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# Welding & Repair Technology Center (WRTC) - Program Overview

***NRC Technical Information Exchange Meeting***

June 3, 2014

Rockville, MD

**Greg Frederick, EPRI Welding & Repair Technology Center**

**(Presented by Dan Patten, FENOC)**

# Outline – WRTC Overview

- Who we are
  - WRTC Program Organization
  - WRTC Program Participants
- What we do
  - WRTC - General Overview
  - Technology Transfer - Roadmaps

# EPRI WRTC Program - Organization

**Materials & Aging Action Plan Committee (MAPC)**

**Executive and Technical Committee**

**WRTC Chair – Dan Patten, FENOC**

**WRTC Executive Sponsor - Ben Mays, Luminant**

BWRVIP, SGMP, MRP, PSCR, PWROG, NDE, WRTC

**(WRTC) Integration Committee**

**Dan Patten, FENOC, Neal Chapman, Entergy**

**Mike Desai, Exelon, Marc Hall, Dominion,**

**John Sisk, Energy NW, Joe Wiecks, Entergy**

**Prioritization and Strategic Plan**

**(WRTC) Advisory Committee**

**All participating utility members**

**Advisory meetings in June and December**

**Engagement with Projects**





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# WRTC Program Participants

**United States**

- 26 of 26 US Utility Organizations participate in WRTC (all operating BWR and PWRs)

**International Participation**

- KHNP - Korea
- CEZ NPP- Czech Republic
- EDF/MAI - France
- KKL - Switzerland
- COG – Canada

**Non Utility Memberships**

- IHI Corporation – Japan
- Fluor Enterprises
- Welding Services Inc. (AZZ WSI LLC)
- Westinghouse

# WRTC Technology Leads

## *Who we are:*

**WRTC Program Manager**

- **Greg Frederick**, (704) 595-2571, gfrederick@epri.com

**WRTC Program Leads**

- **Steve McCracken**, (704) 595-2627, smccracken@epri.com
- **Dana Couch**, (704) 595-2504, rcouch@epri.com

**Material Technical Executives**

- **Robin Dyle**, (205) 426-5371, rdyle@epri.com
- **David Gandy**, (704) 595-2695, davgandy@epri.com

**Program Managers and Technical Staff**

- **Jon Tatman**, (704) 595-2762, jtatman@epri.com
- **Ben Sutton,** (704) 595-2833, bsutton@epri.com
- **Stacey Wells**, (704) 595-2673, swells@epri.com
- **Artie Peterson**, (704) 595-2605, arpeters@epri.com

**Welding/Shop/Labs**

- MK Havens, Metallurgical lab
- Mike Newman, Sr. Welding Specialist
- Mitch Hargadine, Robotics/Welding
- Scott Bailey, Welding processes





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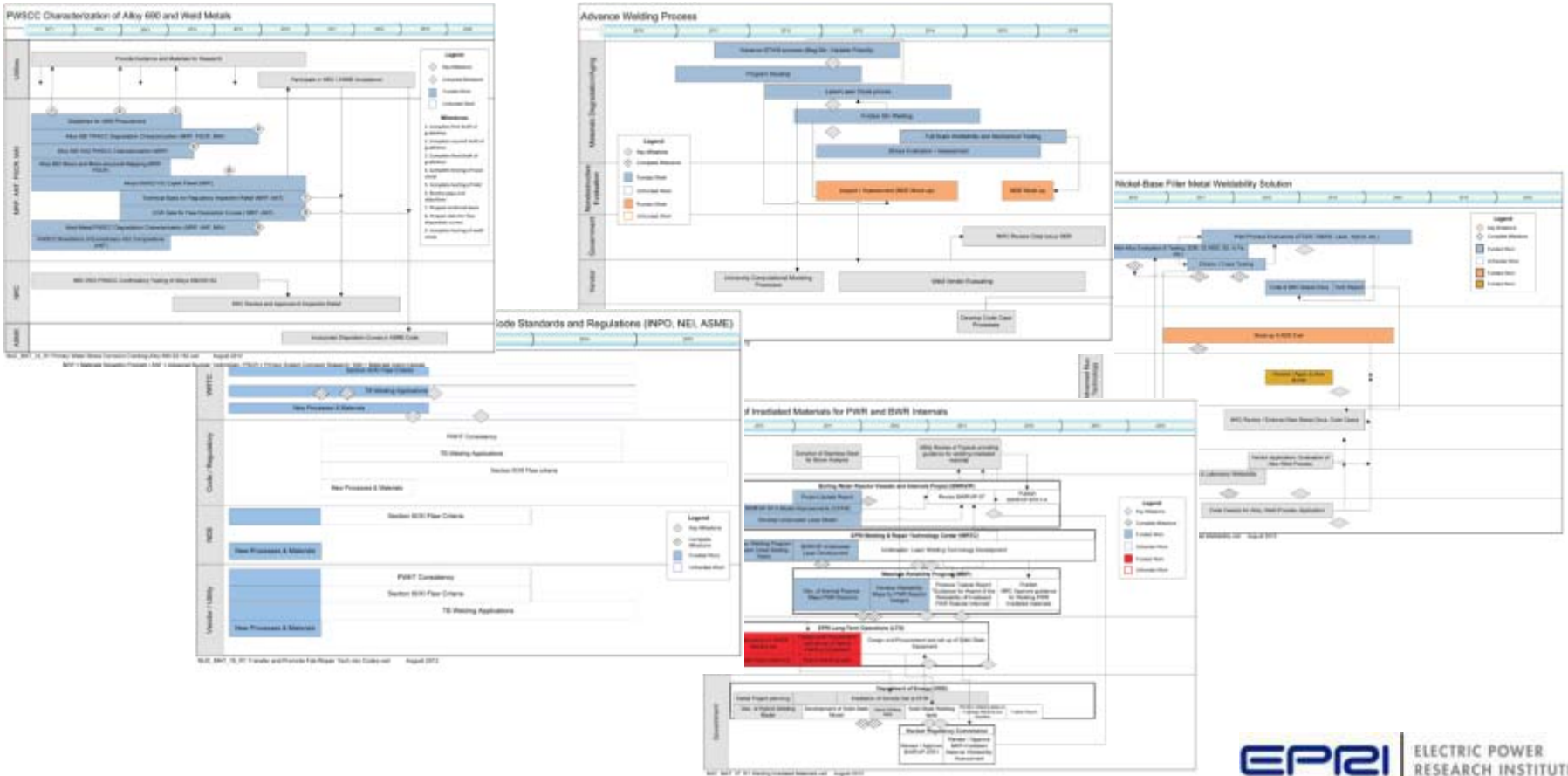
# WRTC Mission and Objectives

- WRTC Mission
- Focus on both tactical issues and strategic research to supply the necessary tools and technology to address current and future repair, fabrication, and mitigation issues in the nuclear industry.

- Primary Objectives
  - Establish repair techniques and technologies that can improve material performance, enable component life extension, increase plant availability, and reduce repair costs and time.
    - Research activities to support technical interactions with Code
  - Forums for sharing operating experience, discussing repair, fabrication and weld program issues and industry emerging issues
    - Provide access to materials, welding, and repair experts across the EPRI and the nuclear industry
    - Provide mentoring early career engineers and technical staff
    - Conferences, training and work shops
  - Strategic roadmaps and WRTC Solution Areas outline research gaps associated with key issues

# Roadmaps Guide the Way

- Roadmaps clearly <u>communicate</u> approach within the power industry for coordination and planning of repair, mitigation and replacement activities - Collaboration



# WRTC Roadmap Listing

- *New welding technology and guidance for the repair of highly irradiated materials*
- *Alloy 52M Nickel-base filler metal weldability guidance and material solutions*
- *Development of PWSCC resistant nickel based welding alloys with improved weldability for repair and fabrication DMWs*
- *Advance welding process development in nuclear power industry*
- *Advancements in Code and regulatory requirements for repair, replacement and mitigation techniques.*
- *Other supporting roadmaps or Solution Areas:*
  - *Best Practices for Welding Residual Stress for Repair and Fabrication*
  - *Used Fuel Storage Issues regarding fabrication and repair*
  - *Spent Fuel Pool Leakage*
  - *Socket Weld Resolutions*
  - *Hardfacing and PM materials.*

# Roadmap: New welding technology and guidance for the repair of highly irradiated materials

- **Develop and advance welding process capabilities**
  - Friction stir welding process
  - Modified/hybrid laser welding process
  - Gas Tungsten Arc Welding
- **Perform welding experimentation and validation tests**
  - Assess overall weldability on representative materials
- **Developed neutron fluence weldability maps**
  - Determine where repairs can be applied with conventional and controlled welding processes
  - Provide guidance for welding (effective heat input equations)

*Low dilution laser welding process with constant wire feed.*

*Modified laser welding for thermal profile and compressive* strain field *controls during welding on highly irradiated materials.*





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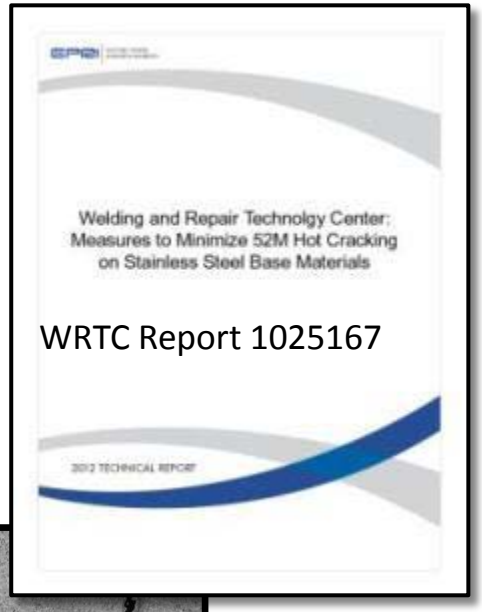
# Roadmap: Alloy 52M Nickel-base filler metal weldability solution

*Objective: Improve understanding of weldability of high chromium nickel-base filler metals used in the nuclear industry*

- Supply measures to control hot cracking on stainless steel base materials and 52 type alloys susceptibility to ductility dip cracking
  - Document the influences of austenitic stainless steel dilution on hot cracking
  - Verification chemistry thresholds
  - Provide solutions to weldability





*Example of hot cracking in*


*Hot Cracking Issues on Overlay applications*





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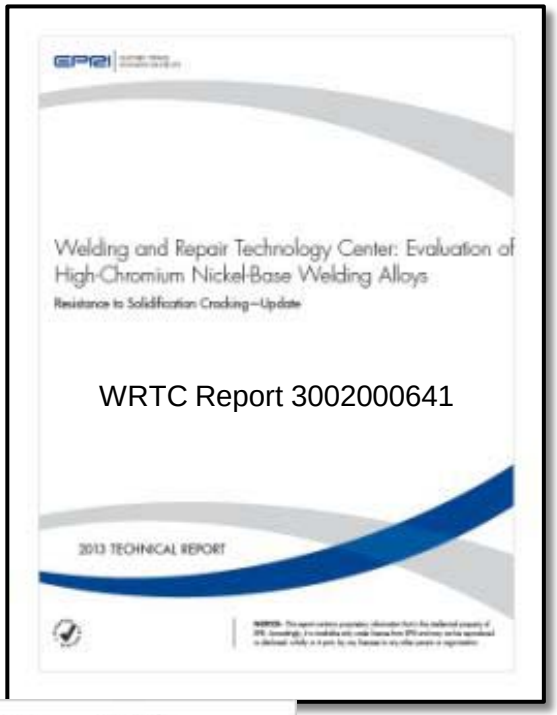
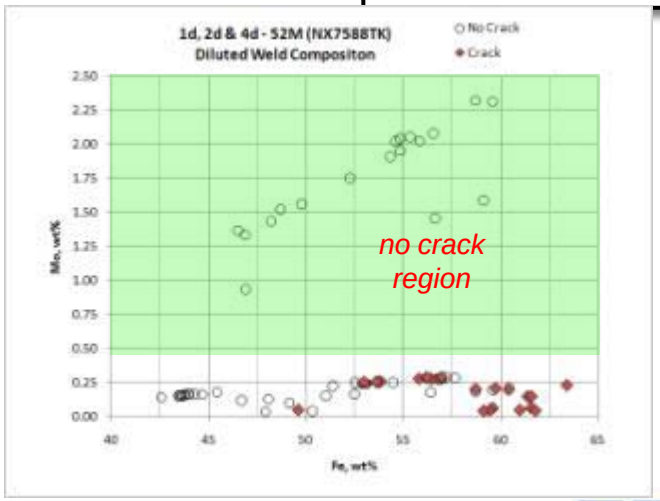
# Roadmap: Alloy 52M Nickel-base filler metal weldability solution

- Provide simple means of screening the susceptibility of welding filler metals to hot cracking, DDC and weldability.
- Development new welding alloy composition with high degree of weldability while maintaining corrosion properties of Alloy 690





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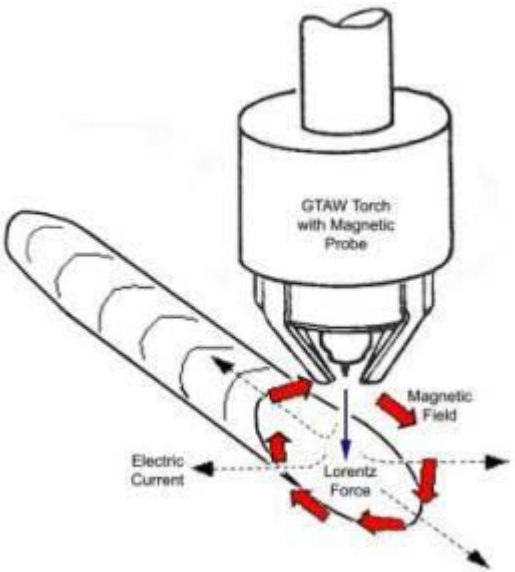
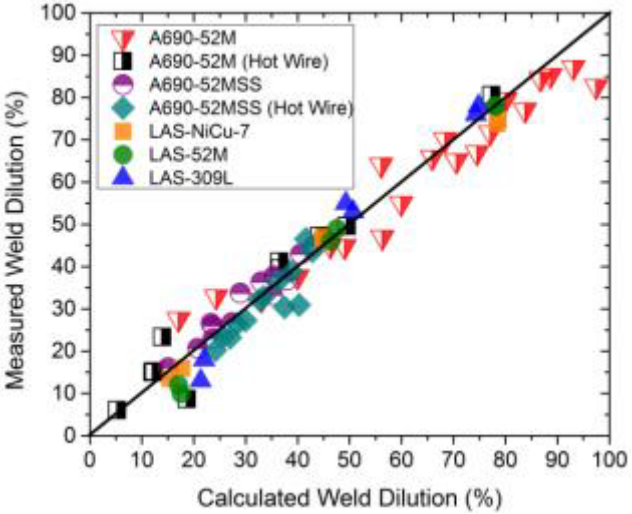
# Roadmap: Alloy 52M Nickel-base filler metal weldability solution

- Evaluation of alternative welding processes and controls to improve weldability of 52M
  - Refined grain structure reduced susceptibility to solidification cracking caused by dilution with deleterious stainless steel, optimize UT examination capability
  - WRTC Report 1025176 – Magnetic Stir Welding
- Development of Improved Heat Input and Dilution Equations for Consumable Welding Processes
  - Improved optimization/control of heat input and HAZ microstructure for critical weld applications
  - Supports highly controlled processes for solidification cracking control and welding of highly irradiated materials.
  - Supports conventional and advance welding processes (e.g., Laser)




*Improved Heat input correlation with weld dilution*

# Roadmap: Advance Welding Process Development in Nuclear Power Industry

*Objective: Roadmap supports the fundamental assessment of welding technologies for repair, mitigation and replacement activities*

- Reduced base material interactions
- Optimizing the welding residual stress profile
- Improving the inspectability of weld deposits
- Welding productivity

- Welding process evaluations include all aspect of power plant component repair and fabrication including
  - Weld simulation and modeling and welding process
  - Real-time NDE and Weld monitoring
  - Adaptive Welding
  - Cladding applications
  - Delivery (automation) of welding process for improved deposition rates and quality.
  - Supporting documentation for augmented welding processes into ASME Code

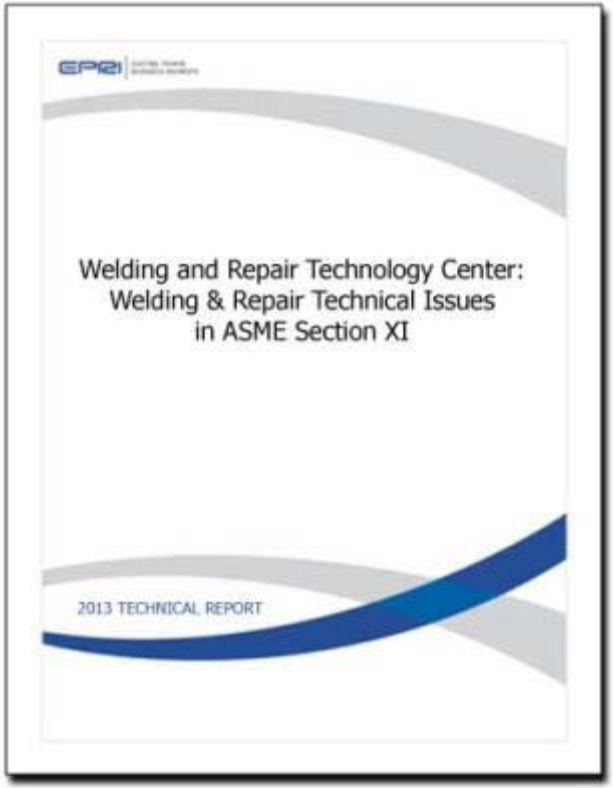
*690 strip cladding mockups and process controls*

*Friction stir welding development*

*Welding residual stress measurements*

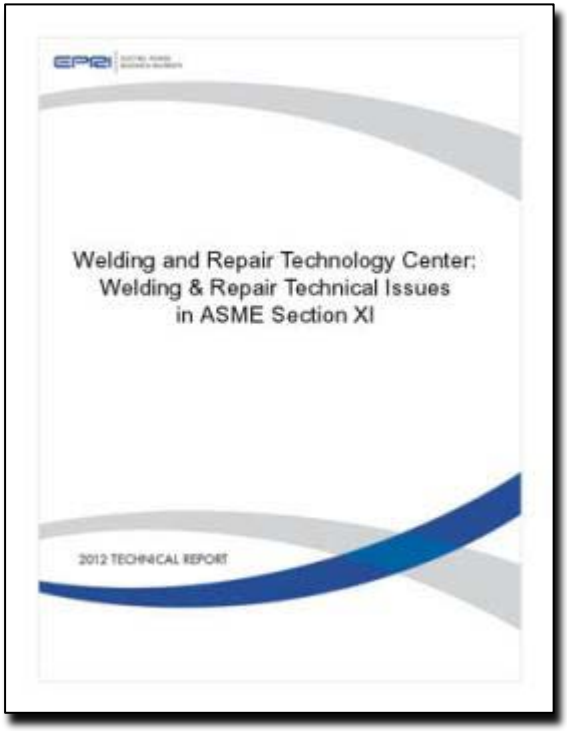
# *Roadmap: Advancements in Code and regulatory requirements for repair, replacement and mitigation techniques*

- Provide long term focus and direction to WRTC projects that address code and regulatory issues:
  - Development of technical bases reports in support of code cases for new mitigation and repair methodologies, and materials
- Progress is summarized in Welding & Repair Technical Issues in ASME Section XI (EPRI Report No. 3002000600)
  - Single reference document for WRTC members to follow progress
    - Provides status of recent Section XI revisions and initiatives (code cases)
    - Provides status of on-going activities supporting code changes or improvements.
    - Updated annually



# Roadmap: *Provide long term focus and direction to WRTC projects that address code and regulatory issues*

- **Welding & Repair Technical Issues in ASME Section XI (1025169) – single source referenced** (living document) for WRTC members to review status and new code changes and initiatives including;
  - Validity of Hardness as a Measure for Temperbead HAZ Toughness
  - Simulated PWHT for Qualifications
  - Alternate Impact Test Rules for Temperbead Qualifications
  - Elimination of Hydrogen Bakeout for SMAW Temperbead
  - Fluence Thresholds Affecting Weldability
  - Methods to Validate Chromium Recovery
  - Interpass Temperature Controls for Temperbead and Weld Overlays
  - Excavate and Weld Repair Code Case
  - Status of Code Cases
    - N-638-7, N-666-1, N-740-2, N-786, N-789, N-818
  - Appendices Include August 2012 ASME WGW – NRC Staff Meeting Presentations

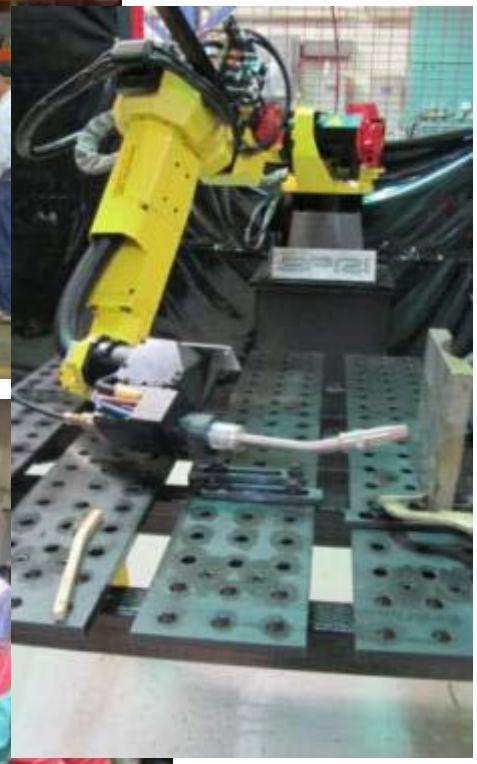


# WRTC Advisory Meetings and Training Programs

- WRTC has two advisory meetings per year (June and December)
  - June 24-28, 2014 (Naples, FL)
  - December 8-12, 2014
- Meeting agenda covers
  - Project Overviews
  - Code and Regulatory Issues
  - Operating Experience (OE)
  - Emerging Issues
  - Demonstrations/Training Session
    - Welding program training
    - Repair and replacement engineer training
    - Welding process demos and training
    - Buried Pipe Repair Training Workshop

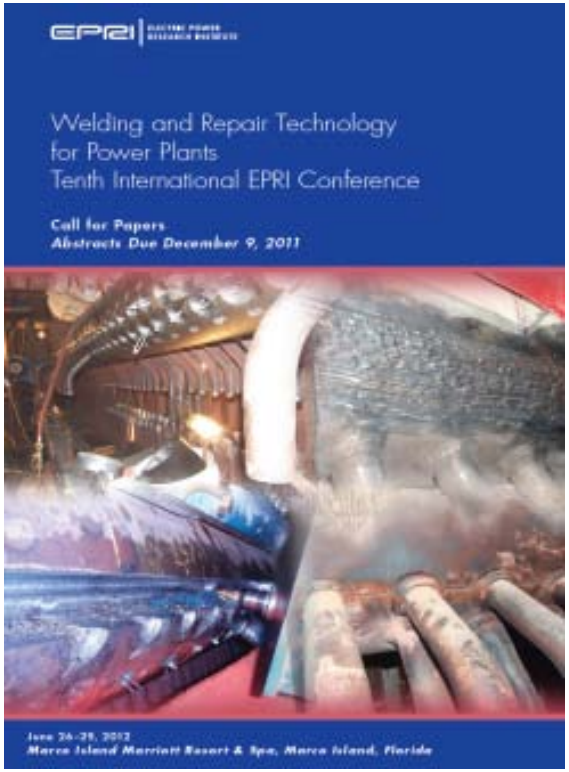
# WRTC Advisory Meetings and Training Programs

- Advance Welding Process demos and training
  - Advance Welding processes
  - Familiarization with conventional process
  - Automated and machine welding
  - Manual welding



# WRTC Welding and Repair Conference Series

- 11th International Conference Welding and Repair Technology for Power Plants
  - June 25-27, 2014, Naples, Florida (in conjunction with WRTC advisory meeting)
- Nuclear & Fossil Topics
- Conference Co-sponsored by Fossil Mat. & Repair (P87), Boiler Life and Availability (P63), HRSG Dependability (P88)
  - Repair, mitigation, code and regulatory issues, and materials
- Vendor Expo - Service vendors, equipment suppliers, material testing
- Poster Session: University studies on welding and material issues



# Together…Shaping the Future of Electricity