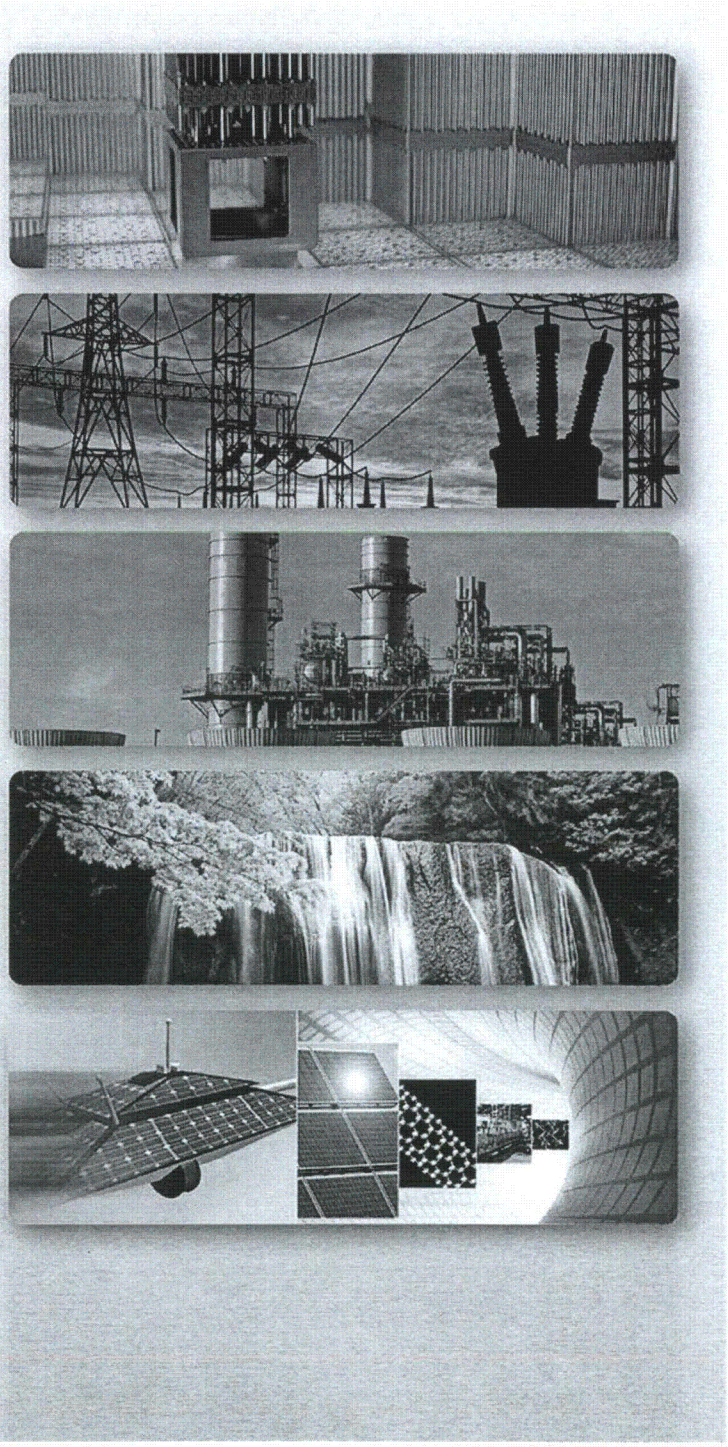

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Welding and Repair Technology Center – Overview

Greg Frederick, EPRI
WRTC Program Manager

Dan Patten, FENOC
Program Chair

June 21, 2011

Outline - Summary

- Welding & Repair Technology Center (WRTC)
  - WRTC Mission/Strategic Plan
  - Advisory Structure/Meetings
  - Technology Roadmaps/Key Areas

WRTC Strategic Plan

- WRTC balances fundamental research (long-term) with tactical projects (short-term)
  - WRTC focus on tactical support and short-term, utility-requested R&D.
  - *emergent repair needs*
  - *code cases*
  - *repair and welding process optimization*
  - *information exchange*
  - Apply resources toward proactive resolution of major industry gaps & development of advanced solutions
  - Collaborations to develop and deploy materials joining and repair fundamental solutions
  - Align WRTC resources, program objectives, and projects for long term research

WRTC Strategic Plan

- WRTC Strategic Plan (Roadmaps)
  - Technology gaps were identified in the area of welding and repair
  - Six areas were highlighted for further development
  - Three roadmaps address fundamental R&D
    1. Develop new welding technology and guidance for the repair of highly irradiated material (PWR and BWR Internals)
    2. Alloy 52M Nickel-base filler metal weldability solution
    3. Develop a new SCC resistant nickel based or alternative alloy with high weldability for dissimilar metal weld applications

WRTC Strategic Plan

- Three roadmaps address tactical applications
  4. Development & Implementation of Advanced Welding Technologies
     - Residual Stress Assessment Solutions
     - Welding Impact on Inspectability
     - Production Rates
  5. Small Bore Pipe Asset Management
  6. ASME Code Issues and Support – White papers and technical bases

- Other Key WRTC Activities
  - Root Cause Analyses
  - Best Practices and Guidelines - Benchmarking
  - Information exchange
  - Training Guidelines (Overlay, Failure analyses, Temperbead welding)

WRTC Advisory Structure

- *25 of 26 US Utility Organizations (operating BWR and PWRs) participate in WRTC*
- *5 International members*
  - *EDF - France*
  - *KNHP – Korea (New 2011)*
  - *COG - Canada*
  - *CEZ NPP (New 2011)*
  - *British Energy Generation Ltd.*

RRAC – WRTC Team

- Program Manager
  - **Greg Frederick**; (704) 595-2571
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- Welding/Repair & Replacement Activities/New Plant Build
  - **Steve McCracken**, (704) 595-2627
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- Welding/Repair & Replacement Activities/Best Practices
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- Welding/Repair & Replacement Activities/New Plant Build
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- Stress Measurement/Mechanical Technologies/Testing
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- Technical Staff Assistant
  - **Stacey Burnett**; (704) 595-2673
    - sburnett@epri.com

Welding Technology Conferences

- Established conference series for Welding and Repair Technology
  - *Welding and Repair Technology for Power Plants, 9th International Conference, Marco Island, FL (2012)*
  - *Welding and Fabrication Technology for New Power Plants and Components (June21-24, 2011, Omni Champions Gate, Orlando)*
  - Sponsored by WRTC and Fossil Materials Repair (Program 87), Boiler Life and Availability (Program 63), HRSG Dependability (Program 88)

Workshops Planned for 2011 Conference

B31.1 Materials, Fabrication, & Examination - Doing It Right

- Discuss the bases for the B31.1 Power Piping Code rules for materials, fabrication, and inspection/examination. Special emphasis will be placed on rules that are different from other ASME Codes
- Course conductor: *Philip D. Flenner, PE*

Basics of Conducting a Failure Investigation

- Intended to educate the power plant engineer on the proper steps to take when conducting a failure analysis
- Course conductor: *Dr. Jude Foulds, P.E., Principal, Clarus Consulting, LLC*

Heat Treating Practices for Energy Construction: Quality and Consequences

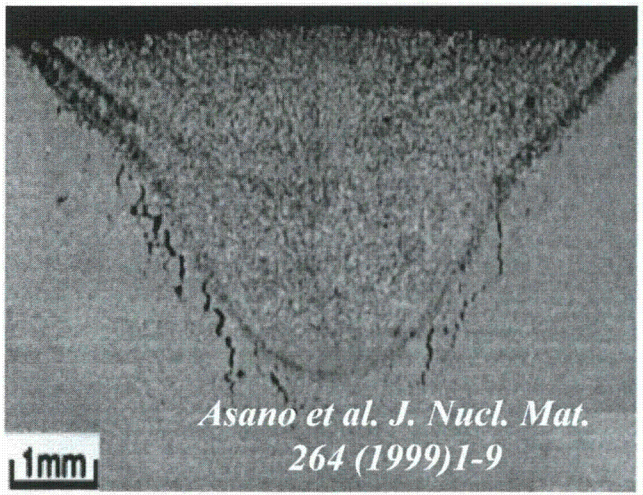
- Discuss the basics of heat treatment and its growing significance in power construction. Emphasis on material quality and illustration of potential failures in base and weld material
- Course conductor: *Gary Lewis and Joe Borror, Superheat FGH*

Roadmap – Weldability of Irradiated Material

ISSUE STATEMENT

- *Continued operation of light water reactors will require repairs or replacement of reactor internal components as degradation occurs (Welding will play an important role)*

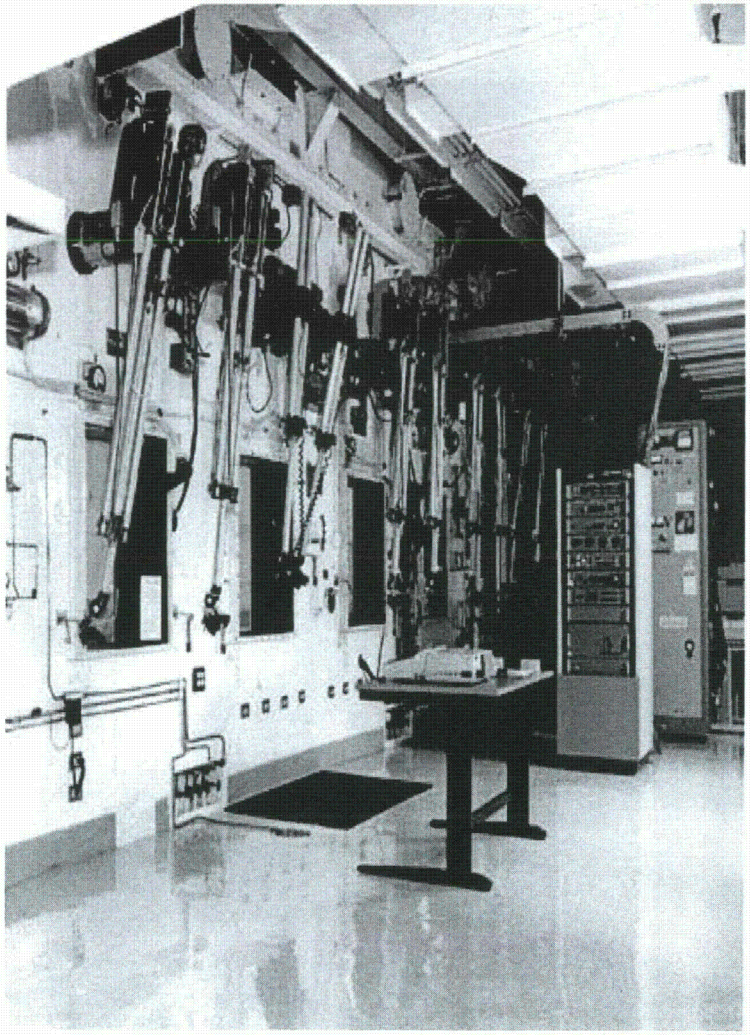
- *Weldability of the materials is altered by the formation of helium (helium-induced cracking)*



Roadmap – Weldability of Irradiated Material

Project Objectives and Scope

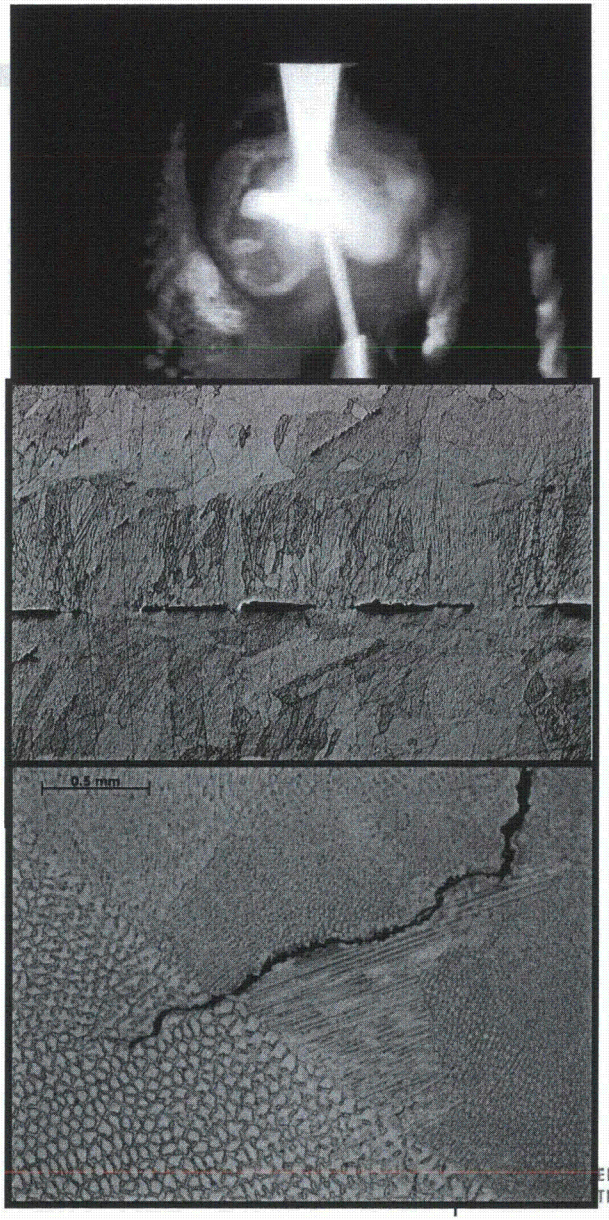
- Develop advanced welding technology required for reactor repairs
- Collaborate with industry experts to support reactor life extension beyond 60 years
- Development Modeling Simulation to Guide Process Development and Predictive Application on Irradiated Materials
- Validate Processes
  - Hot Lab Welding and Testing
    - Laser, hybrid, friction stir
  - Neutron Irradiated Sample Set (Standard)



Alloy 52M Nickel-Base Filler Metal Weldability Solutions

Issue.....

- INCONEL 182 (ENiCrFe-3) filler metal extensively used in DMW welds for critical reactor coolant system components
  - Over time 182 is degraded by primary water stress corrosion cracking (PWSCC)
- High Cr filler metal (52M) has high resistant to PWSCC and required for;
  - Mitigation, Repair and Fabrication
- Weldability and crack susceptibility of 52M are complex, requiring
  - Adequate composition limits
  - Narrow weld process controls
  - Isolation of susceptible base materials
  - Adequate experience required



Roadmap - Development of New SCC Resistant Nickel Based or Alternative alloy

ISSUE…….

- *Alloys 52 and 52M currently required for DMW repairs*
  - *High-chromium, nickel-based weld metals developed specifically for their superior resistance to SCC*
  - *Alloys are susceptible to weld cracking and have less than optimum weldability.*
- *A new high-chromium welding alloy is needed*
  - *With desired mechanical properties and corrosion resistance*
  - *With significantly improvement in weldability and superior resistance to weld cracking.*

Development of New SCC Resistant Nickel Based or Alternative alloy

PLAN.....

- Fundamental research performed to understand cracking mechanisms and weldability problems
- Development of alloy composition
  - Model welding behavior and mechanical properties of target compositions
  - Validate modeled behavior with experimental weld wire heats
  - Perform mechanical, corrosion, and crack growth rate testing
- Assess welding and nondestructive evaluation of alloy composition
  - Assess process parameters for gas tungsten arc and gas metal arc welding
  - Large scale mockups and assessment of nondestructive evaluation
  - Assess feasibility of alternative advanced welding processes (laser welding, magnetic stir, hybrid, etc.)

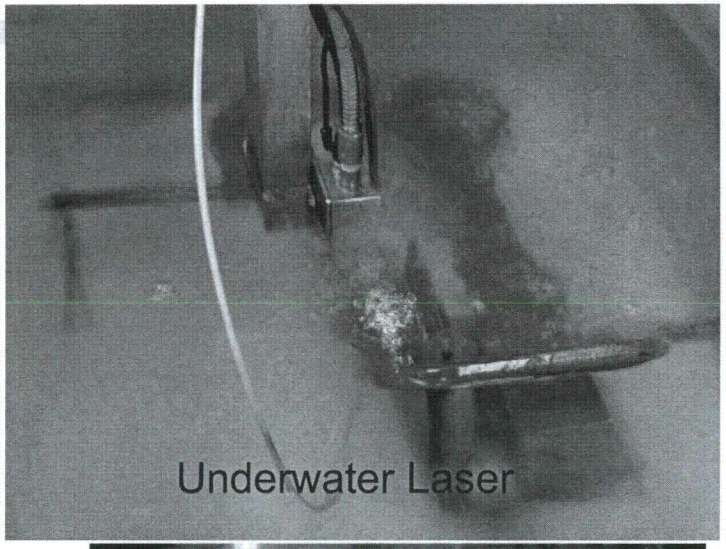
Roadmap - Development & Implementation of Advanced Welding Technologies

Objectives

- Roadmap for advance welding process and application development
  - residual stress improvements
  - welding impact on inspectability
  - increase production rates

Development of Advanced Welding Processes

- Welding Process Studies
  - Controlled dilution and material interactions (residual stress)
  - Evaluate processes that do not create a molten weld pool
  - Evaluation of weld filler materials interactions
- Advantages compared to traditional welding processes
  - Creation of a wider repair welding window
  - Effectively changing the local stress/strain field to a compression
  - Reduced heat affected zone (HAZ)

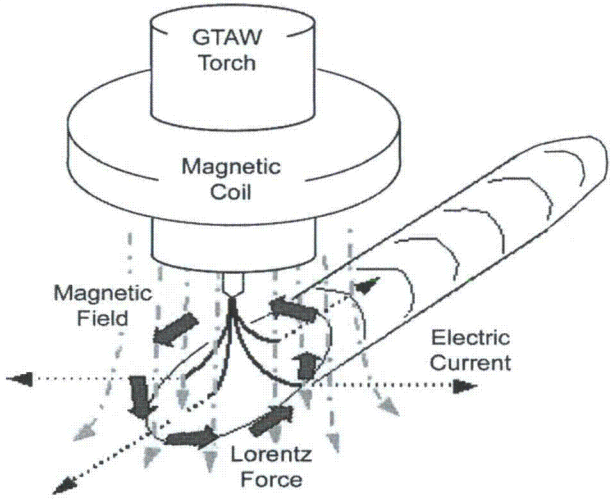

Underwater Laser

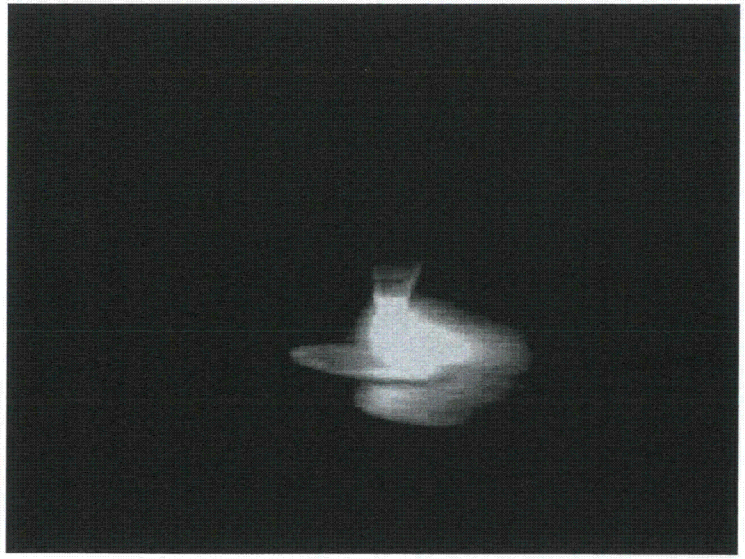

FSW of SS304

Development & Implementation of Advanced Welding Technologies

Magnetic Stir Welding Process Evaluations

- Initial results with overlay configuration with Alloy 52M
  - Show reduction in weld metal grain size
  - Significantly improved NDE (UT) examination capability by reducing ultrasound attenuation
- Work in 2011 will evaluate
  - Potential for reduction in hot cracking
  - Capabilities to address groove welding application for new construction and repair (single sided applications)





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