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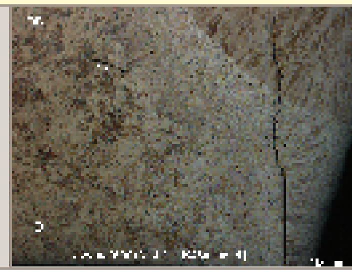
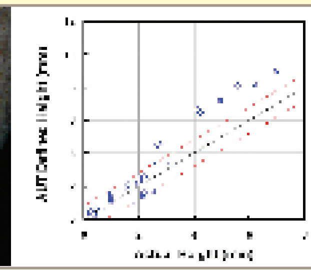
Insights

Sample of Real Weld Flaw Showing Straight and Jagged Fracture Profiles



Example of a Sizing Accuracy Curve



EWI Studies Girth Weld Discontinuity Sizing

Nate Ames | Energy & Chemical Market Leader

Given the critical nature of pipelines and the consequences of structural failure reliability and fitness-for-purpose (FFP), design methods are being adopted to ensure that structural integrity will be maintained throughout the entire design life. The use of reliability and FFP-based design methods requires the use of improved assessment and inspection techniques that can reliably detect and size fabrication flaws produced during construction and repair.

Over the last five years, automated ultrasonic testing (AUT) has been used increasingly in cross-country and offshore pipeline construction to improve defect detection and sizing reliability. Even with advanced AUT methods, there are still uncertainties in defect detection and sizing using the current zonal discrimination, amplitude-based approach. In order to reliably apply FFP-based design and construction methods to both current and next-generation high-strength, high-pressure, cross-country, and offshore pipelines there is a need to define the performance and limitations of current AUT methods and develop improved multi-probe AUT and phased-array (PA) AUT systems to detect, locate, and size flaws and to resolve distance between potentially interacting defects.

EWI has recently completed several independent studies to determine the limits of AUT for cross-country pipelines. EWI evaluated current approaches for girth weld discontinuity sizing accuracy through the pulse/echo, time of flight diffraction and phased array ultrasonic testing techniques as an independent, third party investigator not having a commercial interest in any one equipment or service supplier. This study investigated discontinuity sizing accuracy of the automated ultrasonic testing of girth welds using zonal discrimination with focused and nonfocused search units arranged for the pulse/echo and time of flight diffraction techniques and phased array technology according to the requirements of ASTM E1961-98 (ASTM International, 1998).

The results showed that if the zonal line scan approach with focused, fixed angle beam, and an amplitude-based sizing is used, the results will be similar regardless of whether PA or multi-probe is used. If the electronic steering, focusing and scanning features of PA are used, an improvement in flaw detection and sizing is possible for defects with unknown orientation. Data fusion techniques are used to greatly aid in data interpretation. UT modeling and simulation tools are very beneficial in ultrasonic technique development and for technique validation purposes.

For more information on girth weld discontinuity sizing accuracy, contact Nate Ames at 614.688.5135 or nathan_ames@ewi.org or Mark Lozev at 614.688.5188 or mark_lozev@ewi.org.

The President's Corner


Henry J. Cialone

Innovation. It's at the heart of EWI, in the leading-edge knowledge and skills of our dedicated associates and the continual upgrade of our world-class laboratories. We continue to attract great staff because the opportunity to innovate provides meaningful challenges, and seeing your innovation put to practical use creates real job satisfaction.

How do we define innovation? It's a solution that helps our customers achieve a goal, solve a problem, or satisfy a need. Without member input, our ideas cannot take shape and do not meet our test of innovation.

I'm often struck by the paradox that innovation at EWI represents. On the one hand, we're often asked to conceive of new-to-the-world methods of joining materials that have never before been used together. On the other hand, we need to do this in a way that's readily transferable to the manufacturing environment, and delivered on a demanding schedule and within a tight budget. I like to think of that as innovation with a purpose.

Over the past few years you've no doubt noticed that EWI has made significant strides towards operational excellence. When we conduct quality surveys following each project, one of the factors that our members tell us really matters to them is on-time delivery. I'm proud to say that in the past quarter we achieved 100 percent on-time delivery and continued to maintain a high level of quality.

In this issue of Insights, we've taken the opportunity to spotlight four of our engineers who have received industry recognition for their work. As the stories about those awards indicate, these innovations provided our customers superior design, consistent quality, and improved reliability. While Jose Ramirez, Wei Zhang, Mark Lozev, and Roger Spencer were appropriately recognized, they are representative of all EWI engineers and scientists who have earned a solid reputation for their knowledge, hard work, and candor.

You can also find vital information in this issue on everything from novel modeling software to how EWI is helping improve the manufacturing process of hydrogen fuel cartridges, an innovation that's bringing the hydrogen economy closer to reality. Our award-winning subject matter experts continue to help members grow and advance their interests by applying materials joining technology. I invite you to read on and learn more.

EWI Appoints Candice Mehmetli as Medical/Microelectronics Market Leader


Candice Mehmetli

EWI has announced that Candice Mehmetli has been named Medical/Microelectronics Market Leader. Ms. Mehmetli specializes in the development of new markets for engineering and research and development services in the medical device industry and business sectors using non-traditional materials joining technologies. She is responsible for business development in these areas for EWI which includes joining of dissimilar materials, polymers, and composites.

Ms. Mehmetli was previously an account manager for the member services group at EWI where she was responsible for technical consulting service sales as well as liaison activities for existing and potential customers. In this role she also led teams with representatives from marketing, engineering, and technical service to perform needs assessment, development and/or improvement for customers' manufacturing products/processes.

Since 1996, Ms. Mehmetli has held positions in EWI as the education and training administrator and manufacturing resource office coordinator. Before joining EWI, Ms. Mehmetli was in sales management positions.

Ms. Mehmetli holds a Bachelor of Science degree in Business Administration/Marketing from Franklin University.

Insights is produced four times per year. Please direct general questions and comments to Lisa McClintock, Marketing Communications Manager, at 614.688.5130 (lisa_mcclintock@ewi.org). Questions relating to an article may also be directed to the contact listed in the article.

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EWI Joins Forces to Develop a Center for High Power Ultrasonics

Company Teams with Case Western Reserve University and The Ohio State University

EWI has announced a new initiative that will expand the use of high power ultrasonics (HPU) in the manufacturing, materials processing, biomedical and energy fields. In collaboration with Case Western Reserve University and The Ohio State University, the company will establish a Center for High Power Ultrasonics.

HPU deals with the application of intense, high frequency acoustic waves to change the properties of materials and systems or to drive physical or chemical processes. This diverse area of science and technology is used in fields ranging from materials forming and joining, to environmental remediation.

"OSU, Case, and EWI have developed extensive capabilities in many fields of HPU, as well as in the underlying technology of ultrasonics and ultrasonic systems. The center will bring together field of use experts, expertise in the physics of ultrasound in solids, liquids and gases, and the design and hardware of ultrasonic systems," said Dr. Karl Graff, Technology Leader at EWI and Professor at The Ohio State University. "At the new HPU Center, promising applications conceived in the laboratory will be reduced to practical use for commercial development."

The center will initially focus on manufacturing processes and physical and chemical materials processing. Developments will be carried out in the laboratories of the research experts, while the necessary ultrasonic systems and hardware will be developed at the Edison Joining Technology Center labs of the OSU Welding Engineering Program and EWI.

"The usefulness of ultrasonic techniques for sensing applications (e.g. sonar and medical imaging) is well known, but this HPU Center will promote the use of ultrasonics as an efficient approach to stimulate beneficial changes in materials," said Dr. Donald Feke, Professor of Chemical Engineering at Case Western Reserve University. "HPU is a relatively untapped field that has a tremendous potential to improve a number of advanced and practical manufacturing technologies."

The Center opened on April 1, 2006. The participation of industry and government in setting the research programs, through Center membership, is encouraged.

For more information on the Center for High Power Ultrasonics, contact Karl Graff at 614.688.5269 or karl_graff@ewi.org.

EWI Selected to Work on Joining Technology for Millennium Cell Fuel Cartridge Development Program

EWI has signed a contract with Millennium Cell for a 15-month project to improve the manufacturing process for Millennium Cell's Hydrogen on Demand® fuel cartridges. The work is being funded under a National Center for Manufacturing Sciences (NCMS)/US Department of Energy program with the objective of improving the manufacturability of hydrogen storage technologies.

Millennium Cell is leading a team comprised of The Dow Chemical Company, EWI, and NextEnergy which will focus on developing critical manufacturing technologies that will reduce the overall process and product costs of hydrogen storage technology for near-term implementation in portable power applications. Under the agreement, EWI is tasked with the development of joining technologies for key fuel storage vessels within the fuel cartridges.

"We are excited to collaborate with a team of world-class companies to help move the hydrogen economy one step closer to reality. This award is validation that manufacturability, particularly materials joining, is an enabling technology for cost reduction in both fuel cells and hydrogen storage," said Stan Ream, Technology Leader at EWI.

Adam P. Briggs, President of Millennium Cell, commented, "The team of companies working together on this program is extremely diverse, each with their own talents and abilities. We look forward to leveraging EWI's experience and competency in joining technologies as part of this effort to advance our fuel cartridges from prototype stage to easy-to-manufacture products."

About Millennium Cell

Millennium Cell develops Hydrogen Battery technology through a patented chemical process that safely stores and delivers hydrogen energy to power portable devices. The borohydride-based technology can be scaled to fit any application requiring high energy density for a long run time in a compact space. The Company is working with market partners to meet demand for its patented process in four areas: military, medical, industrial, and consumer electronics. For more information, please visit www.millenniumcell.com.

For more information on hydrogen storage technologies, contact Stan Ream at 614.688.5092 or stan_ream@ewi.org.

Automated Weld Modeling

Shuchi Khurana | Wei Zhang

Finite element analysis (FEA) consists of a computer model of a material or design that is loaded and analyzed for specific results. It is used in new product design, failure analysis, and existing product refinement. FEA helps to verify that a proposed design will be able to perform to its specifications prior to manufacturing or construction. In case of structural failure, FEA may help in failure analysis and to determine the design modifications to meet the new condition.

Weld modeling requires various input variables like geometry, welding parameters and material properties. A sequential thermo-mechanical solution is carried out to calculate the thermal profile, residual stresses, and distortion. The thermo-mechanical solution is carried out with various interactions from the user during the course of computation. Also, various user-defined subroutines are needed to carry out the weld modeling.

Over the years, EWI has developed a suite of software tools and techniques to model the welding processes, microstructure and properties. The software tools are primarily user-defined subroutines which work with commercial FEA or CFD codes like ABAQUS and FLUENT. These computational weld models have been applied to a wide range of EWI customers to address real-world applications. Based on these efforts, EWI customers have reduced expensive trial and error experimentation and saved money. To expand these model usages, many EWI customers have indicated they would like a user-friendly but comprehensive modeling tool that can be used by design and fabricating engineers with limited or no experience in computational modeling. This effort is focused on addressing this critical need to automate the existing weld models so that the powerful computational tools can be readily used by the design and practice engineers, who may not have experience in computational weld modeling.

EWI's approach to a successful analysis using FEA software tools typically involves three steps: (1) pre-processing, (2) solving, and (3) post-processing. In the pre-processing step, a geometry is generated either by drawing from scratch or by importing from an existing Computer-Aided Design (CAD) file. Next, the geometry is meshed, and the appropriate boundary conditions and loads are applied. Often, the loads specific to a materials processing technique (for example, the heat flux from the welding arc) are not available in the FEA tool. User-defined subroutines are developed to incorporate those specific loads into the analysis software. In the solving step, the input file is submitted to the solver and is constantly monitored ensuring that a converged solution is obtained. Finally, in the post-processing step, the results are analyzed and the values of interest are reported. In this work, EWI has automated the modeling steps for the PGMAW process.

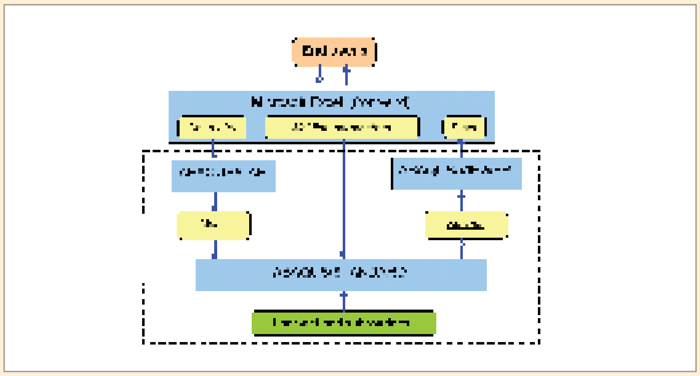

Fig. 1. Schematic flowchart of automated weld modeling.

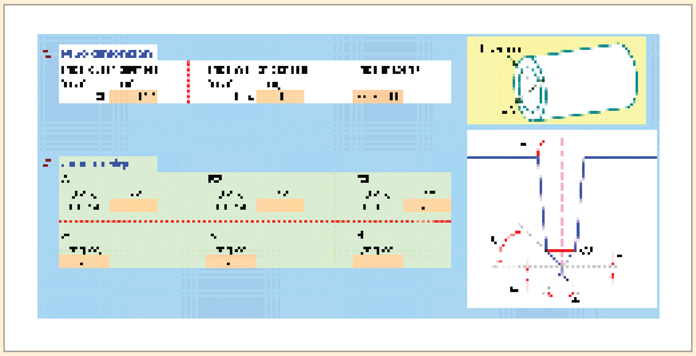

Fig. 2. Snapshot of the Excel based front-end for the user to define the weld joint geometry.

Figure 1 illustrates the automated weld modeling framework developed at EWI. This framework consists of two parts: (1) the front-end and (2) the back-end. The user interacts with the front-end; allowing the user to define the geometry and welding procedure parameters and to view plots after calculation is complete.

The back-end performs the analysis steps automatically and does not require the intervention of the user. The automatic tasks performed by the back-end include meshing, applying boundary conditions and loads, solving, and generating plots.

The example illustrated in Figure 1 was chosen so the front-end based could be developed on Microsoft Excel and the back-end could be based on ABAQUS. The software was chosen due to convenience. The front- and back-ends can be customized using other software tools and can reside in different computers and platforms. For example, the Excel based front-end can reside in a laptop and engineers in the field can remotely connect to the back-end which may reside in a central server located in another part of the world.

As shown in Figure 2, the weld joint geometry is parameterized. The end users input the parameters which defines the geometry. Figures 2 and 3 show snapshots of the Excel based front-end allowing the user to input the welding procedure parameters. Once all the information has been input, the end user can start the calculation by clicking on the "Start Calculation" button. The calculation may take about 30 minutes and is dependent on the computer being used for the calculations. Once the calculation has been completed, the Results worksheet will include the plots and a table containing the results from the thermo-mechanical FE analysis. Some of the plots are shown in Figure 4. The plots provide detailed information regarding the temperature profile, cooling rates at various locations, residual stresses, final distortion and plastic strain. A table containing details of the cooling rate at various locations is outputted too.

EWI can create customized FEA or weld modeling tools for a particular application. EWI's authoring of automated finite element analysis applications that capture your company's key engineering processes and analysis expertise can save a significant amount of time and money.

For more information on EWI FEA modeling, contact Suresh Babu at 614.688.5206 or suresh_babu@ewi.org.

This report was prepared under contract with the State of Ohio with financial support from the Ohio Department of Development. The content reflects the views of EWI and does not necessarily reflect the views of the State of Ohio, Department of Development.

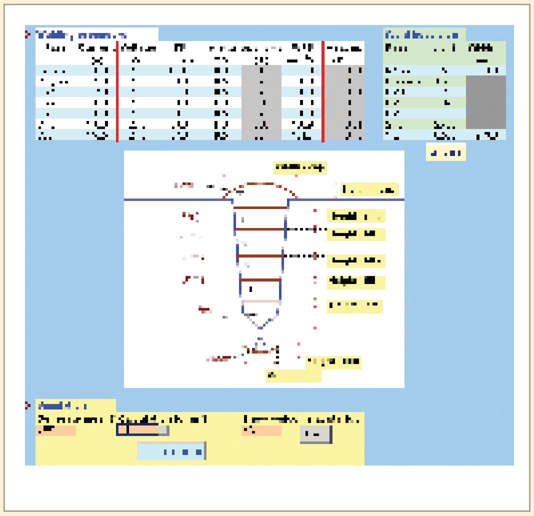

Fig. 3. Snapshot of the Excel based front-end for the user to define the weld procedure parameters.

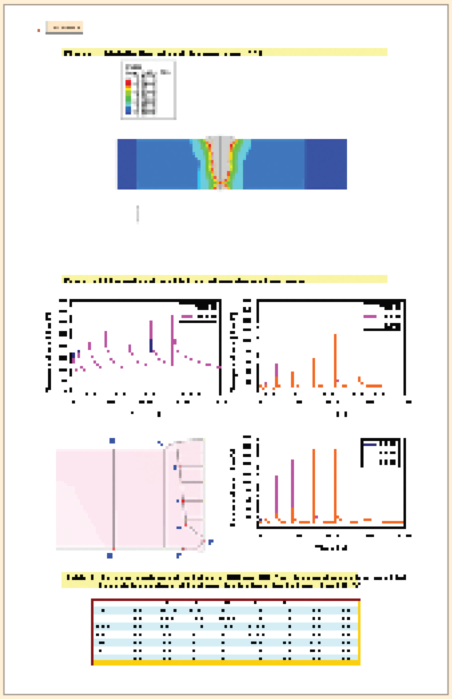

Fig. 4. One set of results available from the Excel spreadsheet after the calculation is finished.

Four EWI Engineers Receive Awards

Granjon Prize, W.H. Hobart Award, and ASNT Outstanding Paper Award presented to EWI Engineers

Four EWI engineers have received prestigious awards. Wei Zhang, Applications Engineer at EWI, is the co-recipient of the Henry Granjon Prize and Jose Ramirez, Senior Engineer at EWI, is co-recipient of the W.H. Hobart Award. Mark Lozev and Roger Spencer were selected to receive the ASNT Outstanding Paper Award.

The Granjon Prize, sponsored by the International Institute of Welding (IIW), is an annual international competition among authors of papers devoted to research into welding technology or a related subject. The research is categorized into one of four areas of joining, surfacing, or cutting technology. Dr. Zhang's Ph.D. thesis from Pennsylvania State University, "Probing heat transfer, fluid flow and microstructural evolution during fusion welding of alloys," was selected in the joining and fabrication category of the Granjon Prize competition. Dr. Zhang will present his research findings and accept the Granjon Prize during the opening ceremonies of the IIW Annual Assembly in Quebec, Canada on August 27, 2006.

The W.H. Hobart Award, sponsored by The Hobart Brothers Company to honor William H. Hobart, Sr., is given to authors of a paper published in AWS' Welding Journal during the previous calendar year that represents the best contribution to pipe welding, the structural use of pipe or similar applications, excluding the manufacture of pipe. In 2005, the Welding Journal published Dr. Ramirez' paper, "Properties and Sulfide Stress Cracking Resistance of Coarse-Grained Heat-Affected Zones in V-Microalloyed X60 Steel Pipe." Dr. Ramirez will receive his award at the Annual AWS Welding Show in Atlanta, Georgia, in October, 2006.

The ASNT Outstanding Paper Award is given to encourage a high degree of effort toward technical, educational or managerial achievement in NDT through publication in ASNT journals. Recipients of the award are selected on the merit of written contributions and based on the material's originality, usefulness and clarity, and on the appropriateness and accuracy of its supporting material. The ASNT publication, *Materials Evaluation,* published Dr. Lozev's and Mr. Spencer's paper, "Developing, Optimizing and Validating Automated Ultrasonic Procedures for Testing Heavy Walled Hydroprocessing Reactors." Dr. Lozev and Mr. Spencer will receive their award at the ASNT Fall Conference and Quality Testing Show in Houston, Texas in October, 2006.

Success Story NASA—Cleveland, Ohio

Challenge

The John H. Glenn Research Center (GRC) in Cleveland, Ohio is one of ten NASA Centers located nationwide. The GRC develops, verifies, and transfers aeropropulsion technologies to U.S. Industry. The GRC is involved in the development of space-based nuclear power systems as part of Project Prometheus. A critical technology for the designs of these systems is the ability to join both wrought and cast Ni-based superalloys (e.g. Hastelloy X and Mar-M247) to a range of refractory metals, specifically Mo- and Ta-based alloys. During joining using conventional fusion welding processes, these material combinations have potential for the formation of deleterious intermetallic reaction layers.

Solution

During a recent visit by GRC staff to EWI, a range of technologies was considered for creating solid-state joints between refractory metal and Ni-based superalloys. EWI suggested using three nontraditional technologies: inertia friction welding (IFW), magnetic pulse welding (MPW), and electro-spark deposition (ESD) welding.

IFW is a solid-state joining process that is not sensitive to solidification-related problems. In addition, the process can be manipulated to produce rapid thermal cycles. Such rapid thermal cycling is advantageous in suppressing any reaction between two materials. MPW and ESD accomplish joining through a series of micro-melt zones, and have been previously demonstrated on material combinations with dissimilar melting points.

EWI provided initial consulting services to define candidate technologies for superalloy to refractory metal joining. Follow-up investigations were completed and the feasibility of these approaches for specific material combinations was established.

Results

EWI applied IFW, MPW, and ESD technologies to the material combinations of interest and samples were made available for examination and testing at GRC. The greatest joining potential was shown by ESD as it was able to join all combinations of refractory metals and Ni-based superalloys of interest.

"EWI provided results that were meaningful," said Frank Ritzert, Materials Research Engineer at NASA Glenn Research. "EWI's engineers advanced our understanding of joining these materials."

NJC Demonstrates Automated Thermal Plate Forming (ATPF) to Navy and Shipbuilders

Navy ship construction requires forming steel plates into a variety of simple and complex curvatures. Presently, plates are processed using mechanical bending and rolling as well as thermal forming methods. Thermal forming methods currently practiced in the U.S. shipyards involve manual line heating procedures. With this process, a skilled operator selectively applies heat with an oxy-fuel torch in a defined pattern while simultaneously cooling the surface with water. With this approach, both simple and compound curvatures are possible. Manual heating methods are labor intensive, and the quality of the resulting product is dependant on the experience of the operator. Requirements to improve the accuracy of ship components and reduce construction costs for the DD(X) advanced multi-mission destroyer and other Navy combatants has created the need for an improved thermal plate forming process.

The Navy Joining Center (NJC) is part of a team that has conducted a project to develop an improved automated thermal plate forming (ATPF) system. Members of the project team include the Navy Metalworking Center, Northrop Grumman Ship Systems, General Dynamics-Bath Iron Works, the Applied Research Laboratory at Penn State University, and the Naval Surface Warfare Center-Carderock Division.

The ATPF system includes four major components: 1) path planning software (PPS), 2) an induction heat source, 3) a manipulation system with plate support and quench capability, and 4) an automated measuring system (AMS). The path planning software determines the location and order of heating patterns that must be applied to form the desired shape. The starting point for PPS is a 3-dimensional design model for the part to be formed. To date, the PPS incorporates the basic heating patterns (lines, diamonds, and triangles), and has been demonstrated on steel plates measuring up to 12 ft. long. Plate shapes representative of those found in ship hulls were used for verification. Demonstrations of the prototype system have been conducted for Navy and shipyard personnel. Heating patterns were applied by an induction system fixtured on a 3-axis gantry with an attached six-axis robotic arm. Plate support was achieved by an innovative gas strut system capable of adjusting to the plate's shape during the process. Quenching was accomplished with water and was applied from the back side with strategically directed spray nozzles. Plate measurements were performed using a portable CMM that was also attached to the gantry.

The ATPF system has the potential to increase productivity, decrease costs, improve quality, and minimize material degradation compared to manual methods. Automation of the process will facilitate increased accuracy and reduce the overall manufacturing costs through increased hull plate forming productivity, reduced rework, and lower skilled labor costs. Expected DD(X) implementation benefits include 100% increase in throughput, 80% reduction in rework, 50% reduction in direct labor costs, and 75% reduction in support labor costs. The technology can also be extended to current and future U.S. Naval surface ship fabrication, (e.g., LHD, LPD, and CVN-21), which will result in additional cost avoidance for the U.S. Navy.

For more information on ATPF, please contact Brian Girvin at 614.688.5117 (brian_girvin@ewi.org) or visit the NJC web site for more information on other NJC projects.

New EWI Members

Applied Spine Technologies, Inc.
New Haven, CT
Business: Manufacturer of dynamic stabilization devices with full anatomic motion for treatment of chronic lower back pain

Arcelor Flat Carbon Steel
Montataire, France
Business: Global producer of flat carbon steel

Berenfield Containers, Inc.
Mason, OH
Business: Manufacturer of metal containers (barrels and drums)

Charter Wire
Milwaukee, WI
Business: Manufacturer and supplier of precision, cold-rolled custom profiles, flat wire, and standard shapes for American industry

Faurecia Exhaust Systems, N.A.
Toledo, OH
Business: Manufacturer of automotive exhaust systems

Federal-Mogul Corp.
Ann Arbor, MI
Business: Global supplier of automotive components, sub-systems, modules and systems serving the world's original equipment manufacturers and the aftermarket

Nektar Therapeutics
Mountain View, CA
Business: Manufacturer or therapeutic and delivery devices for the medical industry

Preco Laser Systems (PLS)
Somerset, WI
Business: Provider of laser systems, diecutting systems, process development and laser contract services for the automotive, aerospace, electronic, packaging and medical industries

Shiloh Industries
Canton, MI
Business: Supplier and manufacturer of automotive parts

Square D
Lincoln, NE
Business: Distributors of electrical and industrial control products, systems, and services

Takata Restraints Systems, Inc.
Auburn Hills, MI
Business: Global manufacturer of automotive safety systems

Insights

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Upcoming EWI Tradeshows & Presentations

Dates	Event	Host	Location	Web Site
5/23 – 5/24/06	Ohio Fuel Cell Symposium	Ohio Fuel Cell Coalition	Canton, OH	http://www.fuelcellsohio.org/pages/831560/index.htm
6/7-6/9/06	Automotive Industry Advancements with NDT	The American Society of Nondestructive Testing	Birmingham, AL	http://www.asnt.org/events/conferences/auto06/auto06.htm
6/21-6/23/06	7th International EPRI Conference	Electric Power Research Institute	Porte Vedra Beach, FL	http://www.epri.com/default.asp
9/19-9/20/06	AWS Welding In Aircraft and Aerospace Conf.	American Welding Society	Dayton, OH	http://www.aws.org/conferences/
9/26-9/28/06	ATExpo	Reed Exhibitions	Rosemont, IL	http://www.atexpo.com/APP/homepage.cfm?modeuleid=42&appname=150