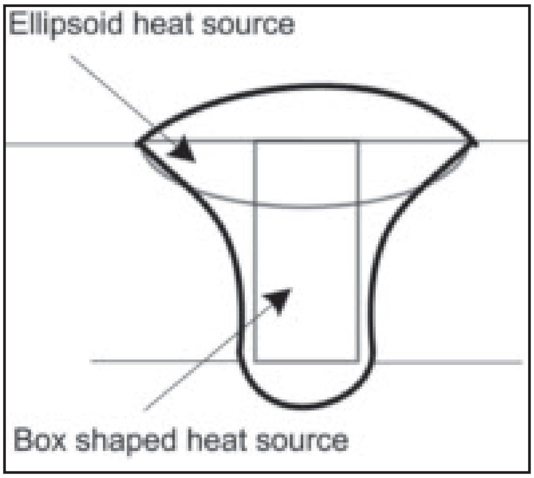

Fig. 3 — Sketch of the heat sources' area of action (gray lines).

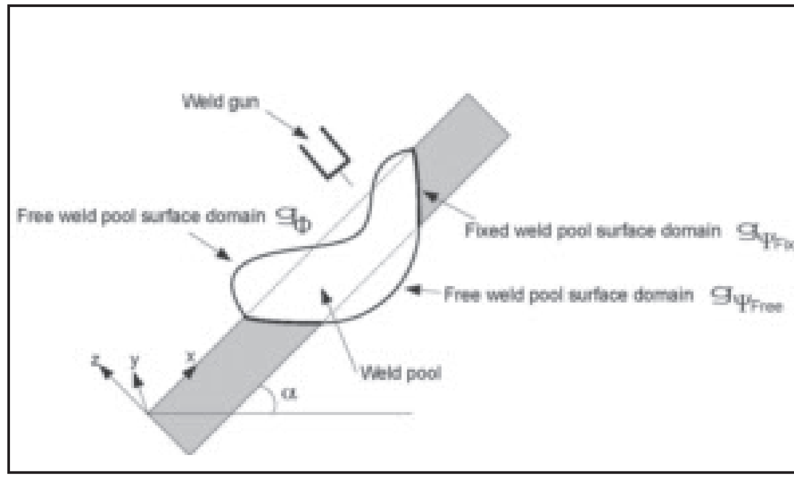

Fig. 4 — Model of workpiece and weld pool.

by use of Fourier's heat conduction equation. On the surface, the heat transport is determined by convection and radiation (Ref. 11). The use of Fourier's heat conduction equation is based on constant values for density of metal (ρ), convection and radiation factors, temperature-dependent values of thermal conductivity (k),and heat capacity (c) (Ref. 8).

The power input to the workpiece from the welding arc and liquid metal is simulated by two different heat sources, which are following each other along the weld joint. The first heat source is a three-dimensional volumetric heat source (Ref. 12):

$$Q_v'''\left(x^*,y^*,z^*\right) = \frac{6\sqrt{3}fQ_{eff}}{abc\pi\sqrt{\pi}} e^{-\left(\frac{3x^{*2}}{a^2}+\frac{3y^{*2}}{b^2}+\frac{3z^{*2}}{c^2}\right)} \quad (1)$$

Q_v''' represents the power input to the workpiece [W/m^3], x^*,y^*,z^* represent space coordinates relative to the position of the heat source, and Q_{eff} represents the effective power delivered by the ellipsoid heat source. a,b,c represent variables that control the energy distribution within the workpieces. a is divided into two parts a_{front} and a_{back} used in front of and behind the heat source center. f represents a factor used to change the energy induced into the workpiece in front of and behind the heat source center. f_{front} and f_{back} is calculated based on a continuous heat source distribution across the x = 0 plan (Ref. 12). With the volumetric heat source, it is possible to approximate the weld pool tail and to obtain a rounded shape of penetration. A drawing of the area of action of the volumetric heat source can be seen in Fig. 2.

The second heat source is a box-shaped heat source (Ref. 8). This heat source was introduced because of material addition, which represents an abrupt transition from an empty joint to a joint filled with liquid metal. The domain Ω_{box} of the box-shaped heat source is the width of the joint, the workpiece thickness, and the length moved by the heat source in each time step during simulation. The power Q_{box} is equally distributed inside the box

$$Q_v'''\left(x,y,z\right)=\begin{cases}\frac{Q_{box}}{V_{box}} & \left(x,y,z\right)\in\Omega_{box}\\ 0 & \left(x,y,z\right)\notin\Omega_{box}\end{cases} \quad (2)$$

Here, V_{box} represents the volume of the box-shaped heat source domain. A cross-section drawing of the two heat sources' area of action can be seen in Fig. 3.

The total heat input Q to the workpiece is calculated based on the heat input from the power supply (Voltage U · Current I) and the efficiency (η): $Q = U \cdot I \cdot \eta$. The total heat input Q is distributed to the workpiece in two ways by the two heat sources: as Q_{eff} by the three-dimensional volumetric heat source and as Q_{box} by the box-shaped heat source. The two contributions fulfill the constraint $Q = Q_{eff} + Q_{box}$. During all experiments, both for calibration and the subsequent validation, the voltage U and current I are chosen such that a usable and stable welding process is obtained. The relationship between U and I is determined during initial experiments. The relation between U and I is also used when planning the process-optimized welding task, where the relation is used to determine the U and I settings based on the value of heat input Q, which is identified as giving the optimal process.

It is important to remember that the heat conduction model does not include any fluid properties of the liquid metal in the weld pool. The heat sources are instead used to simulate the effect of energy distribution caused by the convection of liquid metal.

Weld Pool Surface Shape Model

The weld pool surface shape model (Fig. 4) is used to calculate the surface deformation in the z-direction (vertically to the workpiece surface).

The domain for the weld pool surface shape model is identified by an approximation of the melting point isothermal in the heat conduction model (Ref. 10). The surfaces of the weld pool will in a static equilibrium attain a deformation configuration, which results in minimum energy contents. Based on this energy consideration and the mathematical method of Calculus of Variation, the following deformation equations were developed (Refs. 8 and 13):

$$P_a\left(x,y\right)+\rho g\sin\left(\alpha\right)\cdot x+\rho g\cos\left(\alpha\right)\cdot\Phi-\lambda-\nabla\left(\frac{\gamma\nabla\Phi}{\sqrt{1+\left|\nabla\Phi\right|^2}}\right)=0$$

$$-\rho g\sin\left(\alpha\right)\cdot x-\rho g\cos\left(\alpha\right)\cdot\left(\Psi-s\right)+\lambda-\nabla\left(\frac{\gamma\nabla\Psi}{\sqrt{1+\left|\nabla\Psi\right|^2}}\right)=0 \quad (3)$$

In the above equation, $P_a(x,y)$ is the arc pressure, ρ is the density of liquid metal and is considered as constant (Ref. 8), g is gravity and is constant, α is the workpiece

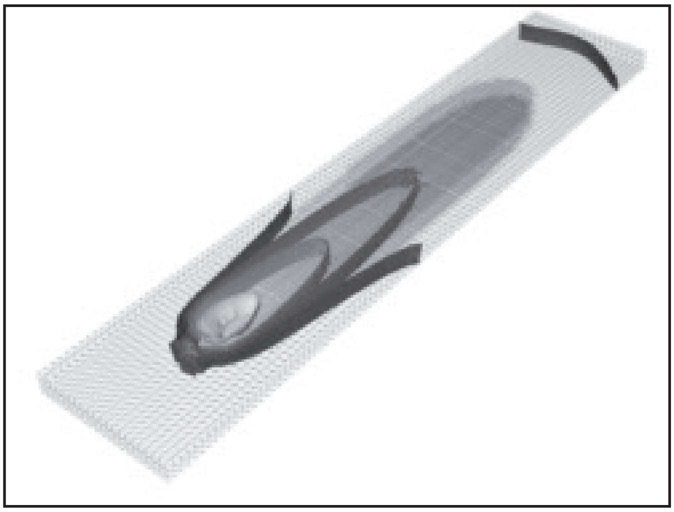

Fig. 5 — Temperature distribution in the heat conduction domain. The isotherms are set at 700°, 900°, 1100°, and 1530°C.

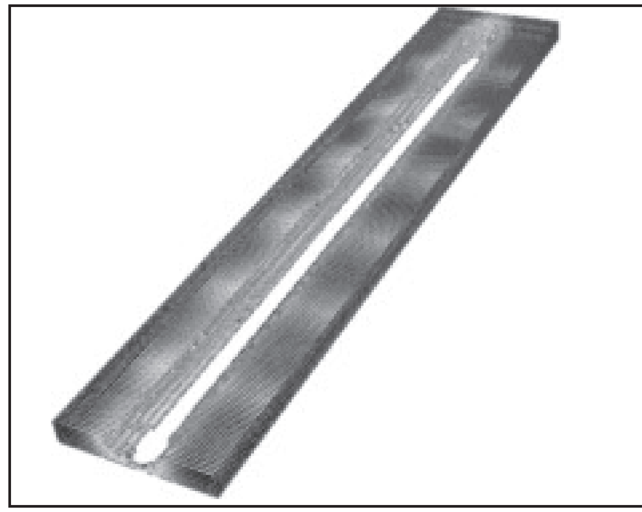

Fig. 6 — Fusion of the workpieces is shown by removing all elements that have been above the melting point. It shows that a complete joint penetration weld is obtained except from the start of welding. At the end of the welding, the weld pool gets wider because the heat input is not able to be conducted away from the fusion zone.

inclination, Φ and Ψ are the surface deformations of the uppermost and lowermost surfaces respectively, γ is the surface tension, s is the workpiece thickness, and λ is a La Grange multiplier, which connects the two equations, for example, by a constraint on the weld pool volume, or in this case of GMA welding, a constraint on the cross section of the crown. The distribution of the arc pressure $P_a(x,y)$ is calculated by an exponential equation (Equation 4), which is a practical simplification of a physically description of $P_a(x,y)$ (Ref. 14).

$$P_a(x,y) = P_{a,\max} \cdot e^{\frac{x^2+y^2}{\kappa}} \quad (4)$$

In GMAW, the continuous feed wire adds material to the welding process, which is used for filling up the joint. Excessive material forms a crown of material on the surfaces of the workpieces, while observing the mass constraint present in Equation 5.

$$\dot{V}_{crown} = \dot{V}_{wire} - \dot{V}_{gap} \quad (5)$$

$\dot{V}_{crown}$, $\dot{V}_{wire}$, and $\dot{V}_{gap}$ are the rate of material used for the crown, rate of filler metal added, and rate of material used to fill the joint. The material used on the crown in the simulation is obtained by identifying the outermost deformation contour of the weld pool surface. This is expected to be equal to the final shape of the crown. This can be formulated as:

$$\dot{V}^{*}_{crown}(\lambda) = v \cdot \int \Phi_{contour}(y,\lambda) - \Psi_{contour}(y,\lambda)\,dy \quad (6)$$

$\dot{V}^{*}_{crown}$ is the simulated rate of material used on the crown, v is the welding speed, $\Phi_{contour}(y,\lambda)$, and $\Psi_{contour}(y,\lambda)$ are the outermost deformation contour of the weld pool surfaces at a given y-position (perpendicular to the welding direction). The constraint that should be fulfilled in search for the correct value of λ is then (Refs. 8 and 13)

$$\dot{V}_{crown} - \dot{V}^{*}_{crown}(\lambda) = 0 \quad (7)$$

Each time the weld pool deformation is calculated, the following iterative calculation is performed: First, on the basis of an initial guess of λ, Equation 3 is solved. Second, the volume constraint is evaluated using Equations 5–7. Based on the results of the volume constraint, the value of λ is updated, and the process is repeated until an acceptable value of λ is obtained (Ref. 15).

Simulation Plots

Results from a simulation can be viewed in Figs. 5–8. The workpiece is 100 mm long, 40 mm wide, and 3 mm thick. Figure 5 shows the temperature distribution in the heat conduction domain by use of four isotherms: 700°, 900°, 1100°, and 1530°C. The last is the melting point of the metal and, therefore, the 1530°C isotherm identifies the boundary of the weld pool. Note that the picture also reveals the adaptive grid used. The fusion of the workpiece and the penetration can be identified in Fig. 6, which shows a reference grid containing the maximum temperatures obtained during simulation. All the elements in the grid, which have had temperatures above the melting point, are removed. It can be seen that complete joint penetration does not occur initially. Therefore, the energy input needs to be higher in the beginning to obtain complete joint penetration from the start of welding. It can also be seen that at the end of the welding process, the weld pool is getting wider in the bottom before the heat source is turned off. This is because the energy cannot be conducted away from the fusion zone at the end of the workpiece. This increases the risk of breaking the weld pool surface. To avoid this, the heat input should be reduced close to the end of the welding process.

Figures 7 and 8 show the surface deformation. Figure 7 shows the front surface deformation Φ_{top}. The center of the heat source is located at the origin of the coordinate system. The effect of the arc pressure can be seen as a depression on the surface. Figure 8 shows the back surface deformation Φ_{bottom}.

The simulation results indicate that the finite element model works. However, the simulation results are not usable for process prediction before the heat source and material addition functions are calibrated.

Calibration of Finite Element Model

Before the finite element based GMAW model can be used for weld planning, several model parameters need to be calibrated. Calibration is needed because the model includes several variables,

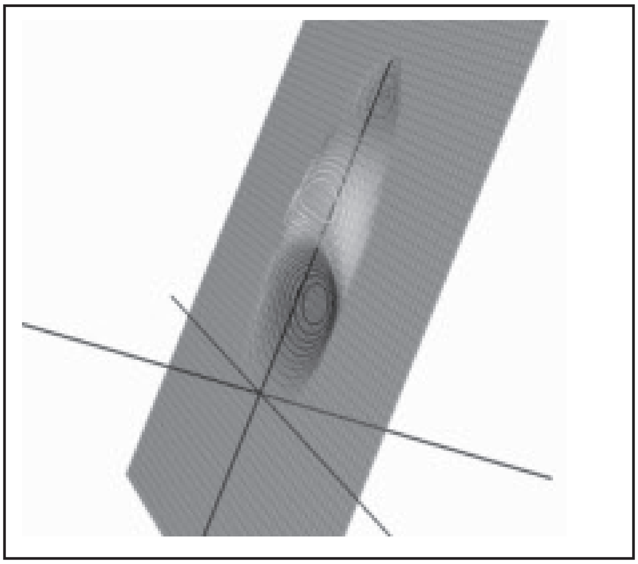

Fig. 7 — The top surface deformation Φ_{top} for the front surface. The heat source is moving from the top and down. The center of the heat source is located at the origin of the coordinate system.

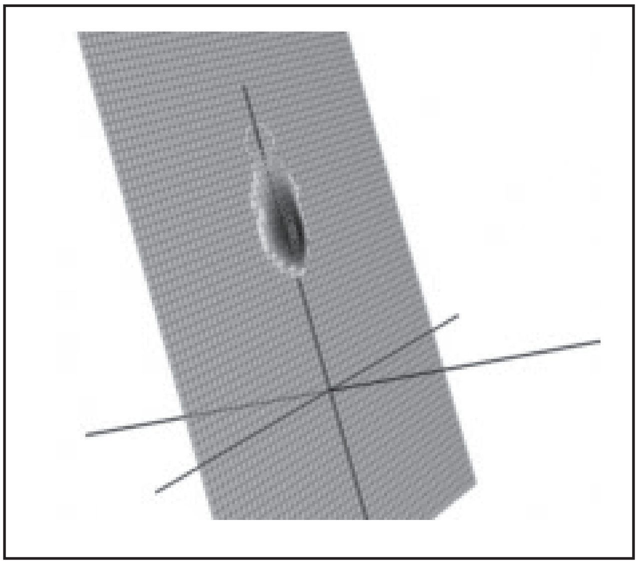

Fig. 8 — The bottom surface deformation Φ_{bottom} for the back surface. The heat source is moving from the top and down. The center of the heat source is located at the origin of the coordinate system.

which do not have any direct physical meaning. An example is the extension parameters *a, b* and *c* in the volumetric heat source. These parameters arise from describing physical properties by simplified expressions. Calibration can also be needed for parameters that have a physical meaning but for which it is difficult to obtain correct values. The developed GMAW model includes parameters of this type, e.g., surface tension γ. Surface tension varies with the actual composition of the material in the weld pool, e.g., the contents of sulfur.

The model parameters to calibrate in finite element model are

1) η, Q_{box} to calculate the power input to the workpiece and the distribution between the two heat sources in the heat conduction model.

2. a_{front}, *a, b, c* to calculate the shape of the three-dimensional volumetric heat source.

3. $P_{a,max}$, κ, γ to calculate the weld pool surface deformation.

The calibration of model parameters can be a complicated task to do manually because of the often nonlinear complex relation between parameter values and the simulated output. This makes the trial-and-error method unfeasible in practice. An automated optimization routine can therefore be helpful in search for the best parameter settings. In this research, an optimization routine called CFSQP (C code for feasible sequential programming, Ref. 16) is used together with the finite element software Diffpack (Ref. 17), which is a scientific-computing environment with emphasis on the finite element method. Overview of the integration can be seen in Fig. 9.

The calibration of a GMAW model can be performed in two different ways: either calibrate to a single experiment or calibrate to multiple experiments. Using a single experiment entails the parameter values to be constant when the model is used for prediction. When using multiple experiments, it is possible to identify the dependence of the model parameters with regard to changes in the control variables welding speed v and power input Q, and hence enable an interpolation of the parameter values throughout the process window when the model is used for prediction. In that way calibration to single or multiple experiments can have a large effect on the range of the acceptable prediction capability of the model. This can influence the usability of the calibrated model in search of optimal settings of the weld process control variables, hence the usability of the calibrated model in process optimized weld planning.

The welding process used for calibration is a top-down complete joint penetration, single-pass butt joint model calibrated to a 5-mm thick workpiece with a 2-mm weld joint width (Ref. 18). An overview of the experiments performed can be seen in Fig. 10. The multiple experiment calibration is performed in this research based on four experiments: QHWL, QLWL, QHWH, and QLWH. The remaining five points are used for validation of the obtained prediction

Table 1 — Results from Manual Welding of a Rectangular Workpiece

Current I(A)	194	Avg. weld speed v(mm/s)	5.33
Voltage U(V)	23	Heat Input E(kJ/mm)	0.84
ξ_{top} (mm)	7.1	ϕ_{top} (mm)	1.1
ξ_{bottom}(mm)	3.5	ϕ_{bottom}(mm)	1.3

Table 2 — Results from a Simulation and Optimization of Welding of a Rectangular Workpiece

Current I(A)	164	Avg. Weld speed v(mm/s)	5.68
Voltage U(V)	20	Heat Input E(kJ/mm)	0.58
ξ_{top} (mm)	7.4	ϕ_{top} (mm)	0.7
ξ_{bottom}(mm)	3.2	ϕ_{bottom}(mm)	1.5

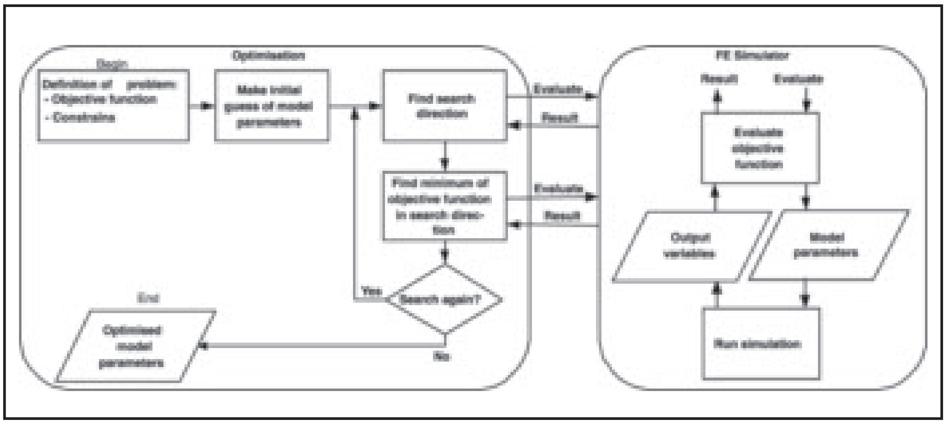

Fig. 9 — A diagram of the integration of the optimization routine and the finite element simulator.

Table 3 — Results from Two Welding Experiments on Rectangular Workpieces Using Optimized Variable

Ex. 1	Current I(A)	168	Avg. Weld speed	5.67
	Voltage U(V)	20.4	Heat Input E(kj/mm)	0.60
	ξ_{top} (mm)	5.9	ϕ_{top} (mm)	0.7
	ξ_{bottom}(mm)	3.3	ϕ_{bottom}(mm)	1.1
Ex. 2	Current I(A)	158	Avg. Weld speed	5.67
	Voltage U(V)	20.2	Heat Input E(kj/mm)	0.56
	ξ_{top} (mm)	4.9	ϕ_{top} (mm)	0.6
	ξ_{bottom}(mm)	3.0	ϕ_{bottom}(mm)	0.6

capability.

Test results from the validation of the model calibrated to a single experiment show a general increasing error level from the calibration experiment to the validation experiments. The results from validation of the model calibrated to multiple experiments do not show the same overall increasing error level. Figure 11 shows a picture of a polished cross section for validation point QMWL. Further elaboration of the calibration results can be found in Refs. 8 and 18.

The multiple experiments calibrated model does also succeed in identifying the process boundary. The three process boundary test experiments are outside the process window. Simulation of these experiments did predict a loss of weld pool. This indicates that the prediction capability of the multiple experiments calibrated model can be extrapolated outside the range of the calibration experiments. In addition to this, the model can be used to identify an approximate location of the process boundary beyond which the process will be invalid. This is an important property of the multiple experiments calibrated model, and it increases the usability of the model for weld planning.

When performing prediction of the welding process, the varying interpolated parameter values are identified by using a two-dimensional bilinear interpolation method, which is expected to be sufficient for obtaining a suitable model prediction capability. This two-dimensional bilinear interpolation method utilizes the multiple experiment calibration performed in this research, which is based on four experiments. To secure linear interpolation despite the location of the four experiment points in the process window, an isoparametric formulation of the two-dimensional bilinear interpolation method is introduced (Ref. 19), which is an essential formulation in the finite element method. The derivation and solving procedure can be found in Refs. 8 and 20.

In general, the gain of new knowledge, obtained from models, about the part of the process windows in which the models themselves have been trained or calibrated, can be questioned. This is because the same gain of knowledge might be retrieved from the experiments themselves without use of models. Interpolating model parameters is a method to improve the gain of knowledge and thereby the usefulness of models. The reason is that the density of necessary calibration points in the process window may be much lower than the density of necessary experimental points to obtain applicable process knowledge, e.g., to build a process database. The fewer necessary calibration points, the more useful the model is and less experimental resource consuming.

Iterative Learning Control

Iterative learning control (ILC) is a method for improving the transient response in an iterative process. Information about the output error e_k from iteration k is used to update the input u_{k+1} for the next iteration $k+1$. The basic principle can be seen in Fig. 12 where $u_k(t)$ is the input to, and $y_k(t)$ is the output from, the *k'th* process iteration at time t. The variables $y_d(t)$ and $u_{k+1}(t)$ are the desired output and input to the next process iteration, respectively.

Iterative learning control needs the following conditions to function (Ref. 22):

1) The initial conditions are identical in each iteration.

2) The disturbance is identical in each iteration.

3) The plant parameters are stationary or slowly varying.

4) Each iteration has the same duration.

5) The desired output y_d is identical in each iteration.

The use of ILC in the off-line process optimized weld planning system benefits from the fact that the simulation can be repeated an infinite number of times with zero disturbance, identical model parameters, and identical initial conditions. Normally, ILC is applied to processes where the input is a function of time. In welding applications, the input as a function of position along the weld joint x is of interest and therefore time t is replaced with distance x — Fig. 13. Each process iteration will have the same weld joint length and the five conditions for ILC to function are fulfilled.

The ILC algorithm used in the weld planning in this paper is

$$\bar{e}_k(n)=\bar{y}_d(n)-\bar{y}_k(n)$$

$$\bar{u}_{k+1}(n)=\bar{u}_k(n)+\bar{\bar{\zeta}}\bullet\bar{\bar{\Gamma}}\bullet\bar{\bar{E}}_k(n)\bullet\bar{L} \quad (8)$$

where $\bar{u}_k(n)$, $\bar{y}_k(n)$, $\bar{y}_d(n)$, $\bar{e}_k(n)$ are the i-dimensional input vector, the j-dimensional output, desired output and error vectors at point, n respectively. The $\underline{(i,i)}$ dimensional diagonal damping matrix $\bar{\bar{\zeta}}$ is used to avoid oscillations in $\bar{u}_k$. The elements in $\bar{\bar{\zeta}}$ are in this paper set to the same value ζ. $\bar{\bar{\Gamma}}$ is the

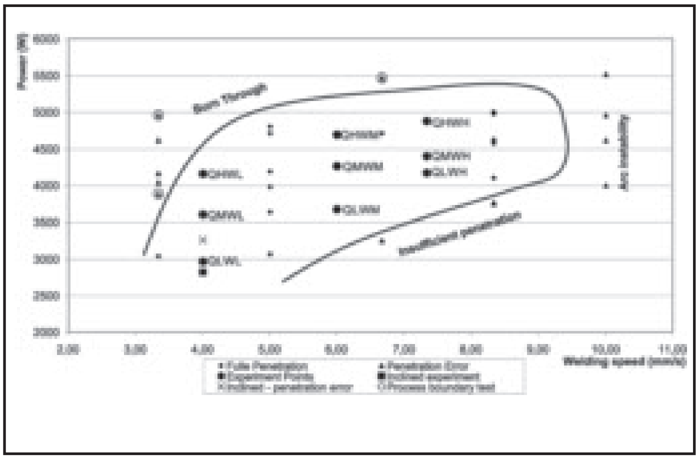

Fig. 10 — Diagram of the identified process window. The diamond and triangle show the experiment points in the first series of initial experiments. The triangles with a circle around are used to validate the capability of identifying the process boundaries. The round dots show the experiment points in the second series of experiments used for calibration and validation. The points are marked as Q and W for power and welding speed and L, M, and H for low, middle, and high level, respectively. The thick black curve shows the contour of the approximate process window.

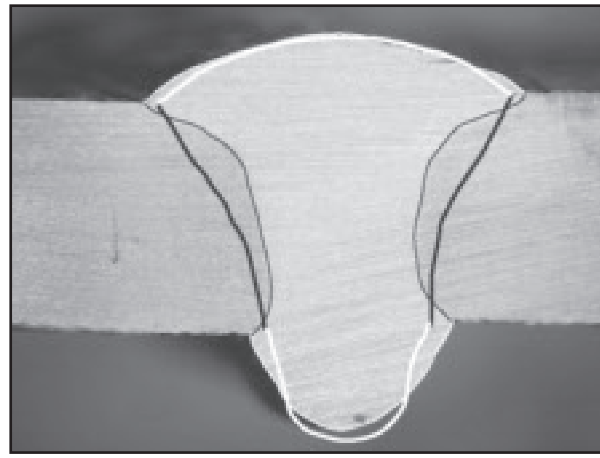

Fig. 11 — Picture of polished cross section for the validation point QMWL. The thin line marks the weld pool boundary, while the thick line marks the simulated weld pool boundary.

(i,j) dimensional error-weight matrix. $\bar{\bar{E}}_k(n)$ is the (j,m) dimensional error matrix, which includes the error vectors at different points n used to update $\bar{u}_k$. As an example $\bar{\bar{E}}_k(n)=[\bar{e}_k(n)\bar{e}_k(n+1)]$ where $m = 2$. $\bar{L}$ is the m-dimensional point-weight vector, which weights the influence of the error at different points n. n is the location on the workpiece along the weld joint — Fig. 13.

The error $e(n)$ is minimized with regard to the l_2-norm

$$\min \left\| \sqrt{\sum_{n=1}^{N} \bar{e}_{k,1}^2(n) + \ldots + \bar{e}_{k,j}^2(n)} \right\| \quad (9)$$

Many different configurations of the ILC algorithm presented in Equation 8 are possible, which can have vital influence on the effectiveness and efficiency of the ILC method. Based on simulation tests, the following basic settings have been chosen (Ref. 23):

$$\bar{L}=\begin{bmatrix}0.6 & 0.4\end{bmatrix}^T, \zeta = 25\%, \bar{\bar{E}}_k(n)=\begin{bmatrix}\bar{e}_k(n) & \bar{e}_k(n+1)\end{bmatrix}$$

and a 4-mm spacing between the points along the workpiece.

Simulation with Varying Workpiece Geometry

Simulation based on the heat conduction model is performed to illustrate the capability of process optimized weld planning with dynamic welding control variables. A sketch of the workpiece can be seen in Fig. 14.

The input is welding speed v and power input Q. The output is the widths of the fusion zone at the top ξ_{top} and the bottom ξ_{bottom} of the workpiece and hence $i = j = 2$. This gives the following input and error vector:

$$\bar{u}_k(n)=\begin{bmatrix}v_k(n) & Q_k(n)\end{bmatrix}^T \quad \bar{e}_k(n) = \begin{bmatrix}e_{k,\xi_{top}}(n) & e_{k,\xi_{bottom}}(n)\end{bmatrix}^T \quad (10)$$

The $\bar{\bar{\Gamma}}$ can be seen in Equation 11. Its values are based on information obtained during calibration of the model (Ref. 8). These settings entail that a too small ξ_{top} decreases v, and a too small ξ_{bottom} increases Q.

$$\bar{\bar{\Gamma}}=\begin{bmatrix}-1.1 & 0\\ 0 & 4.5e5\end{bmatrix} \quad (11)$$

In Fig. 15 a comparison of the process optimized planned trajectory of the welding control variables with the initial constant-valued guess can be seen. The resulting width of the fusion zone of the initial guess and of the process optimized planned trajectory can be seen in Fig. 16.

The fusion zone width has primarily been optimized with regard to the bottom fusion zone width, which initially was too small compared to the desired reference. The process optimized trajectories of the control variables show as expected a significant variation in the welding speed v in the area where the workpiece width is small. The variation in power input Q in the area of the small workpiece width is not that significant, but it does show an increase.

The identified trajectories of the process control variables seen in Fig. 15 show settings, which are known to be outside the process window and will result in loss of the weld pool. In the ILC-based process optimization, only process progress information about the width of the fusion zone is used to update the input. As long as the error is not zero, the ILC method will continue to search along the direction given by $\bar{\bar{\Gamma}}$ although it crosses the process boundary and the weld pool is lost. Therefore, process progress information about the weld pool deformation will be included in weld planning for physical execution to identify when the process boundary is being crossed and the weld pool is lost.

Experiment with Rectangular Workpiece

To evaluate the benefit of the system for process optimized off-line weld planning at its present development status, two open loop execution experiments of planned optimized welding tasks were performed. The goal of the process optimized weld planning was to minimize the heat input while securing a minimum fusion zone width ξ_{min}, and a maximum crown height Φ_{max}. Φ_{max} was set in accordance with the welding standard used at Odense Steel Shipyard, which is 1.0 mm + 0.2·ξ. It is based on the standard DS/EN25817. However, the constraint on $\Phi_{max, bottom}$ was tightened by 0.5 mm in the optimization due to a model weakness.

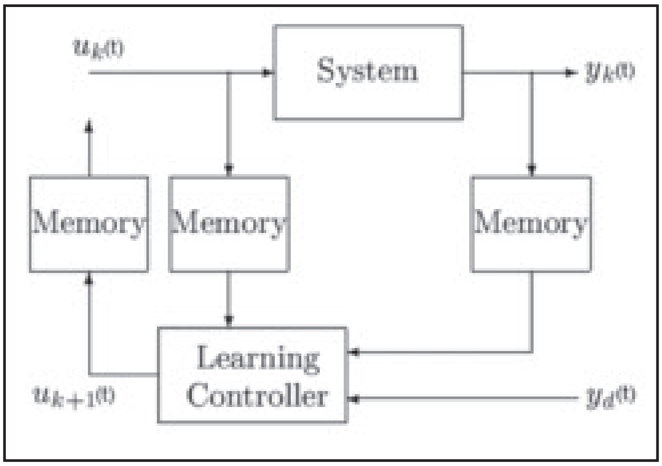

Fig. 12 — Diagram of the basic principle of ILC (Ref. 21).

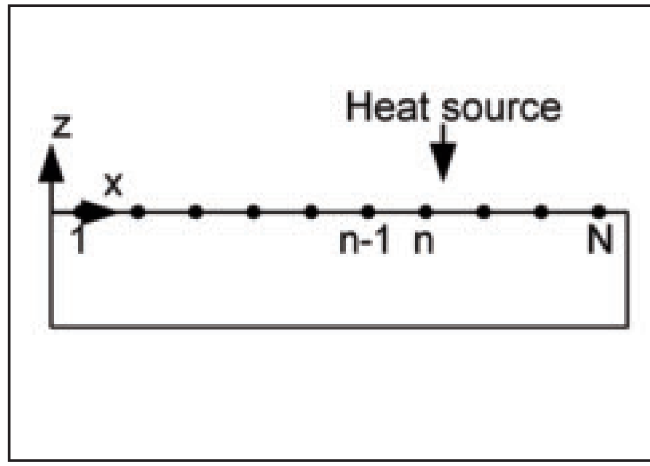

Fig. 13 — Sketch of the workpiece along the weld joint where the points 1..n..N are marked.

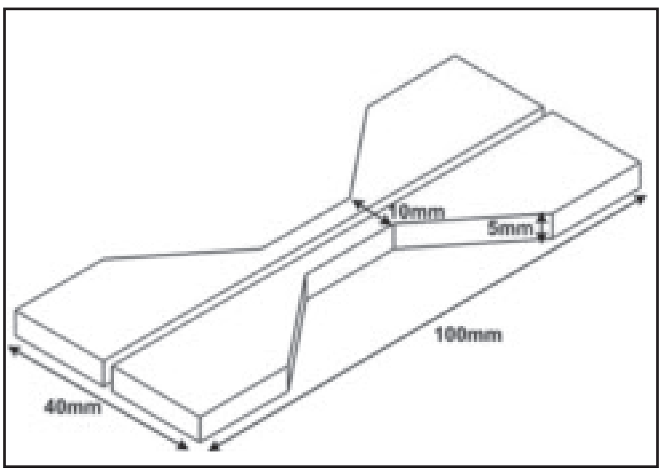

Fig. 14 — Picture of the nonuniform workpiece used for simulation.

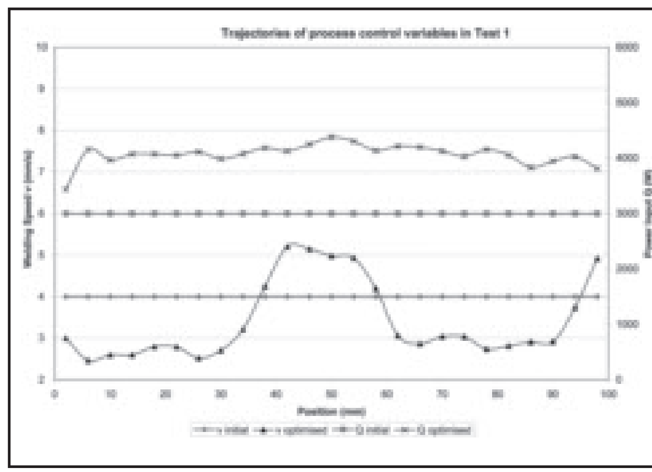

Fig. 15 — Graph of the process optimized planned trajectory of the welding control variables and the initial constant-valued guess.

Table 4 — Results from Manual Welding of a Nonuniform Workpiece

Process Settings	$I(A)$	$U(V)$	v(mm/s)	E(kJ/mm)
	189	22.9	5.33	0.81
Pos.	ξ_{top}	ξ_{bottom}	ϕ_{top}	ϕ_{bottom}
40 mm	8.2 mm	3.4 mm	1.2 mm	1.5 mm
100 mm	12 mm	5.2 mm	1.9 mm	1.0 mm
160 mm	8.6 mm	3.7 mm	1.3 mm	1.1 mm

Table 5 — Results from Welding a Nonuniform Workpiece with Optimized Process Variables

Process Settings	$I(A)$	$U(V)$	v(mm/s)	E(kJ/mm)
	177	20.9	5.50	0.67
Pos.	ξ_{top}	ξ_{bottom}	ϕ_{top}	ϕ_{bottom}
40 mm	6.6 mm	3.0 mm	1.3 mm	0.8 mm
100 mm	8.0 mm	3.7 mm	0.8 mm	0.9 mm
160 mm	6.9 mm	3.2 mm	0.9 mm	1.2 mm

This weakness is caused by the finite element model's lack of capability to fully simulate the outward opening of the weld pool at the bottom of the workpiece. This causes the model to predict a too small weld pool width at the bottom and hence a too small bottom crown height (Ref. 18). The constraint settings were

$\xi_{min,top} = 4.0$ mm

$\Phi_{max,\ top} = 1.0$ mm $+ 0.2 \cdot \xi_{top}$

$\xi_{min,bottom} = 3.0$ mm

$\Phi_{max,\ bottom} = 0.5$ mm $+ 0.2 \cdot \xi_{bottom}$

If the constraints are passed, the error will be different from zero and is included in the updating algorithm of $\bar{u}_{k+1}$. In process optimized weld planning with regard to minimum heat input, the $\bar{e}_k(n)$ and $\bar{\bar{\Gamma}}$ used can be seen in Equation 12A, which again is obtained from Ref. 8.

$$\bar{\bar{\Gamma}} = \begin{bmatrix} -1.1 & 0 & 0 & 0.58 & -le\text{-}9 \\ 0 & 4.5e5 & 0 & 5e5 & 1.5e\text{-}4 \end{bmatrix} \quad (12A)$$

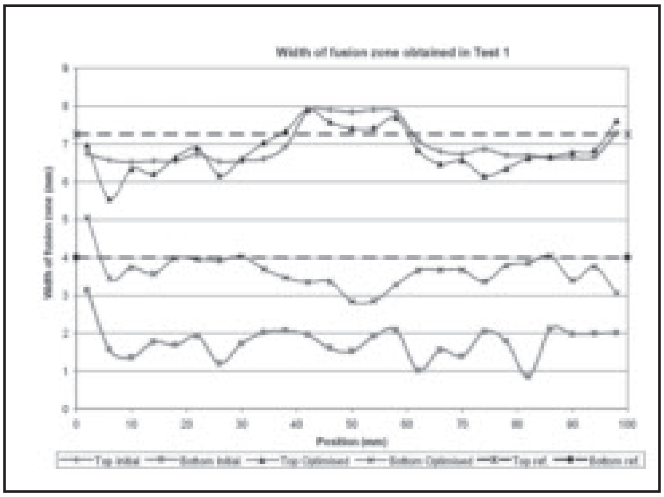

Fig. 16 — Graph of the resulting width of the fusion zone of the initial guess and of the process optimized planned trajectory. The desired reference is also shown.

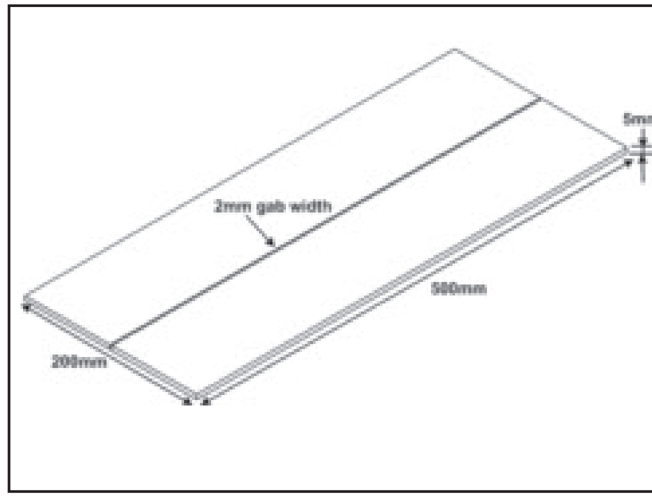

Fig. 17 — Picture of the rectangular workpiece used in the first open-loop experiment.

$$\bar{e}_k(n) = \begin{bmatrix} e_{k,\xi top}(n)\, e_{k,\xi bottom}(n)\, e_{k,\Phi top}(n) \\ e_{k,\Phi bottom}(n)\, e_{k,heat\ input}(n) \end{bmatrix}^T \quad (12B)$$

The first experiment was welding of a rectangular workpiece (Fig. 17), where the open-loop execution of a process optimized planned trajectory is compared with a manually executed weld.

The average settings of the process variable obtained during manual welding and the average resulting process output are shown in Table 1.

The result of the manual welding does in general fulfill the constraints except for Φ_{bottom}. However, Φ_{bottom} does not pass the welding standard used at Odense Steel Shipyard, except occasionally due to a variation caused by manual execution of the weld.

The manually obtained setting of the process variables was used as an initial guess for the process optimized weld planning. The planned process optimized trajectories of the process control variables reduced the relative error to 67%. The heat input E was reduced to 69% of that manually obtained. The planned process optimized trajectories showed minor fluctuations around an average value. The average values of the process control variables and the resulting simulated process output are shown in Table 2.

Again, the process output fulfilled the constraints except for Φ_{bottom}, which passed the constraint used during optimization by 0.4 mm, but the welding standard used at Odense Steel Shipyard was not passed.

Based on the heat input minimized weld planning, two open-loop executions (Ex. 1 and Ex. 2) were performed. The average values of the realized process control variables and the resulting process output are shown in Table 3.

The resulting process output of Ex. 1 was in most agreement with the planned weld. However, of major interest was the reduction in heat input to 71% and 67% for Ex. 1 and Ex. 2, respectively, compared to manual welding. The goal of the process optimized weld planning was to reduce heat input while the quality constraints were fulfilled. The reduction in heat input entailed a reduction in the deformation. The maximum deformation of the workpiece plate from its initial position wasManual ≈ 9 mm, Ex. 1 ≈ 4 mm, Ex. 2 ≈ 0 mm.

The deformation of Ex. 1 was reduced to 44% of the deformation obtained with manual welding, and the deformation of Ex. 2 was practically zero. This showed one of the benefits of using process optimized planned trajectories of the weld process control variables as mentioned in the introduction.

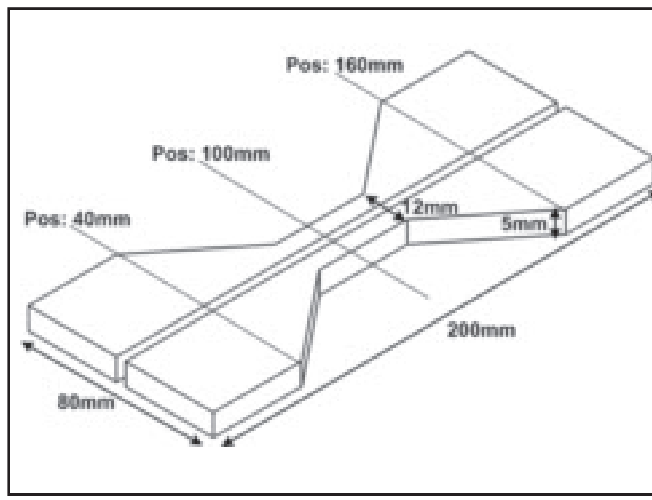

Fig. 18 — Picture of the nonuniform workpiece used in the experiment with a varying thermal region.

Experiment with Varying Workpiece Geometry

To investigate the effect of the process optimization with regard to minimizing heat input on a workpiece where the geometry changes influence on the thermal process conditions, a second experiment was performed. The workpiece, for which the trajectories of the optimal process control variables were planned, can be seen in Fig. 18.

For comparison, the weld was executed using a robot and the manual settings of the process variables found in the experiment with the rectangular workpiece (Table 4). This gave results measured along the weld joint. The data fulfilled the demands from the welding standard:

In the narrow part of the workpiece, the weld pool was as wide as the workpiece, and examination of the workpiece showed that the edges were melted and the shape was altered.

The planned process optimized trajectories of the process control variables weld speed v and power input Q were almost constant along the weld joint. This is because the quality constraints on the minimum fusion zone width ξ_{min} and the maximum crown height Φ_{max} were in general not violated during the optimization. When quality constraints on the minimum fusion zone width ξ_{min} and the maximum crown height Φ_{max} are not violated, the error $e_{k,\xi top}(n) e_{k,\xi bottom}(n) e_{k,\Phi top}(n)$ $e_{k,\Phi bottom}(n)$ in Equation 12B is zero. This means that the result from the weld pool surface shape model is not included in calculating the error *e(n),* which is minimized during the optimization. Instead the minimization of the error, and hence the update of the welding control variable, was predominated by the wish to minimize the heat input, which means that the optimization was based on results from the heat conduction model. This will cause a uniform update of the welding control variables when the initial guess is uniform. A more fine-tuned ILC based process optimized weld planning, which drives the process more to the edge of the process window, is expected to result in nonconstant process control variables as seen in Fig. 15, because the quality constraints are then expected to be activated. The improvement of the routine for ILC based process optimized weld planning is part of further work needed.

The planned weld was executed in an open loop and the obtained average values of the process control variables and the resulting process output are shown in Table 5.

The resulting process did also comply with the welding standard, and the heat input was minimized to 81% by using the process optimized settings. This reduction avoided melting of the workpiece edges, and it indicates how the weld planning system is able to handle changes in the process conditions.

Conclusion

A system for process optimized weld planning based on numerical simulation of the weld process by finite element, and iterative learning is presented. The system's present capability to perform weld planning that minimizes the heat input and hence workpiece distortion was tested. The results of welding width optimized welding control variables are promising.

The calibration of the GMA model to multiple points has shown a promising capability to predict the weld pool and surface shape within the process window. Going beyond the part of the process window in which the model is calibrated, the model has proven capable of identifying the process boundary between lost and not lost weld pool. This increases the model's usability in industrial applications when there is a search for optimal process settings, because optimal process settings can be rather robust and easy be located near the process boundary.

The capability of the weld planning system to obtain dynamic trajectories of the process control variables was shown in simulations of the welding of a workpiece with varying geometry. Especially, the welding speed showed clear variations. This is important in the planning of welds with varying material distribution around the weld joint, such as with pipe connections. The simulations also showed that not only information about the fusion zone width, but also information about the crown height are essential to reliable weld planning.

Acknowledgments

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Analysis of Metal Transfer and Correlated Influences in Dual-Bypass GMAW of Aluminum

Various factors, including the welding gun setting, joint penetration, and base metal heat input during this process were examined

BY Y. SHI, X. LIU, Y. ZHANG, AND M. JOHNSON

ABSTRACT. Dual-bypass gas metal arc welding (DB-GMAW) is a modified GMAW process. In this novel process, the base metal current is decreased from the melting current by adding two tungsten electrodes to a conventional GMAW system. The resultant bypass arcs change the forces affecting on the droplet, and the resultant metal transfer becomes more desirable. To understand the desirable changes in the metal transfer, this paper applies established theories to analyze the changes in the forces acting on the droplet and the effects of these changes on the metal transfer behaviors. Analysis shows that the bypass arcs and currents lower the critical current needed to achieve the desired spray transfer. Experimental results obtained by a high-speed camera show that the analysis agrees with experimental data.

Introduction

Gas metal arc welding (GMAW) is an arc welding process that establishes an arc between a continuously fed consumable metal electrode and the workpiece. Due to its high productivity, it has become one of the predominant methods to join metals. In recent years, more and more aluminum alloy welded structures have been widely applied. The use of aluminum as an alternative material in more applications has brought a higher requirement and challenge to aluminum welding (Ref. 1). As one of the widely used aluminum welding methods, the GMAW process needs improvements in order to achieve higher weld quality and higher productivity. Since the characteristic of metal transfer in GMAW significantly affects the weld quality especially with respect to its microstructure, porosity formation, strength, and fatigue properties, etc., researchers have made great efforts to study the metal transfer in GMAW (Refs. 2–7). This paper studies the metal transfer in welding aluminum using a novel process that can reduce the heat input.

Low base metal heat input and arc pressure are often critical in meeting specified requirements in aluminum welding (Ref. 8). In a traditional GMAW process, it operates in the globular metal transfer mode at relatively low continuous waveform currents. However, this transfer mode is characterized by periodic formation of large droplets that detach from the electrode primarily by the gravitational force and are typically associated with arc instability (Ref. 9). At higher currents, the transfer mode changes to the desirable spray mode that offers high deposition rate and desirable arc stability, but at the expense of high heat inputs that may be too much for many aluminum welding applications. Moreover, solidification or hot cracking due to the overheating of base metal is also a critical weld quality concern. In order to solve this problem, pulsed gas metal arc welding (GMAW-P) has been developed. In GMAW-P, the pulse parameters can be adjusted to control the droplet transfer mode, heat input, droplet size, or droplet velocities for different applications. However, to achieve the spray transfer, the peak current has to be greater than the transition current, which is relatively high. This relatively high peak current produces a large arc pressure that can easily generate melt through in complete-joint-penetration applications especially during aluminum welding. Further, the parameters for the pulse waveform need to be determined according to material, shield gas, and wire diameter.

Recently, a modified GMAW process has been developed at the University of Kentucky (Ref. 10) to decouple the melting current (which melts the wire and determines the deposition rate) into the base metal current (which determines base metal heat input and arc pressure) and a bypass current. This process is formed by adding a bypass tungsten electrode to bypass part of the melting current that would otherwise, in conventional GMAW, also flow into the base metal. This modified process is referred to as double-electrode GMAW or DE-GMAW. It can achieve the desirable spray transfer at a wide range of low base metal (continuous-waveform) currents. To further reduce the current needed for the desirable spray transfer to address the need of aluminum welding for low heat input and low arc pressure, the authors have further modified the process to result in dual-bypass GMAW (DB-GMAW) in which two bypass tungsten electrodes are used. Experimental results have indicated that the bypass arcs in DB-GMAW do affect the arc forces and their distribution and consequently affect the metal transfer process. This paper is thus devoted to the analysis of the influences of bypass arcs on the forces acting on the droplet and their influences on metal transfer during DB-GMAW of aluminum.

KEYWORDS

Dual-Bypass Gas Metal Arc Welding (DB-GMAW)
Current
Bypass Arcs
Droplet
Base Metal Heat Input
Spray Transfer

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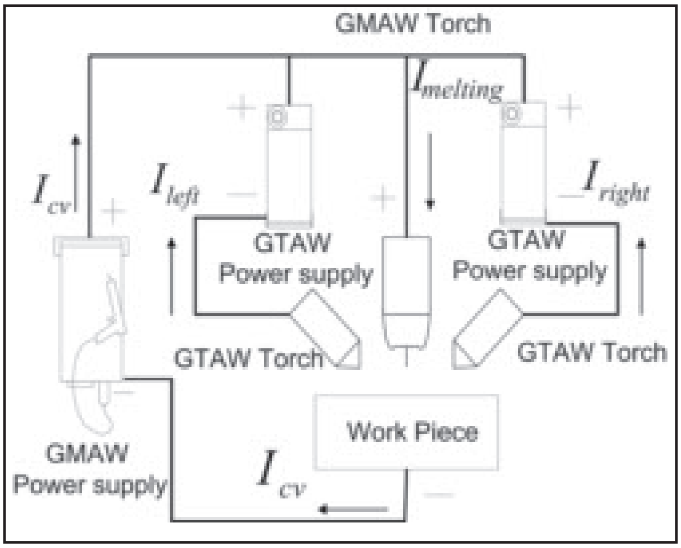

Fig. 1 — Illustration of DB-GMAW.

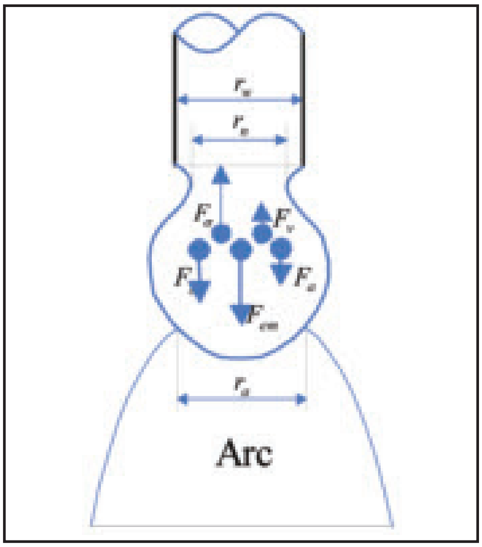

Fig. 2 — Major forces acting on the droplet in GMAW.

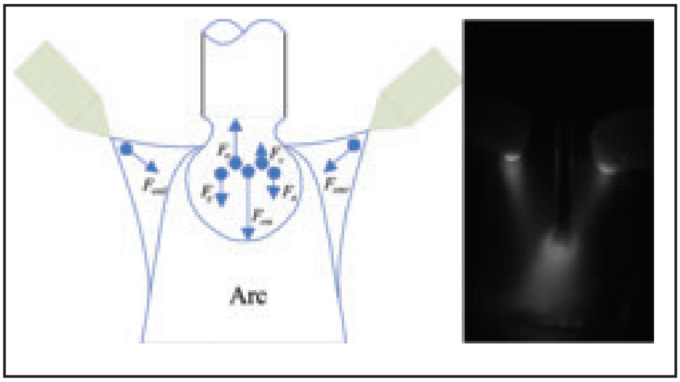

Fig. 3 — Schematic of forces affecting droplet in DB-GMAW.

Principles of DB-GMAW

A dual-bypass GMAW process shown in Fig. 1 was at the University of Kentucky. As illustrated, the system includes a constant voltage (CV) power supply to provide the base metal current I_{cv}, and two constant current (CC) power supplies to provide the left and right bypass currents: I_{left} and I_{right}. The positive terminals of all three power supplies are connected together to the GMAW gun (which provide the bypass tungsten electrodes), respectively. In this way, the total melting current that melts the wire is the sum of currents, i.e., $I = I_{basemetal} + I_{left} + I_{right}$. Thus, the base metal current that controls the base metal heat input and arc pressure imposed on the base metal can be much less than the total melting current. It has been verified by experiments that the total melting current is determined by the preset wire feed speed (WFS) and the welding voltage for the CV power supply. Hence, the base metal current can be decreased by increasing the bypass currents because their sum is a constant. Because the bypass currents are provided by two CC power supplies and can be adjusted freely, the DB-GMAW can provide a large range of base metal currents for each set of wire feed speeds and welding voltages to meet the needs from different applications for different heat inputs and arc pressures. While the effects of DB-GMAW on the base metal heat inputs and arc pressures are straightforward, an analysis is needed in order to understand its effects on the metal transfer process.

Force Analysis

Conventional GMAW

Previous research indicates that the type of transfer obtained is determined by the welding current magnitude and polarity, the wire composition, and activation. It also is affected by the wire diameter and wire extension (Ref. 11). The reason that these factors have an impact on metal transfer is because all these parameters can change how the forces act on the droplet.

In conventional GMAW, the major forces acting on the droplet include the gravity, electromagnetic force (Lorentz force), aerodynamic drag force, surface tension, and vapor jet force (Ref. 12). According to the static-force balance theory (SFBT) (Ref. 3), the balance of these forces determines the metal transfer process, i.e., droplet formation, size, and frequency. These forces are shown in Fig. 2.

The force due to gravity can be expressed as

$$F_g = mg = \frac{4}{3}\pi r_d^3 \rho g \qquad (1)$$

where r_d is the droplet radius, ρ is the droplet density, and g is the acceleration of the gravity.

The surface tension is given as (Ref. 12)

$$F_\sigma = 2\pi R\sigma \qquad (2)$$

where R is the electrode radius, while σ is the surface tension coefficient.

The aerodynamic drag force can be expressed as (Ref. 12)

$$F_a = 0.5\pi v_f^2 \rho_f r_d^2 C_d \qquad (3)$$

where C_d is the aerodynamic drag coefficient, ρ_f and v_f are the density and fluid velocity of the plasma. This force is higher with higher droplet radius and plasma velocity.

The vapor jet force is given by (Ref. 12)

$$F_v = \frac{m_0}{d_f} IJ \qquad (4)$$

where m_0 is the total mass vaporized per second per ampere, I is the welding current, and J is the vapor density.

The electromagnetic force, F_{em}, is given by (Ref. 13)

$$F_{em} = \frac{\mu_0 I^2}{4\pi}\left(\frac{1}{2} + \ln\frac{r_i}{r_u}\right) \quad (5)$$

where μ_0 is the magnetic permittivity, I is the welding current, r_i is the exit radius of the current path, and r_u is the entry radius of the current path. At the time the droplet is initially formed, the radius of the droplet is smaller than the arc radius. At this particular time, $r_i = r_w$ (r_w is the radius of the welding wire), $r_u = r_a$ (r_a is the radius of anode area). After the appearance of droplet neck, $r_i = r_n$ (r_n is the droplet neck radius) and $r_u = r_a$.

The balance of the forces on a droplet is given by

$$F_g + F_a + F_{em} = F_\sigma + F_v \quad (6)$$

For spray transfer, Ref. 13 calculated F_g, F_{em}, F_σ, and F_a when the welding current is 300 A and the droplet mass is 30 mg. Calculation indicated that the influence from F_g and F_a to droplet is relatively smaller; F_v obviously influences the droplet only under large welding currents (Ref. 12). Therefore, the electromagnetic force is the dominant force facilitating the droplet transfer, and the surface tension is the dominant force retaining the droplet from being transferred. The value of electromagnetic force is exceptionally sensitive to the variation in r_a (Ref. 13). The electromagnetic force only facilitates the spray when r_a is larger than r_w.

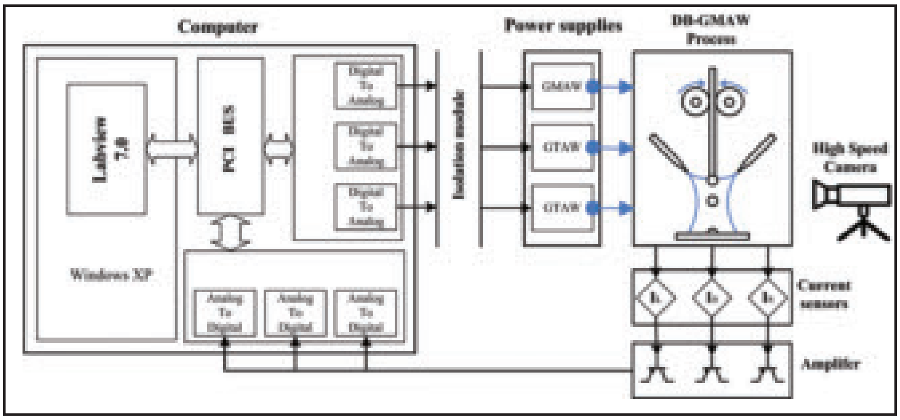

Fig. 4 — Schematic of experimental system.

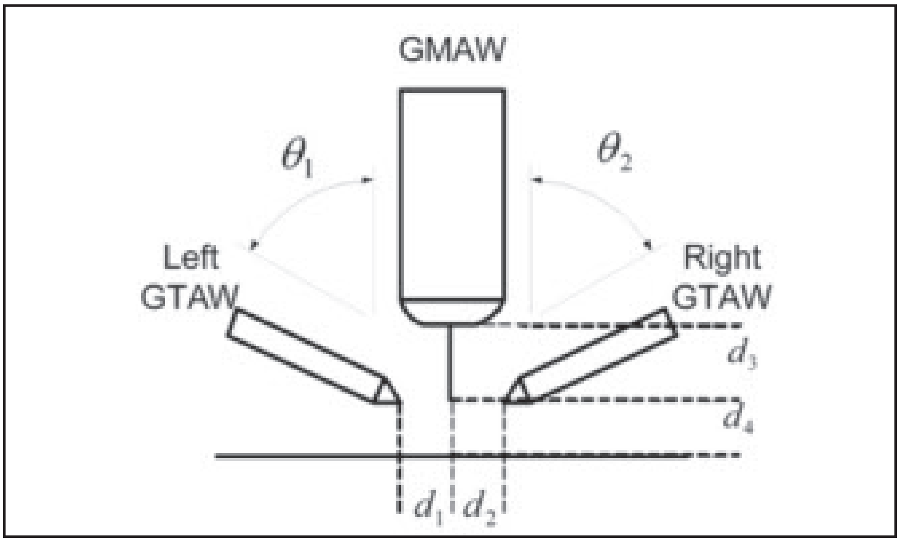

Fig. 5 — Torch installation parameters.

DB-GMAW

The forces in DB-GMAW change significantly from conventional GMAW due to the existence of bypass arcs/currents and the resultant changes in the electromagnetic forces. The two bypass currents that generate F_{eml} and F_{emr} are also governed by Equation 5. Assume the bypass currents/arcs are symmetrical and the two bypass currents are equal, then

$$F_{eml} = F_{emr} = \frac{u_0 I_{by}^2}{4\pi}\left(\frac{1}{2} + \ln\frac{r_i}{r_u}\right) \quad (7)$$

where I_{by} is the amperage of the left and right bypass current, $r_i = r_{byl}$ (r_{byl} is the bypass arc root radius), $r_u = r_{by2}$ (r_{by2} is the bypass arc tip radius). However, due to the change in the direction of the current flow, the direction of the electromagnetic forces generated by the bypass currents changes from that of the electromagnetic force in conventional GMAW as shown in Fig. 3.

Due to the direction change, the bypass currents generated electromagnetic forces that can be projected into two directions: along the axis of the electrode and perpendicular to the axis. The components along the electrode axis balance out part of the surface tension. In addition, the perpendicular components of F_{eml} and F_{emr} will try to shrink the neck of the droplet so that r_u should be reduced. As a result, both F_{eml} and F_{emr} would tend to increase to accelerate the separation of droplet from the wire.

In addition, bypass arcs would increase the anode area so that the arc root now covers the majority or entire droplet surface — see the differences between Figs. 6, 14. Hence, DB-GMAW increases r_a, F_{emr}, and F_{eml}. As a result, the droplet is easier to transfer than in conventional GMAW.

The bypass arc will facilitate the air flowing from the upper portion of the droplet to the lower so that the plasma fluid velocity V_f is increased. According to Equation 3, an increase in V_f will cause an increase in the aerodynamic drag force F_a. Although not as dominant as electromagnetic forces, F_a enhances the detachment of the droplet as well.

The distribution of the forces acting on the droplet in DB-GMAW is shown in Fig. 3. As a result, the introduction of the bypass arcs facilitate the upper part of the droplet in various ways leading to the consequence that the critical current for the spray transfer be decreased from that in conventional GMAW.

Experimental Procedure

Experimental System

Figure 4 demonstrates the experimental system that includes a welding system,

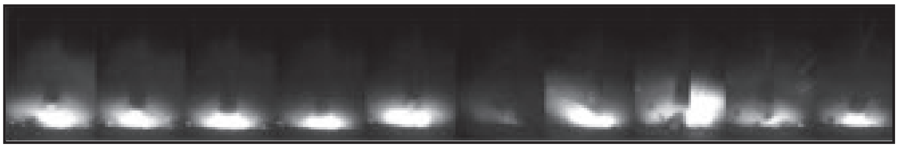

Fig. 6 — Metal transfer without bypass current in Experiment 1. The interval between each frame is 1 ms.

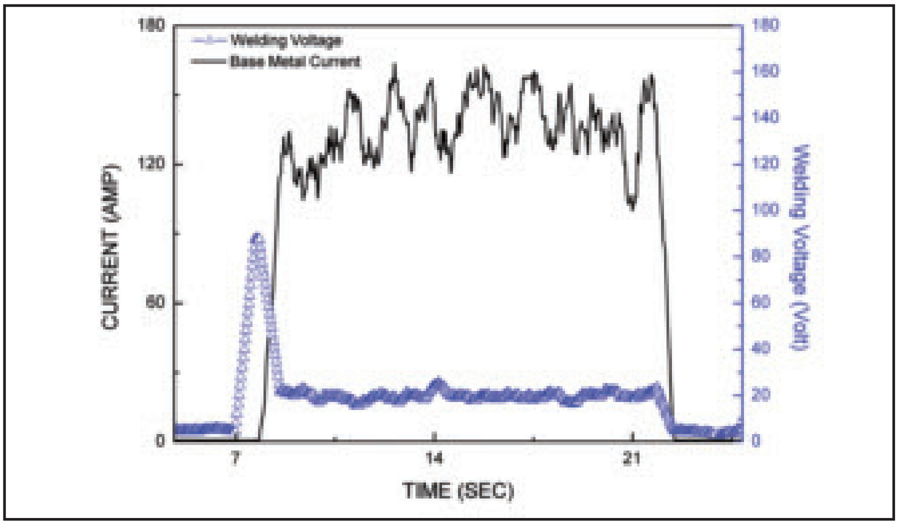

Fig. 7 — Current and voltage in Experiment 1. Bypass currents equal to zero.

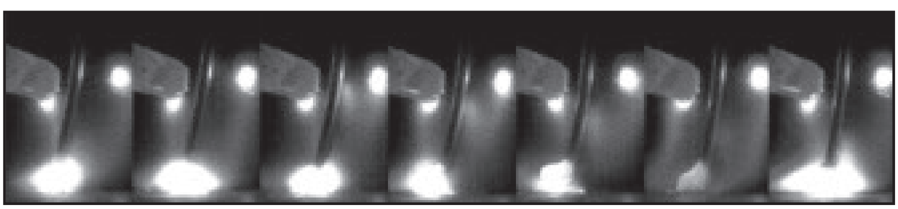

Fig. 8 — Metal transfer with dual 30-A bypass current in experiment 2. The interval between each frame is 2.5 ms.

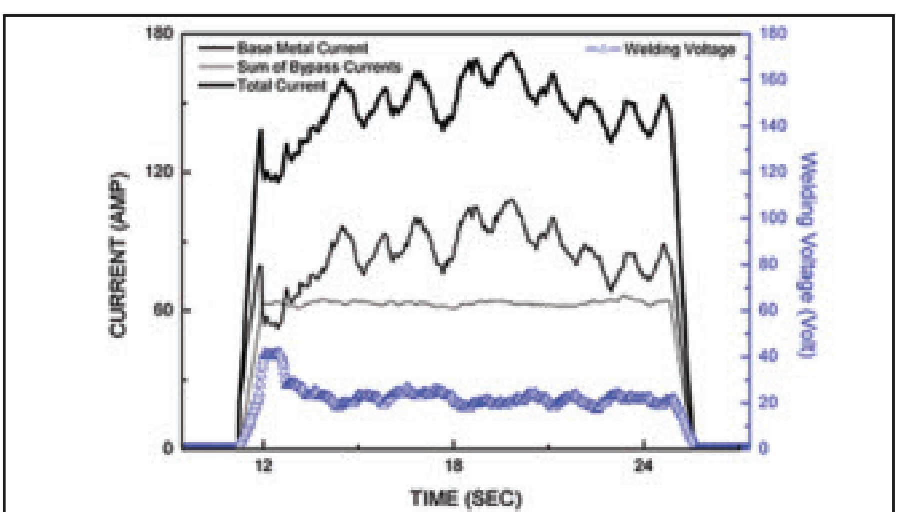

Fig. 9 — Currents and voltages in Experiment 2. Bypass currents equal to 30 A for each.

Table 1 — Experimental Parameters

Bypass Current (left and right)	
0 A	Experiment 1
30 A	Experiment 2
40 A	Experiment 3
50 A	Experiment 4
60 A	Experiment 5
Constant Parameters	
Wire	0.8 mm (0.03 in.) ER 4047
Base metal	Al6061 T6 thickness: 3.2 mm (0.125 in.)
Shielding gas	Pure argon
Gas flow	12 L/min (25.42 ft^3/h)
Welding speed	240 cm/min (94.5 in./min)
Wire feeding speed	18.6 m/min (733 in./min)
Preset welding voltage	21.5 V
Total welding current	160 A

control system, and sensing system. The welding system is formed by two GTAW torches and one GMAW gun connected to their own power sources, which are two GTAW power supplies and one GMAW power supply. Also, it has a rotation device to rotate the pipe fixed on it. The current (both bypass and base metal) data being monitored by the CLN 500 current sensors is sent to A/D channels of a data acquisition board (PCI-1602). The main arc voltage is also monitored. A high-speed camera is placed horizontally aiming at the GMAW gun to record the metal transfer process. As the major element in the control system, the computer outputs control signals to adjust the bypass currents through the D/A channel during this experiment.

Noise is filtered by a specially designed signal isolation board in order to avoid inaccuracy. LabView 8.2 is adopted in a Windows XP system as the software platform.

Due to the constraint of total current value, the sum of the bypass could not overstep 140 A to ensure the minimum base metal current for the cathode pulverization effect that is the key factor to maintain aluminum GMAW stability.

DB-GMAW Gun Installation

In the dual-bypass GMAW process, there are three welding arcs: the main arc between the welding wire and the workpiece, the left bypass arc between the welding wire and the left bypass electrode, and the right bypass arc between the welding wire and the right bypass electrode. Here, the welding wire serves as the common anode, and there are three cathodes: the workpiece and the two tungsten electrodes. While the main arc is ensured by the continuous wire feeding, the bypass arcs are ensured by an appropriate setting of the bypass guns.

In order to obtain stable bypass arcs and process, the gun setting must be able to ignite and maintain the bypass arcs easily. To this end, a dual-bypass GMAW gun setting illustrated in Fig. 5 has been developed. It can be seen that it has two GTAW torches symmetrically mounted to the GMAW gun, which is perpendicular to the surface of the workpiece. The two GTAW torches act as the bypass electrodes to pass the bypass currents. All three torches are in the same plane perpendicular to the welding direction.

The tungsten in the bypass GTAW torch can easily emit electrons to ensure the ignition of the bypass arc because of its low electron work function (eV). At the same time, the bypass tungsten electrodes must be close enough to the wire to establish the bypass arcs after the main arc is ignited. To that end, the following geometrical parameters illustrated in Fig. 5 must be set appropriately:

d_1 — Distance from the tip of the left bypass electrode to the wire.

d_2 — Distance from the tip of the right bypass electrode to the wire.

d_3 — Vertical distance from the axis of the GMAW contact tube to the tips of the bypass electrodes.

d_4 — Vertical distance from the tips of the bypass electrodes to the workpiece.

θ_1, θ_2 — Angle between left or right bypass torch and GMAW gun, usually 60–70 deg, and θ_1 always equals to θ_2.

Among these parameters, d_1, d_2, θ_1, and θ_2 should be preset, while d_3 and d_4 will be determined by wire feed speed, welding voltage, and electrode extension in welding process. In this experiment, the d_1 and d_2, θ_1 and θ_2 were set to 2 mm and 60 deg, respectively. Before every experiment, the wire extension is set as the same length as d_3.

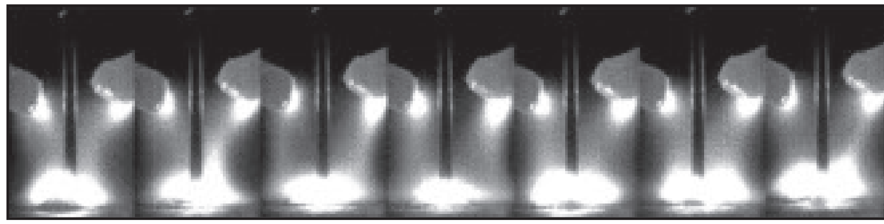

Fig. 10 — Metal transfer with dual 40-A bypass current in Experiment 3. The interval between each frame is 1 ms.

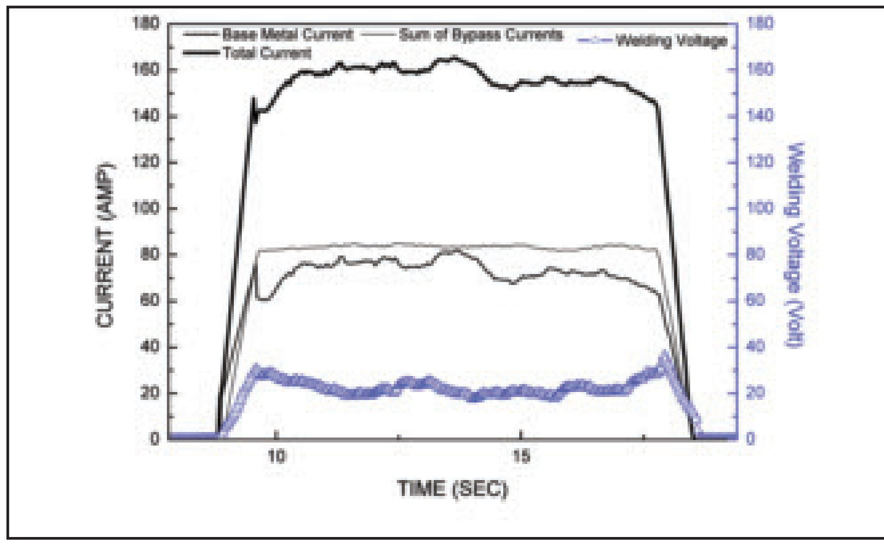

Fig. 11 — Currents and voltage in Experiment 3. Bypass currents equal to 40 A for each.

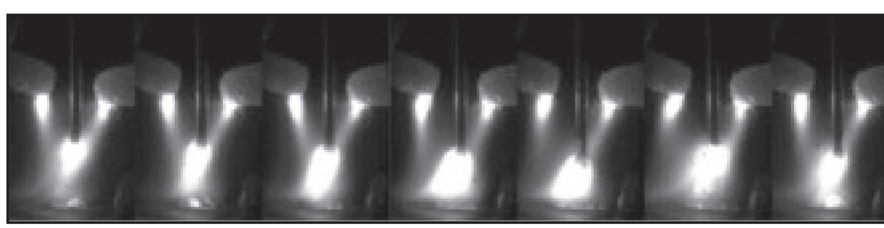

Fig. 12 — Metal transfer with dual 50-A bypass current in Experiment 4. The interval between each frame is 1.5 ms.

Experimental Procedure and Results

Different experiments have been performed using the DB-GMAW process under the parameters shown in Table 1.

Figures 6 and 7 demonstrate the droplet transfer process captured by the high-speed camera and the welding current waveform for Experiment 1 where the bypass current is 0. (The process is thus conventional GMAW.) In this case, as can be seen from Fig. 6, the metal transfer is obviously of short circuit transfer. The droplet grows during the process and transfers itself from the wire tip into the weld pool when it touches the weld pool surface. Spatter is observed.

In Experiment 2, the bypass current increased from 0 to 30 A and the process is truly DB-GMAW. Figures 8 and 9 are the droplet transfer images and welding current waveform, respectively. In this case, the arc length increased but the transfer is still short circuit although the bypass current increased. As can be seen in the images, the droplet keeps increasing before it is transferred into the weld pool; however, it is difficult for the cathode spot to climb from the bottom of the droplet to the wire tip because of the puniness of the bypass arc. In this case, cathode spot force and F_{emr} would become a resistance that blocks the droplet from transferring. As long as the droplet keeps growing, the transfer sometimes becomes repelled transfer because of the existence of such resistance. The whole process lacks stability and can lead to undesirable bead shapes.

Figure 10 is the droplet transfer images in Experiment 3 where the bypass current is 40 A. Figure 11 shows the current and voltage waveforms. Observation shows that the droplet size under this parameter is smaller although the droplet transfer is still in a short circuit. In this case, short circuit duration in each period has become

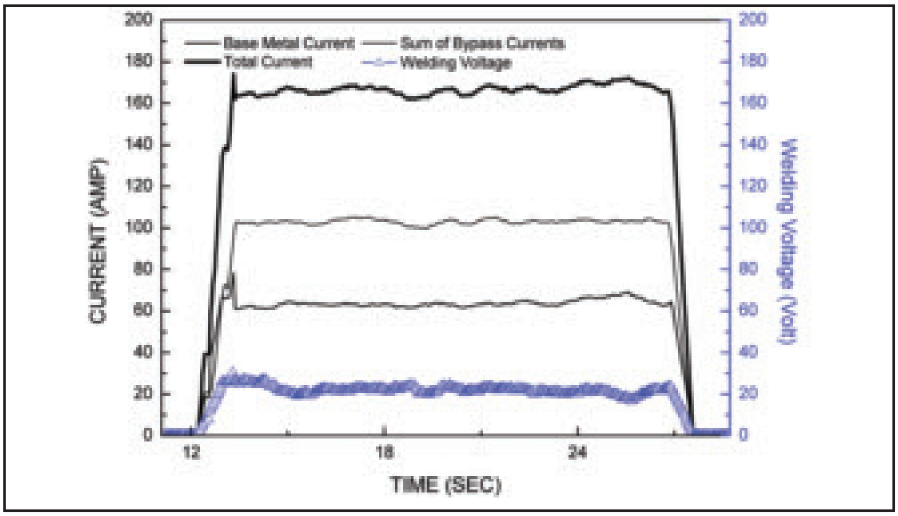

Fig. 13 — Currents and voltage in Experiment 4. Bypass currents equal to 50 A for each.

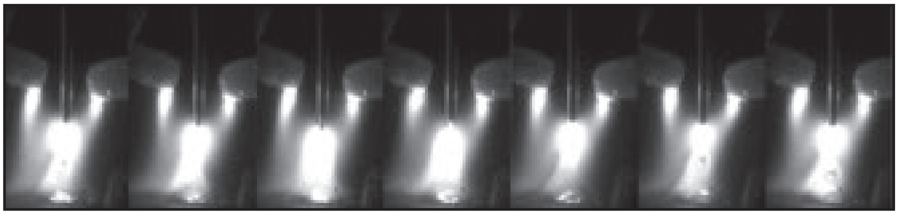

Fig. 14 — Metal transfer with dual 60-A bypass current in Experiment 5. The interval between each frame is 0.5 ms.

much shorter. This suggests that the metal transfer under this set of parameters is a combination of free transfer and short circuit transfer. Such behavior is very similar to the meso-spray transfer obtained in the aluminum GMAW process. When performing as a combination of free transfer and short circuit transfer, the droplet neck pinching and transfer would be accomplished within a very short time beginning with the moment that the droplet touches the weld pool surface. The process is more stable and leads to better weld beads.

Figure 12 is the droplet transfer images captured when the bypass current is 50 A (Experiment 4). Figure 13 shows the current and voltage waveforms. After the bypass current reached 50 A, the droplet transfer becomes globular free transfer with a very stable process and well-shaped weld beads produced. The arc could climb itself from the bottom of the droplet to the upper during the droplet growing. This makes the droplet transfer resistance forces decrease rapidly. The transfer frequency becomes 150~250 drops/s under such set of parameters. Hence, 50 A of bypass current can be considered as a "critical" current for the transfer changes from short circuiting to a free transfer in aluminum DB-GMAW when the total current is approximately 160 A.

In Experiment 5, the bypass is further increased to 60 A. The transfer becomes a stable spray transfer as shown in Fig. 14. The current and voltage waveforms in this case are shown in Fig. 15. Observation confirmed that the whole process of droplet growing, neck shrinking, and droplet detaching from the wire tip is quite stable. The frequency of transfer is approximately 400~600 drops/s with uniform droplet size and desirable weld beads produced with no spatters.

All experimental results thus have demonstrated that the droplet transfer mode varies with the parameters. This is caused by the changed forces acting on the droplet, and the change in the bypass current under the same total current is responsible for the force changes. Such results agree with the theoretical analysis in the force analysis section.

Please keep in mind that the purpose of all current and voltage waveforms shown in Figs. 7, 9, 11, 13, and 15 is to briefly demonstrate the experimental process of Experiments 1–5. Since all these experiments are very stable and parameter fixed during welding, the metal transfer picture captured by a high-speed camera can represent the whole process. It will be difficult correlating the droplet detachment with voltage signal in these figures due to the significant difference of sample rate.

Influences of DB-GMAW Metal Transfer in Base Metal Heat Input

The metal transfer characteristics of DB-GMAW will certainly bring influences in many aspects such as welding bead profile and base metal heat input.

Influences on Penetration

The DB-GMAW process has the ability to reduce the arc force acted on the welding pool, which means DB-GMAW can reduce penetration under the same total welding current. The arc force acting on the welding pool can be estimated by Equation 8:

$$F_{arc} = \frac{\mu_0 I^2}{4\pi} \log\left(\frac{r_{bottom}}{r_{top}}\right) \tag{8}$$

r_{top} and r_{bottom} are radii of the top arc root and bottom arc root, which usually stay steady as long as the process is stable. Since the arc force acting on the welding pool is extraordinary sensitive to base metal current, we can predict that the arc force will significantly decrease in the DB-GMAW process, which would lead to a smaller penetration. Figure 16 demonstrates an experimental verification of theoretical analysis.

Influences on Base Metal Heat Input

The DB-GMAW process could also reduce base metal heat input because of its ability to minimize base metal current. In conventional GMAW, radiation from the arc plasma and the weld has only a negligible effect upon the electrode melting rate. Anode, cathode, electrical resistance, and radiation heating have been considered as the sources of heat that conceivably could control the melting rates of welding electrodes (Ref. 14). Anode and cathode heating is directly related to welding current. In DB-GMAW, the contribution of base metal current to the base metal heat input is much smaller than the traditional GMAW process. Thermocouples are used to monitor the base metal heat input during experiments, and the thermal data have provided us significant evidence that DB-GMAW contributed less base metal heat input. The thermocouples are placed on the inner surface of the workpiece that rotates together with base metal. The thermocouple will go right through the arc column, and the temperature waveform can be recorded by it. Figure 17 indicates the highest temperature waveform from four different processes: two single GMAW processes and two DB-GMAW processes. From Fig. 17, it is obvious to tell that DB-GMAW holds a relatively lower temperature waveform than a single GMAW, which means the base metal heat input is reduced by DB-GMAW under the same welding condition and circumstances.

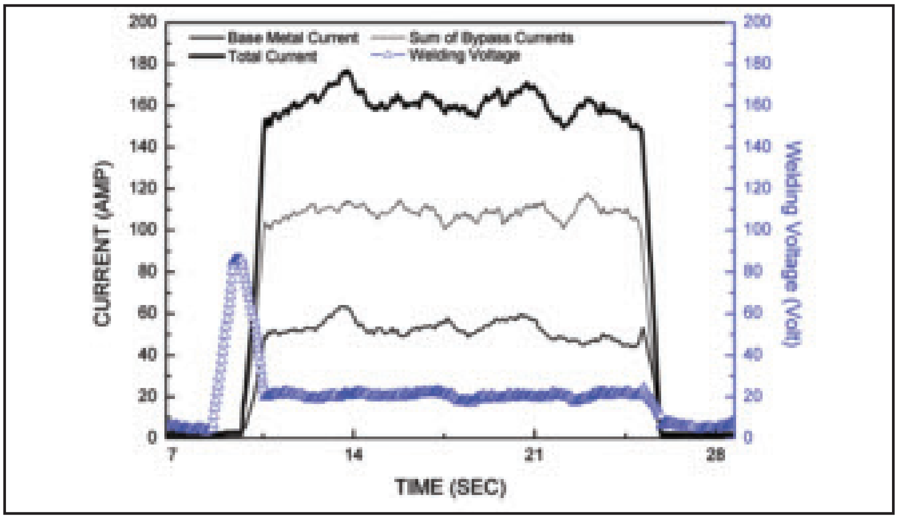

Fig. 15 — Currents and voltage in Experiment 5. Bypass currents equal to 60 A for each.

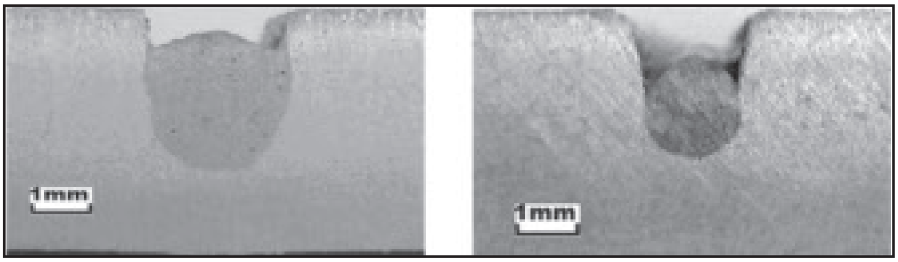

Fig. 16 — Welding cross section of GMAW (left) and DB-GMAW (right) under same welding conditions.

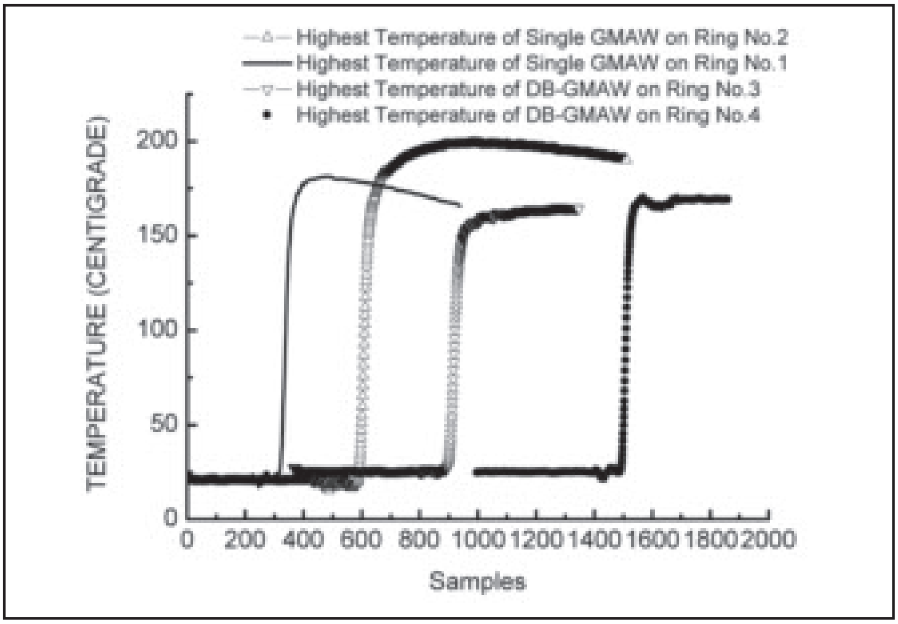

Fig. 17 — Highest temperature comparison on the same workpiece.

Conclusions

1. DB-GMAW decouples the total welding current into bypass currents and base metal current and then controls them separately. This mechanism provides an advantage to reduce the base metal heat input without compromising the wire melting speed and efficiency. As a result, the heat-affected zone (HAZ) and distortion can be reduced in certain applications without affecting the productivity.

2. The bypass arcs significantly affect the forces acting on the droplet that determine the droplet transfer mode:

- The electromagnetic forces generated by the bypass arcs enhance the shrinking of the droplet neck and enlarge the anode area on the bottom of the droplet. The net effect of the neck shrinkage and anode enlargement is to increase the detaching forces.
- The bypass arcs increase the aerodynamic drag force by changing the arc size and plasma flow speed to accelerate the droplet detachment from the wire tip.

The combination of these effects is that the critical current needed to generate the desirable spray transfer is reduced.

3. A series of experiments has been performed to confirm that DB-GMAW indeed has the ability to achieve spray transfer at a lower current than that in conventional GMAW. In addition, it has also been experimentally demonstrated that the metal transfer in DB-GMAW possesses four different modes: short circuiting, globular, meso-spray, and spray transfer. When the total current is given, the transfer mode is determined by the bypass currents or the distribution of the current in three directions: left bypass, base metal, and right bypass.

Acknowledgment

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WELDING JOURNAL

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Defining a Critical Weld Dilution to Avoid Solidification Cracking in Aluminum

A new weldability test and a new approach for relating cracking susceptibility, filler metal dilution, and local strain rate conditions inaluminum welds were developed

BY N. CONIGLIO, C. E. CROSS, T. MICHAEL, AND M. LAMMERS

ABSTRACT. Al-Mg-Si alloys are known to be highly susceptible to solidification cracking except when using an appropriate filler metal (e.g., 4043 or 5356), although the amount of dilution required to avoid cracking has never been a well-defined quantity. The aim of the present study is to determine a relationship between filler metal dilution, local strain rate conditions, and cracking susceptibility. Making use of the controlled tensile weldability (CTW) test and local strain extensometer measurements, a boundary has been established between crack and no-crack conditions for different local strain rates and dilution amounts, holding all other welding parameters constant. This boundary, presented in the form of a critical strain rate-dilution map, defines the critical amount of 4043 filler metal required to avoid solidification cracking when arc welding 6060 aluminum, depending upon local strain rate.

Introduction

Al-Mg-Si extrusion alloys are widely used in fabricated structures because of their good corrosion resistance, moderate strength achieved through heat treatment, and good weldability when using an appropriate filler metal. When welded autogenously, however, these alloys are known to be highly susceptible to solidification cracking (Refs. 1–3). Typical welding filler metals, such as Alloy 4043 (Al-5%Si) or Alloy 5356 (Al-5%Mg), shift the weld pool composition to an alloy regime that is less crack sensitive. Because the filler and base metals have different compositions, the amount of dilution will influence the composition of the weld pool, determining its metallurgical and mechanical properties and cracking susceptibility. The choice of the filler is sometimes related not only to the weld cracking susceptibility, but to the desired mechanical properties of the welds. Normally, Alloy 5356 is selected for higher strength, whereas 4043 is selected for improved cracking resistance.

Although it is well established that use of an appropriate filler metal improves weldability, the amount of filler dilution required to avoid cracking has remained an undefined quantity. Curiously, this has never been considered an important issue to industry, perhaps because standard welding practice routinely results in sufficient dilution to avoid cracking. This would particularly be true for gas metal arc welding, where high filler metal dilution (30–60%) is common.

The objective of the present study was to characterize the solidification cracking susceptibility of the 6060 aluminum base metal welded with 4043 filler metal. Alloy 6060 was selected because of its high susceptibility to solidification cracking (Ref. 4). Using a newly developed controlled tensile weldability (CTW) test, the amount of 4043 dilution required to avoid crack formation was determined for different local strain rate conditions. Strain rate was identified as an important parameter to monitor, particularly because of its direct relationship to cracking mechanisms as is discussed further in this paper. Also, in realization of the importance of solidification range and liquid feeding to cracking, the solidification path was characterized using thermal analysis techniques combined with metallographic observations. A new approach to crack evaluation was taken whereby a strain rate vs. dilution map was developed to identify critical conditions needed for cracking.

KEYWORDS

Dilution
Solidification Cracking
Al-Mg-Si Alloys
6060 Aluminum
Arc Welding
Strain Rate

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Background

Cracking Mechanism

Research work spanning 50 years has led to the belief that tensile stresses and strains at the trailing end of the weld pool are responsible for forming solidification cracks (Refs. 5–10). Likewise, it has long been understood that some alloys have greater susceptibility to cracking, and that this higher susceptibility can sometimes be related to solidification range (Refs. 11–13) or the ability to feed shrinkage (Ref. 14). Strain accumulated as a result of solidification shrinkage and thermal contraction serves to pull weld metal grains apart in the mushy zone, resulting in the separation of grain boundary liquid films. Pellini (Ref. 5), Prokhorov (Ref. 6), and Senda et al. (Ref. 7), in succession, helped develop a concept for cracking based upon limited ductility, assuming that only a limited strain can be accommodated over a brittle temperature range (BTR) during solidification.

Strain rate was also realized to be an important factor by these same researchers (Refs. 6, 7), but only insofar as it serves to determine how much strain can be accumulated during the time of solidification. Accordingly, several weldability tests have been developed specifically to measure critical strain rate, including the variable tensile strain test (Ref. 15), the slow bending trans-varestraint test (Ref. 16), and the variable deformation rate (VDR) test (Ref. 17). Meanwhile, new models arising from a better understanding of nonequilibrium solidification have suggested that strain rate may play a more direct role in the actual liquid fracture mechanism, e.g., controlling the pressure drop in the interdendritic liquid to initiate cracks (Ref. 18). Crack growth mechanisms have been less studied, but it appears that strain rate may likewise play a direct role, influencing the balance between transverse displacement, liquid feeding, and crack advancement (Ref. 19).

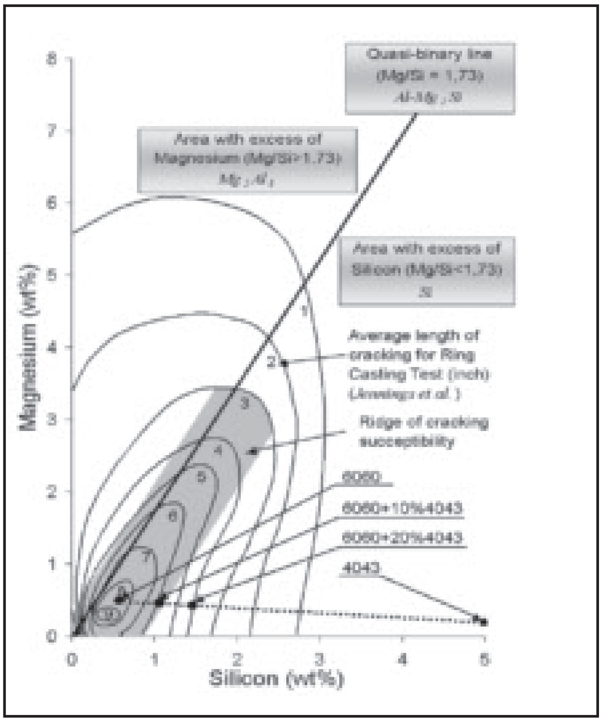


Fig. 1 — Quasi-binary line superimposed on ring casting data of Jennings et al. (Ref. 20) showing solidification cracking susceptibility for Al-Mg-Si ternary alloy system.

Table 1 — Nominal Mid-Range Composition for Aluminum Alloy 6060 and 6060/4043 Mixtures (Ref. 21)

Aluminum Alloy	Composition (wt- %)		
	Si	Mg	Fe
6060	0.50	0.50	0.20
6060+5%4043	0.72	0.48	0.21
6060+10%4043	0.95	0.46	0.22
6060+15%4043	1.17	0.43	0.23
6060+10%4043	1.40	0.41	0.24
4043	5.00	0.05	0.40

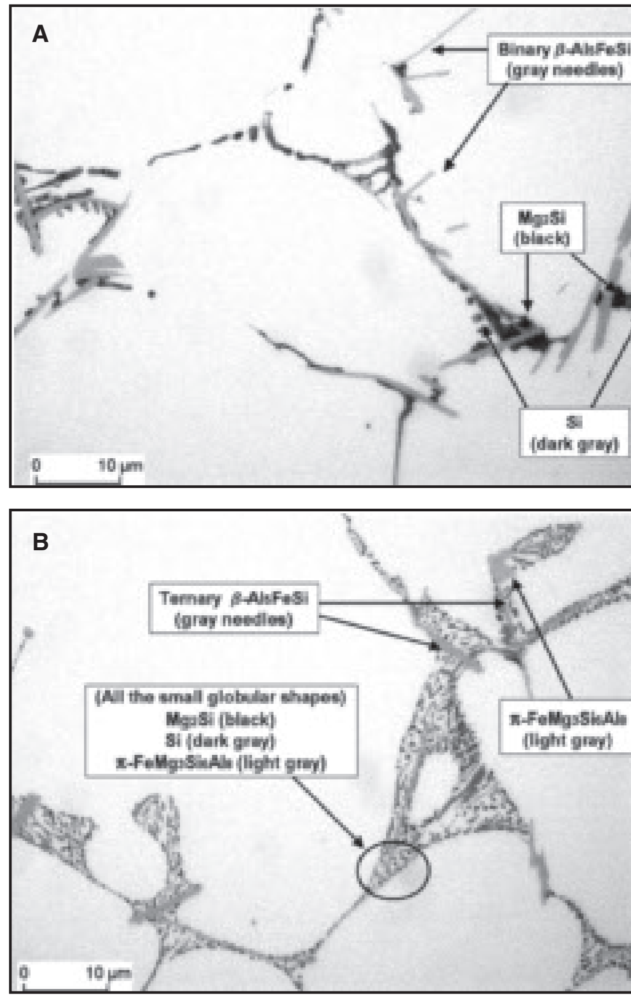


Fig. 2 — Comparison of as-cast structures noting the different phases (Ref. 23) for the following: A — 6060; B — 6060+20% 4043 .

Weldability of Al-Mg-Si Alloys

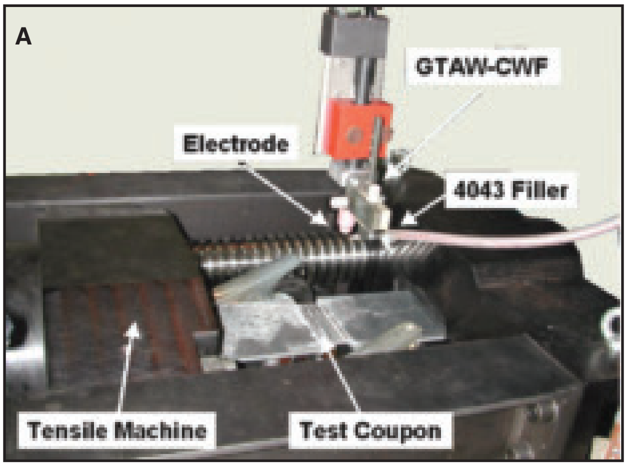
Jennings et al. (Ref. 20) examined the influence of composition on the cracking susceptibility of high-purity Al-Mg-Si ternary alloys (Fig. 1) using a ring casting test. A ridge of high cracking susceptibility is observed along the Al-Mg_2Si quasi-binary line (Mg/Si = 1.73, weight ratio) with a peak in cracking susceptibility occurring at 0.4 wt-% Si and 0.3 wt-% Mg. Alloy 6060 sits close to this peak, and hence should have a high susceptibility to

Table 2 — Phase Reactions in Al-Mg-Si-Fe Quaternary System for Aluminum 6060 Castings with and without 4043 Dilution (Ref. 23)

No.	Phase Reaction	Temperature (°C) 6060	6060+20%4043
1	Start solidification	666	666
2	L+$TiAl_3$→α(Al)	666	666
3	L→α(Al)	653–650	650–647
4	Coherency Point	642–637	642–639
5	L→α(Al)+α(Al_8Fe_2Si)	—	—
6	L→α(Al)+β(Al_5FeSi)	609–597	—
7	L→α(Al)+Mg_2Si	597–589	—
8	L→α(Al)+Si	587–578	584–577
9	L→α(Al)+Siβ(Al_5FeSi)	—	564–556
10	L+β→α(Al)+Si+β($FeMg_3Si_6Al_8$)	—	539–534
11	L→Mg_2Si+Si+α(Al)+π($FeMg_3Si_6Al_8$)	—	524–509
12	End Solidification	578	509

Table 3 — Base Welding Parameters for GTAW–CWF Process

Current	110A
Voltage	17.8
Arch Length	2 mm
Electrode Diameter	3.2 mm
Electrode Type	Tungsten + 1% LaO2
Electrode Tip Angle	30 deg
Torch Gas	Helium
Gas Flow Rate	0.33 L/s
Polarity	DCEN
Torch Travel Speed	4 mm/s
Wire Diameter	0.8 mm
Wire Feed	0–41.7 mm/s



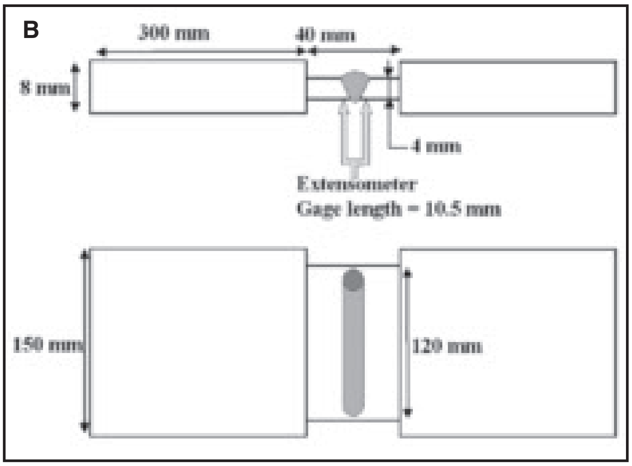


Fig. 3 — A — Overview of CTW test machine; B — dimensions of test coupon showing test coupon joined to two load-transfer plates.

cracking, something that has been verified in circular patch tests (Ref. 4). The weld metal composition is shifted to a less crack-sensitive region when diluted with Alloy 4043, changing primarily the silicon content (Table 1), increased by a factor of 3 for 20% filler dilution.

In relation to the quasi-binary line, it is expected that when welding with 4043 filler metal and an increased weld metal silicon content, the microstructure should consist of increasing amounts of silicon phase in addition to the quasi-binary eutectic phase Mg_2Si (Ref. 22). However, due to the presence of the impurity iron (0.20 wt-% Fe, Table 1), the phase reactions that actually occur are considerably more complex for as suggested in Table 2 for castings. Even at low concentrations, iron has a strong influence on solidification structure due to its strong capacity to partition (equilibrium partition ratio: k = 0.03) and form compounds with silicon and aluminum.

Based upon thermal analysis, microstructure observations and available literature, small increases in Si content have been found to have a major effect on the solidification path of 6060 castings (Ref. 23). Increasing silicon from 0.50 to 1.40 wt-% causes the solidus temperature to drop from 577° to 509°C, increases the quantity of interdendritic constituent from 2 to 14 vol-%, and results in different phase formation. Binary β (Al_5FeSi) and Mg_2Si phases are replaced with ternary β (Al_5FeSi), π ($FeMg_3Si_6Al_8$), and a low melting quaternary eutectic — Fig. 2. Higher silicon content has also been observed to result in grain refinement and reduced solidification shrinkage.

Experimental

Controlled Tensile Weldability Test

Solidification cracking susceptibility was studied by means of a newly developed controlled tensile weldability test shown in Fig. 3A, consisting of a horizontal tensile test apparatus (500-kN load capacity) that can apply a plane tensile strain during welding, transverse to the welding direction, at a controlled strain rate. This test provides a way to determine the critical strain rate needed for solidification crack formation. The concept for such a test is not new, with different variations appearing in the literature (Refs. 15, 24). In comparison, for example, the programmable deformation cracking (PVR) test consists of applying a tensile strain during welding, in the direction of welding, while ramping up the strain rate (Ref. 24). The point at which cracking is first observed defines a critical strain rate. While such tensile tests can be used to apply a global strain at a fixed strain rate during welding, of more importance is the local strain and strain rate (i.e., in the

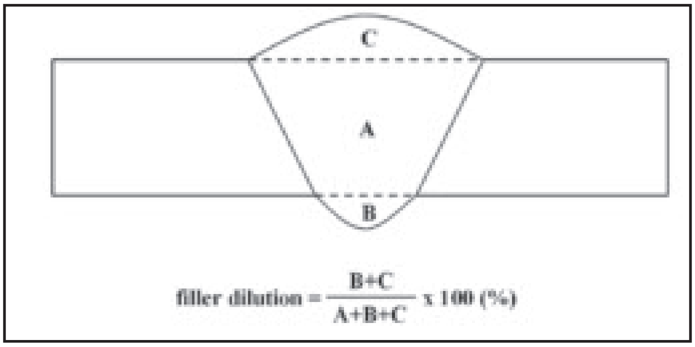


Fig. 4 — Illustration for dilution calculation from weld metal cross section.

Table 4 — Etchants Used for Oxide Removal and Metallographic Analysis

Etchant	Description
E1	869 mL H_2O, 125 mL HNO_3 65%, 6.25 mL HF 48%
E2	100 mL H_2O, 66 mL HCI, 66 mL HNO_3 16 mL HF
E3	100 mL H_2O, 4g $KMnO_4$, 1g NaOH

Table 5 — CTW Test Sequence

Step Number	Distance from the Weld Start (mm)	Related Action
1	0	Start weld
2	30	Start cross-head travel
3	50	Electrode at the top of the extensometer
4	90	Stop cross-head travel
5	100	Stop weld

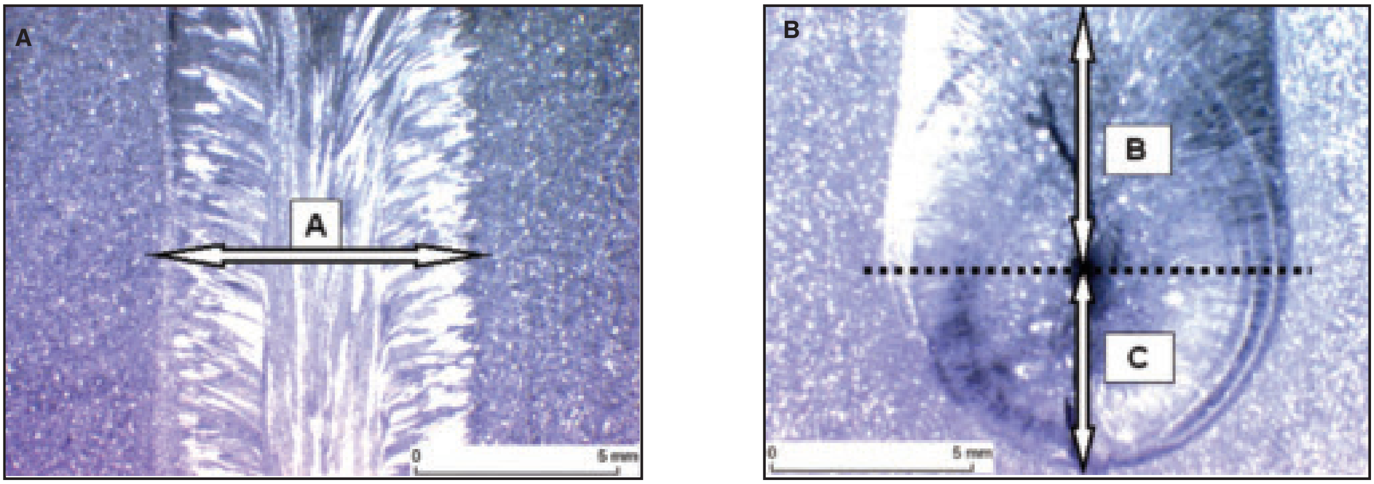


Fig. 5 — Weld pool measurements from top surface as follows: A — Width (A); B — distance behind electrode (B) and distance in front of electrode (C).

mushy zone or vicinity), which is not the same as global strain values and hence must be measured separately.

Welding Parameters

Welding was performed using the gas-tungsten arc, cold wire feed process (GTAW-CWF). Weld coupons 120 mm in length were cut from 40 × 4 -mm extruded bars of 6060-T4, with a hardness of 40 HV0.5. In preparation for testing, each coupon was welded to two load-transfer aluminum plates (300 × 150 × 8 mm, Fig. 3B), suitable for clamping into the head-stock of the CTW machine. Following testing, coupons were cut out and the load-transfer plates reused. The base welding parameters, held constant throughout this study, are listed in Table 3. Arc voltage was kept constant using an arc voltage control system, maintaining a 2-mm arc length corresponding to a 17.8-V arc voltage. Parameters were developed to obtain a complete-joint-penetration, bead-on-plate weld. Welding wire speed and tensile cross-head speed were experimental variables. Welding wire speed was varied from 0.0 to 41.7 mm/s in incremental steps of 8.3 mm/s. Prior to welding, the oxide layer on the test coupon was chemically removed (etch E1 applied at room temperature for 15 min, Table 4), followed by degreasing with acetone.

CTW Test Sequence

The CTW test sequence is summarized in Table 5. A preload of 15 kN was applied prior to welding to compensate for thermal expansion of the weld coupon during welding, maintaining it in tension even at a 0 mm/s transverse cross-head speed. The arc was initiated by touch contact between the electrode and the weld coupon. In a 100-mm-long weld, the transverse cross-head speed was applied 30 mm after the start of welding. Local strain was measured at the weld midlength. At the end of the weld, the arc was abruptly extinguished, providing information as to the shape of the weld pool. Each individual test was run at a constant applied strain rate, where the tensile transverse cross-head speed was varied from 0.000 to 0.083 mm/s in incremental steps of 0.017 mm/s per test. This globally applied strain rate resulted in variations in local strain rate (i.e., region adjacent to weld pool), which was measured with an extensometer.

Local Strain Rate Measurement

Ideally, what is most pertinent to cracking is the strain rate experienced at the grain boundaries in the mushy zone (i.e., grain boundary strain rate). Attempts to measure this have been reported in the literature, e.g., the MISO technique (Ref. 25), whereby video recordings of the top surface of the weld metal were analyzed by noting the displacement of oxide particles over time. However, this analysis is cumbersome, not necessarily accurate, and is not easily adapted for regular application. In this study, the strain rate was measured instead using an extensometer in the local vicinity of the weld (referred to as local strain rate).

Strain distribution measurements made using digital image correlation (DIC) suggest that the strain rate is constant within the immediate vicinity of the weld (Ref. 26). This means that the extensometer measurements made in this study are related to what is happening at mushy zone grain boundaries. What is not known is how the local strain (and strain rate) is partitioned within the mushy zone. It can be argued, for example, that most of the strain in the mushy zone will occur at grain boundaries, which would explain the importance of grain refinement in improving crack resistance. However, because of our limited un-

Table 6 — Measured Chemical Analysis for Aluminum Alloy 6060 and 6060/4043 Mixtures (Wet Chemical Analysis for 4043 Welding Wire and Spectrometry for 6060 Base Metal)

Aluminum Alloy	Composition (wt%)									
	Si	Mg	Fe	Mn	Cu	Cr	Ni	Zn	Ti	Zr
6060-T4	0.42	0.59	0.19	0.020	0.012	0.004	0.004	0.009	0.020	0.001
6060+5% 4043	0.66	0.56	0.19	0.019	0.012	0.004	0.004	0.009	0.019	0.001
6060+9%4043	0.86	0.54	0.19	0.018	0.013	0.004	0.004	0.009	0.018	0.001
6060+11%4043	0.96	0.53	0.19	0.018	0.013	0.004	0.004	0.009	0.018	0.001
6060+14%4043	1.10	0.51	0.19	0.018	0.013	0.004	0.004	0.008	0.018	0.001
6060+16%4043	1.20	0.50	0.19	0.017	0.013	0.004	0.004	0.008	0.017	0.001
4043	5.30	0.002	0.22	0.003	0.018	0.002	0.005	0.005	0.003	0.002

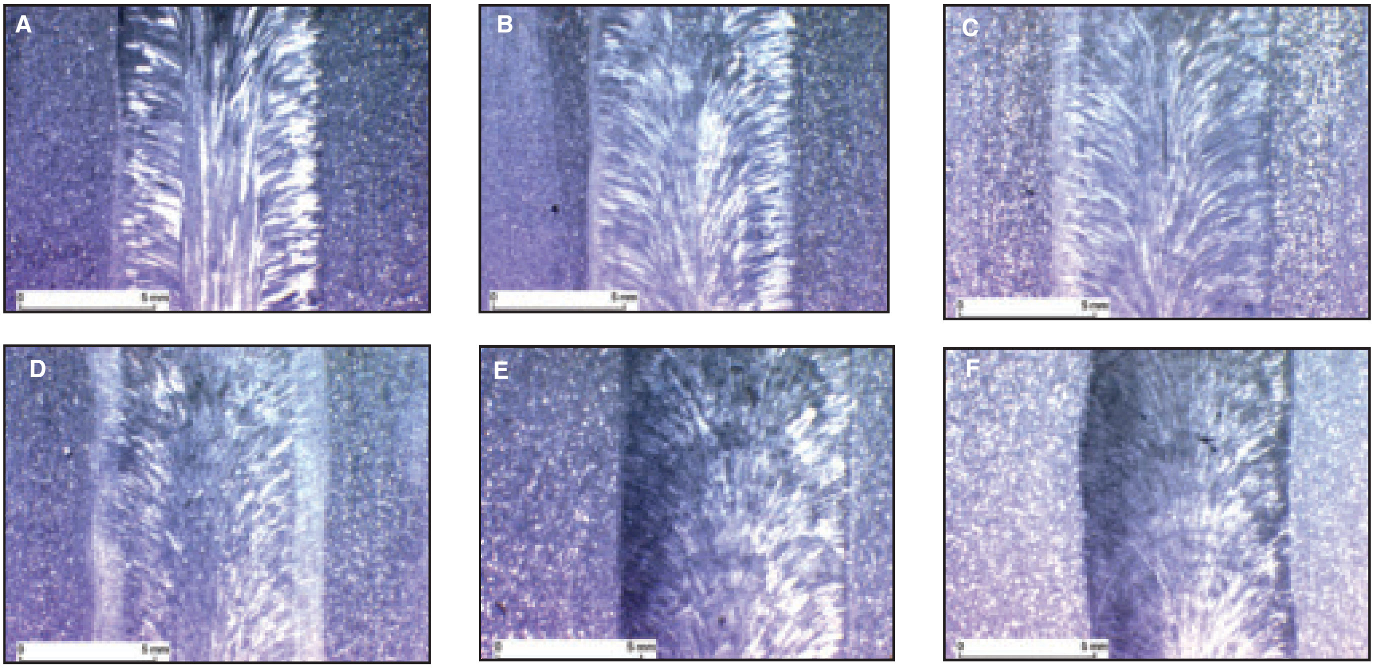


Fig. 6 — Grain structure at the top surface of the weld metal for Al 6060 with the following amounts of dilution with the 4043 filler metal: A — 0%; B — 5%, C — 9%; D — 11%; E — 14%; F — 16%.

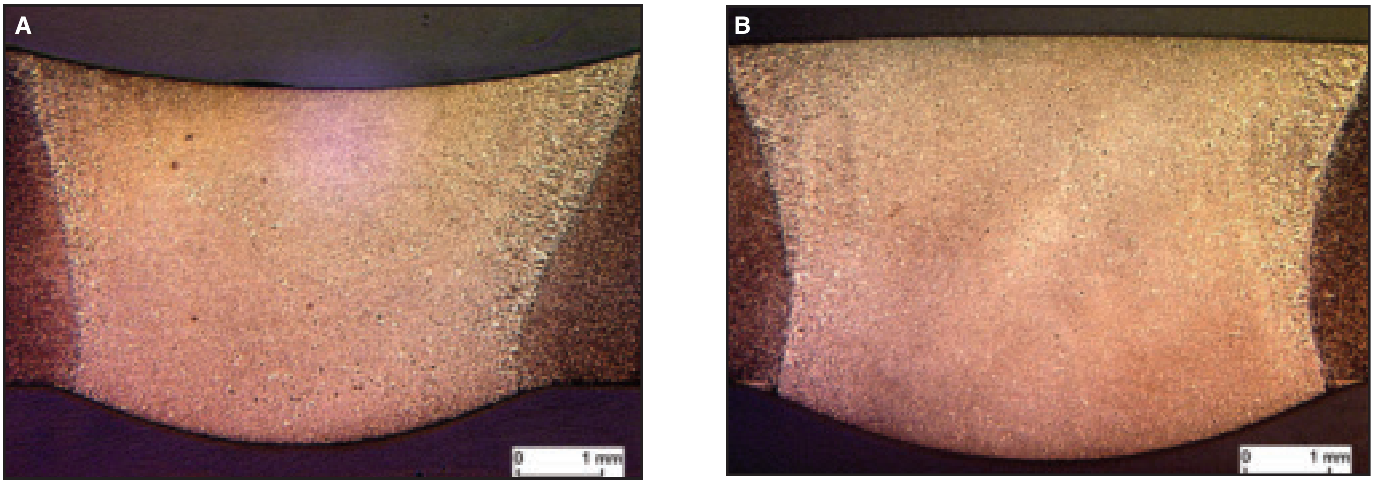


Fig. 7 — Weld metal cross sections for the case of zero cross-head speed: A — 6060; B — 6060+16% 4043.

derstanding of strain distribution within the mushy zone, the measurement of strain rate in the local weld vicinity will be taken as a useful indicator to reflect upon what is happening in the mushy zone.

An extensometer was attached underneath the weld coupon, in the path of the weld at midlength (Fig. 3B), to measure the local transverse strain across the weld pool during the welding process. The gauge length of the extensometer was 10.5 mm, spanning across an 8-mm-wide weld bead. The extensometer output was recorded at a 100-Hz frequency during the entire test using CATMAN 4.5 computer software for data acquisition and a Spider 8 analog-to-digital converter. Local strain rates were calculated from these recorded strains and, with incrementally increased applied strain rate for each succeeding test, the critical local strain rate for cracking was identified when cracks were first observed.

Strain and strain rate values were examined at the coherency temperature

Table 7 — Weld Pool Measurements According to Fig. 5

Filler Dilution (%)	Top Width: A (mm)	Distance behind Electrode: B (mm)	Distance in Front of Electrode: C (mm)
0	7.5	6.1	4.7
5	7.8	6.0	4.6
9	8.0	6.3	4.8
11	8.1	6.3	4.7
14	8.1	5.9	4.6
16	8.1	5.9	4.8

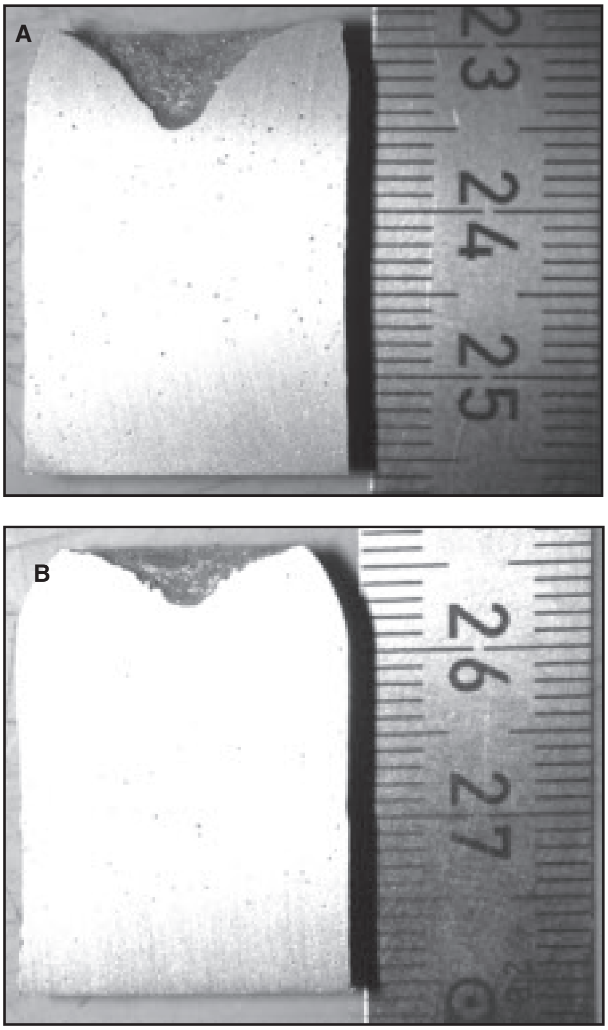


Fig. 8 — Shrinkage cavity observed in castings of the following: A — 6060; B — 6060+20% 4043. Cooling rate was 9°C/s between 750° and 500°C.

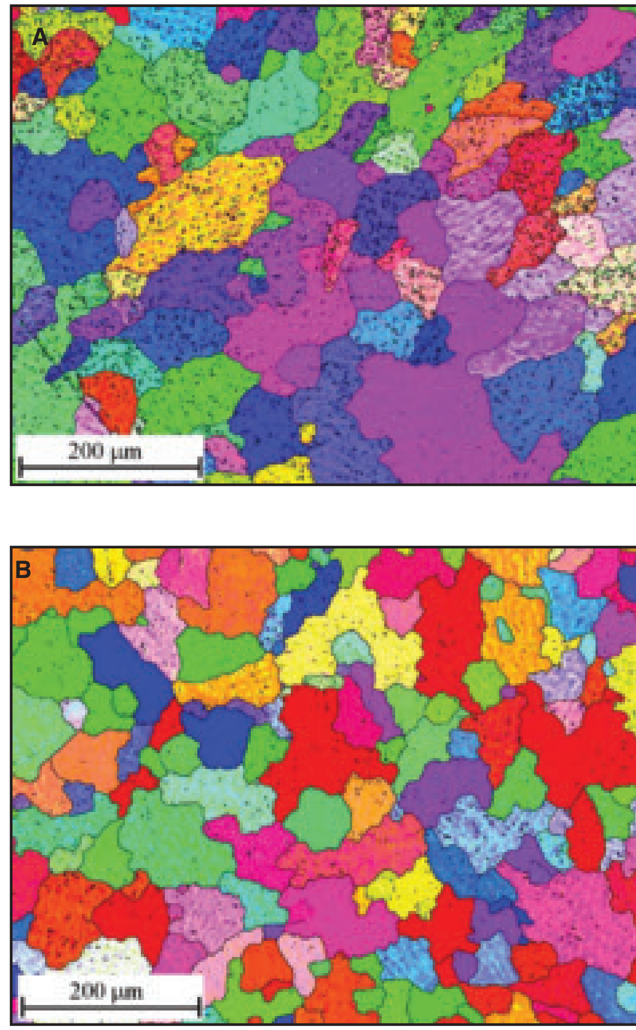


Fig. 9 — SEM-EBSD micrographs for Al-6060 with the following amounts of dilution: A — 0%; B — 16% 4043.

(i.e., when the mushy zone passed over the extensometer), corresponding to the point during solidification where the secondary arms of adjacent dendrites first begin to coalesce. This is normally taken to be the region where cracking initiates (Ref. 11), and can be determined experimentally from thermal analysis corresponding to the first arrest in the cooling curve following the beginning of α-Al dendrite solidification (Ref. 27). Coherency represents a sharp reduction in interdendritic liquid feeding and thus a change in convective heat flow. The position of coherency relative to the torch along the weld centerline was determined from weld pool size (i.e., distance between torch and trailing weld pool boundary) and cooling rate measurements (i.e., time between liquidus and coherency temperatures). The position of the torch relative to the extensometer was determined from time of travel.

Table 8 — Characteristic Dimensions of Weld Metal Depending on Filler Dilution

Welding Wire Speed (mm/s)	Filler Dilution (%)	Cross-Section Area (mm^2)	Bead Thickness (mm)	Root Width (mm)	Overbead Width (mm)	Overbead Curvature (mm^{-1})
0	0	25.1	4.2	5.5	7.5	-0.068
8.3	5	25.5	4.4	5.1	7.8	–0.023
16.7	9	25.9	4.6	5.4	8.0	–0.031
25.0	11	28.0	4.7	5.4	8.1	–0.007
33.3	14	29.0	4.9	5.7	8.1	0.007
41.7	16	31.7	5.0	6.5	8.1	0.011

A few select strain rate measurements were made by moving the extensometer to different locations along the weld length, including the actual site where cracks were observed to form. The difference between these values and those measurements obtained at midlength was found to be within the error of experiment (± 0.05%/s). Also, because welds were made complete penetration on relatively thin (4-mm-thick) coupons, it was assumed that conditions of plane strain exist and that transverse strain in the through-thickness direction is the same as at the surface.

Thermal Analysis

Cooling curves for the weld pool at 0 and 16% 4043 dilution were examined during solidification to determine the position of the coherency point relative to the liquidus and to determine the solidification range. A hole, 0.6 mm in diameter and 1 mm deep, was drilled from the bot-

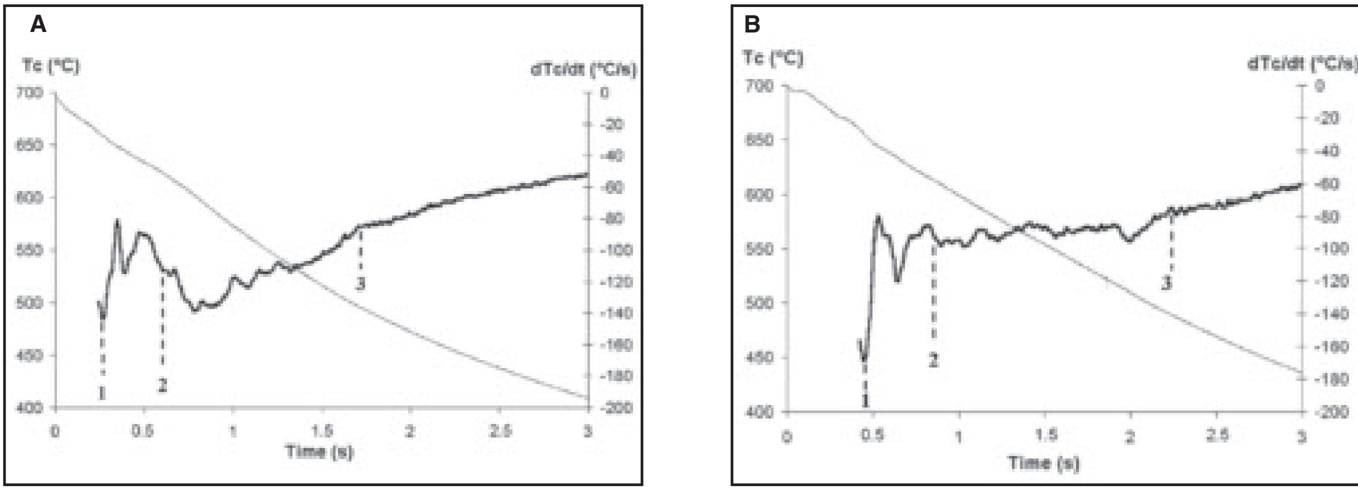


Fig. 10 — Application of cooling rate methods to the 6060 aluminum weld metal with the following: A — 0%; B — 16% 4043. Arrest numbers correspond to numbered reactions in Table 9.

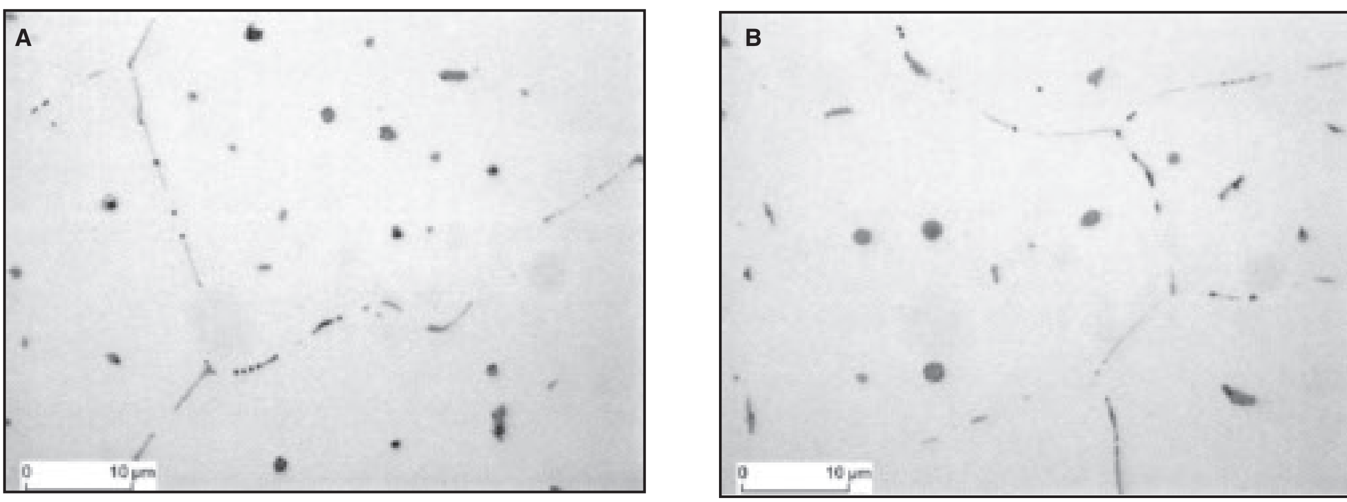


Fig. 11 — Micrographs for Al-6060 weld metal with the following amount of dilution: A — 0%; B — 16% 4043.

tom side of the weld coupon, in the path of welding at weld midlength. A 0.5-mm outer diameter, sheathed, electrically ground, nickel/chrome-nickel (Type K) thermocouple was preplaced inside this hole (friction fit) before welding. The thermocouple output was recorded at a 200-Hz frequency during solidification using CATMAN 4.5 computer software for data acquisition and a Spider 8 analog-to-digital converter.

Metallographic Analysis

Metallographic cross sections were cut transverse to the weld, at weld midlength. These sections were ground and polished to 1 μm and then chemically polished using a slightly basic solution of colloidal silicon dioxide. The microstructure was examined using optical metallography. Electron backscattered diffraction (EBSD) was employed to help define grain boundaries for grain size measurement. Grain size was measured using a line-intercept technique, taking a mean value of four line-intercept measurements. Other polished cross sections were etched with Etch E3 (Table 4) for 45 s to reveal the weld pool size and geometry.

Dilution Measurements

The critical strain rate to form cracks was compared for several different filler metal dilutions: 0, 5, 9, 11, 14, and 16% 4043, calculated using Equation 1

$$\text{filler dilution} = \frac{B+C}{A+B+C} \times 100\% \qquad (1)$$

where A is the cross-sectional melted area of the 6060 base metal, and $B+C$ is the difference between the total area of the weld metal and A — Fig. 4. Measured weld metal compositions are compared in Table 6 for each of these weld dilutions. As expected, it is observed that silicon is the primary alloying element affected by dilution.

In CTW testing, for each dilution level the transverse cross-head speed was incremented in steps of 0.017 mm/s from 0.000 to 0.068 mm/s, noting the value where cracking first occurred. Because of the fixed incremental step of transverse cross-head speed (0.017 mm/s), the exact location of the crack-no crack boundary lies somewhere within this fixed step. This corresponds to the difference between the highest measured strain rate without cracking and a strain rate slightly greater than that required to form a crack. Hence, the accuracy for determining the critical strain rate, for a given dilution, is limited by the magni-

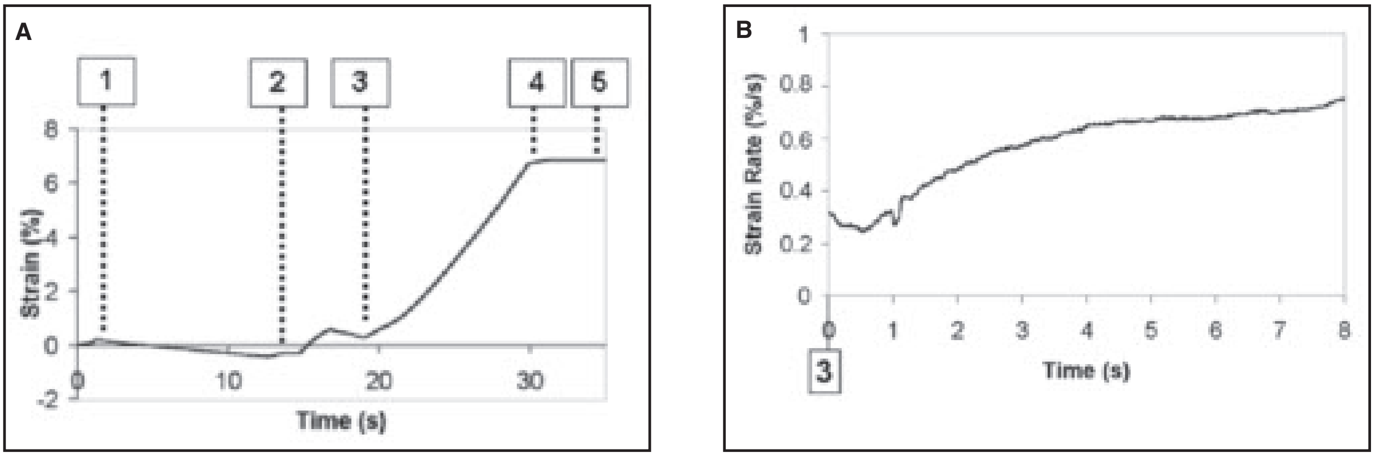


Fig. 12 — A — CTW test sequence superimposed on measured strain; B — calculated strain rate, for test conditions 6060 + 9% 4043 dilution and 0.067 mm/s cross-head speed.

tude of this step. Data were plotted as a critical strain rate-dilution map, demarking the region between crack and no-crack conditions.

Results and Discussion

Weld Pool/Weld Metal Characterization

Application of Etch E2 at room temperature for 1 min (Table 4) revealed the grain structure and weld pool shape from the top surface as shown in Fig. 5. Weld pool shape was approximately constant for different 4043 dilutions, with distances A, B, and C summarized in Table 7. Of particular importance is distance B, approximately 6 mm, which represents the distance between the electrode and the fusion boundary along the weld centerline. Thus, with a torch travel speed of 4 mm/s, solidification along the weld centerline starts approximately 1.5 s after passage of the electrode.

Observation of weld metal microstructure from the top surface reveals stray centerline grains for autogenous welds (i.e., with no 4043 filler added, Fig. 6A). These stray grains are no longer observed with as little as 5% filler dilution (Fig. 6B), with additional increases in dilution causing further grain refinement (Fig. 6A–F).

Metallographic transverse cross sections taken from the weld midlength were examined for all 4043 dilutions, and weld bead dimensions were measured as summarized in Table 8. An example of weld cross sections made on 6060 coupons with 0 and 16% 4043 dilution are compared in Fig. 7, showing an increase in weld bead thickness from 4.2 to 5.0 mm and only a slight increase in bead width. Cross-sectional area also increased with dilution and overbead curvature changed from –0.068 (concave) to +0.011 mm^{-1} (convex). The change in curvature from concave to convex occurred between 11 and 14% filler dilution, and is reported to provide better cracking resistance (Ref. 28).

Increased filler dilution is also likely to affect solidification shrinkage. Silicon is known to reduce the shrinkage volume of die-cast aluminum alloys, where shrinkage decreases linearly in Al-Si binary alloys to reach a zero value at 25% Si (Ref. 22). This behavior is believed due to the volume expansion of silicon as it solidifies, compensating in part for the solidification shrinkage of aluminum (Ref. 29). Alloy 6060 castings made in-house have also demonstrated this, where the shrinkage cavity is reduced when increasing 4043 dilution — Fig. 8. Considering the shrinkage feeding theory of Feurer (Ref. 14), a reduction in solidification shrinkage should improve weldability.

Grain size measurements for weld cross sections were made for 0 and 16% 4043 dilution with the aid of ESBD to help delineate grain boundaries, as shown in Fig. 9. Increasing 4043 dilution from 0 to 16% decreases the mean grain size from 63 to 51 µm. This small refinement in grain size may contribute at least in part to improved weldability, based upon a previous study (Ref. 4).

Thermal Analysis

The solidification path was characterized by examining cooling curves for low and high levels of filler dilution in the welds — Fig. 10. The solidification start/stop and coherency temperatures identified from Fig. 10 are compared in Table 9. These critical temperatures were identified from the first derivative curves based upon thermal arrest behavior characterized in previous work for 6060/4043 castings (Ref. 23). Increasing 4043 dilution decreases the coherency point by approximately 12°C, but had little effect on solidification start and stop. This behavior is different from that observed for 6060/4043 castings (Table 2). Unlike in castings, the solidification range remains at around 165°C, independent of the 4043 dilution. This is also suggested by the micrographs of the weld cross sections (Fig. 11), which differ from the micrographs of 6060/4043 castings (Fig. 2) in that they appear unaffected by 4043 dilution.

Increasing 4043 dilution from 0 to 16% decreases the mean cooling rate during solidification from 114 to 94°C/s. This could be due to either an increase in latent heat, or to an increase in weld pool size (Table 8), both possibilities resulting in a higher quan-

Table 9 — Solidification Start /Stop and Coherency Temperatures for Aluminum 6060 Welds with and without 4043 Dilution Taken from Fig. 10

No.	Reaction	Temperature (°C)	
		6060	6060+16%4043
1	Start solidification	660	659
2	Coherency point	624	612
3	End solidification	494	488

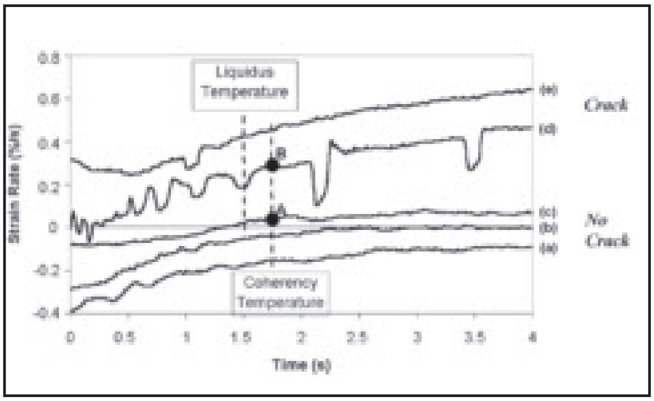


Fig. 13 — Strain rate measurements for a filler dilution of 9% and a cross-head speed of (a) 0; (b) 0.017; (c) 0.033; (d) 0.050; (e) 0.067 mm/s. Note the points A (insufficient strain rate to form crack) and B (sufficient strain rate to form crack).

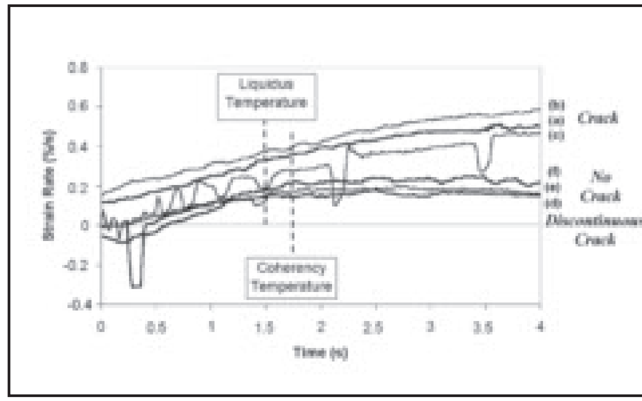


Fig. 14 — Strain rate measurements for a cross-head speed of 0.050 mm/s and a filler dilution of (a) 0%; (b) 5%; (c) 9%; (d) 11%; (e) 14%; (f) 16%.

tity of heat evolved during solidification. This observation supports the Feurer theory (Ref. 14), where a lower cooling rate should reduce the rate of shrinkage and thus decrease the cracking susceptibility, as observed when adding 4043 to 6060.

For all dilution conditions, thermal analysis showed that the time it takes for the temperature to drop from the liquidus to the coherency temperature is approximately 0.2 s. Thus, for a 4 mm/s travel speed, the distance from the weld interface to the coherency point is approximately 0.8 mm along the weld centerline. Combining this with weld pool shape measurements (distance B in Table 7), the coherency temperature along the weld centerline is reached approximately 1.7 s after the passage of the welding electrode.

Local Strain Rate Measurement

An example of strain measurement made during a CTW test is presented in Fig. 12A, shown as a function of time with the CTW test sequence superimposed from Table 5. Positive strain represents displacement toward the weld centerline. Note that the strain becomes negative between 5 and 15 s, which is likely due to thermal expansion in the test sample caused by heating ahead of the advancing weld torch (Ref. 30). Figure 12B shows the calculated strain rate from point 3 to point 4 during weld solidification. Time has been set to zero in Fig. 12B, corresponding to step 3. The local strain rate value is taken at the coherency point, 1.7 s behind the torch (torch is at point 3) as discussed in the previous section.

Although a continuous centerline crack is formed under the test conditions represented in Fig. 12, the irregularity in the curve (at 1 s, Fig. 12B) likely represents erratic crack growth, as has been observed by other researchers (Ref. 31). The repeatability of CTW test results was examined for the test conditions 11% 4043 dilution and 0.033 mm/s cross-head speed. Performing the CTW test three times for these fixed conditions resulted in a variation in measured strain rates of between +0.10 and +0.11%/s (±0.005%/s) demonstrating good repeatability within 10%.

Additional strain rate plots are compared in Figs. 13 and 14 showing, respectively, the influence of cross-head speed and dilution on cracking susceptibility. Both the liquidus and coherency temperatures are indicated to identify the region of interest to solidification cracking. A general trend is observed for strain rate over time, whereby it either continuously increases (for the case of crack formation), or it first increases and then plateaus (for the case of no crack formation). In the case of cracking, the increase in crack length over time reduces the specimen resistance to the applied transverse cross-head speed, and thus the local strain rate continues to increase. In the case where no crack forms, a plateau appears once welding is complete and the thermal condition is stabilized.

For a fixed filler metal dilution of 9% (Fig. 13), the cross-head speed is observed to have a direct effect on strain rate. Increasing the cross-head speed increases the local strain rate, as to be expected. For a cross-head speed up to 0.033 mm/s (curves a, b, c) no cracking was observed. Over 0.050 mm/s (curves d and e), a continuous centerline crack was formed, with a crack forming instantaneously with the application of strain. The critical condition for crack formation is bounded by the curves (c) and (d), where the maximum strain rate measured without cracking (point A) corresponds to a value close to the critical strain rate required to form cracking. When considering mechanisms for crack formation, one must be careful to distinguish between crack nucleation and growth. However, it is not understood at this point which of these two phenomena is actually being represented here by these observed critical strain rate conditions.

Figure 14 illustrates the influence of filler dilution on strain rate and cracking susceptibility, in this case for a cross-head speed of 0.050 mm/s. A continuous centerline crack formed with up to 9% dilution (curves a, b, c), but with 11% dilution (curve d) only discontinuous cracks were formed. For welds made with over 14% dilution (curves e and f), no cracking was observed. As was the case in Fig. 13, crack-free welds exhibited lower strain rates. Irregularities were observed on strain rate curves that are close to the critical conditions needed to form cracking (Fig. 13, curve d; Fig. 14, curve c), suggesting that crack growth is unstable.

Dilution affects local strain rates even for uncracked welds (Fig. 13, curves e and f). This could be due to the lower cooling rate at higher filler metal dilution (Fig. 10) resulting in lower rates of solidification shrinkage and thermal contraction, or an increased weld pool width in relation to a fixed extensometer gauge length (10.5 mm).

Negative local strain rates were sometimes measured at low (or zero) applied tensile cross-head speeds. For example, a tensile cross-head speed of 0.017 mm/s for a dilution of 9% resulted in a negative (compressive) local strain rate — Fig. 13, curve b. This suggests the existence of local compressive cells behind the weld pool, formed in reaction to thermal and shrinkage stresses (Ref. 30), precluding the possibility for crack nucleation or growth. The development of such compressive cells was proposed by Zacharia (Ref. 8) as a means to avoid cracking.

Cracking Susceptibility Evaluation

Filler metal dilution was calculated per Equation 1 and plotted as a function of welding wire speed as shown in Fig. 15.

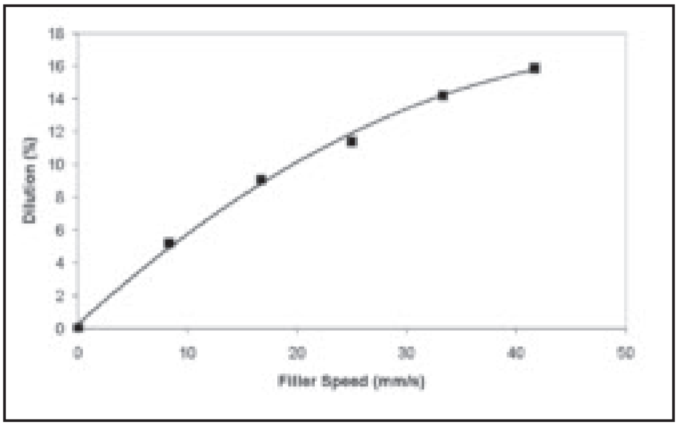


Fig. 15 — Calculated dilution as a function of welding wire speed.

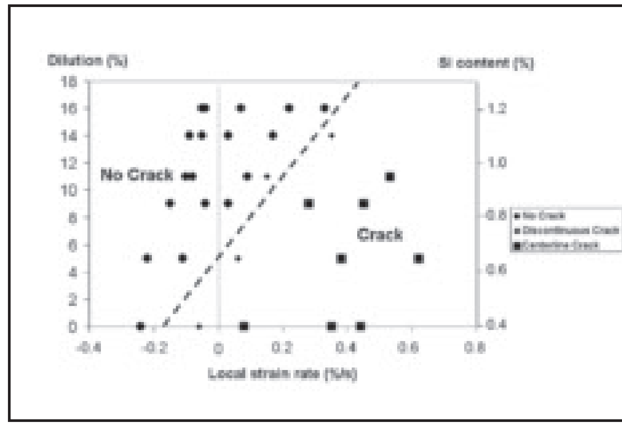


Fig. 16 — Cracking susceptibility of Alloy 6060 for variable 4043 dilution shown as a function of local strain rate (10.5-mm gauge).

Filler dilution was found to vary between 0 and 16% for welding wire speeds between 0.0 and 41.7 mm/s. For each dilution examined, the weld metal composition is given in Table 6, showing that silicon content is the main compositional change when increasing 4043 dilution.

The type of crack encountered in CTW testing is plotted as a function of local strain rate and filler dilution in Fig. 16. A border (approximated with dashed line) is established between crack and no-crack conditions, with discontinuous cracking occurring near the dashed line. Cracking susceptibility is seen to increase with local strain rate, requiring a higher amount of 4043 dilution to avoid cracking. The strain rate is, by convention, negative when the material is moving toward the weld centerline, and positive when it is moving away. Solidification cracking forms at a local strain rate of –0.16%/s at 0% 4043 dilution and 0.35%/s at 16% 4043 dilution. Note that at low 4043 dilution, a solidification crack can form even under a negative (i.e., compressive) local strain rate. This suggests that this low compressive local strain rate does not entirely compensate for solidification shrinkage, still permitting tensile strains in the mushy zone.

Critical strain rates measured using the CTW test for crack formation are compared in Table 10 against values obtained from other tests taken from the literature, including the variable tensile strain test using an extensometer (Ref. 15) and the slow bending trans-varestraint test using the MISO strain measurement technique (Ref. 16). Critical strain rates are found to reflect directly upon weldability, where alloys with relatively poor weldability have low (or in some cases negative) critical strain rates. These values are typically on the order of a few tenths of a percent per second, for each of the different testing methods.

Conclusion

A new CTW weldability test and test procedure has been developed that allows for the experimental determination of the critical strain rate needed for solidification crack formation during welding. In particular, the weldability of aluminum Alloy 6060 was examined for different 4043 dilution levels. Use was made of a critical strain rate-dilution map to identify the boundary between crack-no crack conditions for the 6060/4043 alloy system, where it was found that higher local strain rates require higher filler dilution levels to avoid cracking. The improvement in weldability observed with increased 4043 dilution may be due to a number of different factors including grain refinement, concave bead shape, and reduced solidification shrinkage. However, the solidification range remained independent of 4043 dilution for the dilution levels examined in this study.

Although the CTW test is in some regards unique in its application of controlled transverse global strain rate, what is of particular importance here is the measurement of local strain rate critical to crack formation. The same approach could be accomplished using other established weldability tests incorporating tensile tests (e.g., VTS (Ref. 15) or PVR (Ref. 24)) or prestress applied in the plane of the test specimen (e.g., Sigmajig (Ref. 32) or PLTS (Ref. 33)). Weldability tests that do not lend themselves to this approach are those involving bending, where the strain rate is not uniform throughout the duration of the test or through the test specimen. The disadvantage of strain rate analysis is that it adds to test complexity and is time consuming. However, expressing cracking susceptibility in terms of a critical parameter directly related to a cracking mechanism has the advantage of providing a more meaningful representation of weldability. Of particular importance is the possibility to use these data in the modeling of cracking mechanisms, allowing for future prediction of cracking.

Table 10 — Critical Strain Rates Required for Solidification Crack Formation

Test	Welding Speed (mm/s)	Aluminum Alloy Base Metal/Filler Metal	Critical Strain Rate for Cracking Formation (%/s)
CTW Test (present study)	4	6063/4043 (0%)	–0.24
		6060/4043 (5%)	–0.06
		6060/4043 (9%)	0.08
		6060/4043 (11%)	0.15
		6060/4043 (14%)	0.26
		6060/4043 (16%)	0.33
Variable Tensile Strain Test (Ref. 15)	5	5052	0.15
		5083	0.20
Slow BendingTrans-Varestraint Test (Ref.16)	1.7	2017	0.15
		5083	0.47
		2219	0.50
		5052	0.64
		5154	0.70
		1070	5.00

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