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## **Generic Industry Response Hot Leg Cracking Experience**

### **Materials Reliability Program Alloy 600 Issue Task Group (ITG)**

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## **Background**

- There have been two recent through wall cracks in Alloy 82/182 welds in PWR plants in the US
  - A short through-wall axial crack in a hot leg nozzle safe end weld at VC Summer resulted in a leak generating over 200 pounds of boric acid crystals accumulation
  - An axial-radial crack through a CRDM nozzle J-groove weld at Oconee 1 resulted in a small volume (<0.5 in<sup>3</sup>) of boric acid crystals at the point where the CRDM nozzle exits the vessel head

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## Background (continued)

- Both of the leaks have been repaired
  - A 12" long section of the VC Summer hot leg pipe containing the leaking weld was replaced with a new section of pipe with stainless steel and Alloy 52/152 welds
  - The cracked portion of the Oconee 1 CRDM nozzle weld was ground out and weld repaired with Alloy 152 weld metal

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## NRC Questions re: Summer Crack

- Are techniques other than UT appropriate
- Qualification of alternative techniques
- What qualified UT techniques are used by industry
- Capabilities of UT techniques for "Summer-type" flaws
- Applicability/benefit of enhancing leakage detection capabilities
- Scope of the problem, ie. where are the Alloy 82/182 welds and what are safety consequences, if any, of cracks
- Impact on leak before break (LBB)

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## MRP Recommendations from Dec. 2000 Meeting

- MRP A600 ITG will take lead in developing an Industry plan.
- Have meeting between MRP and NRC in early 2001.
- MRP to work with NRC addressing their concerns
- Near-term efforts will be focused on continued safe operation of plants

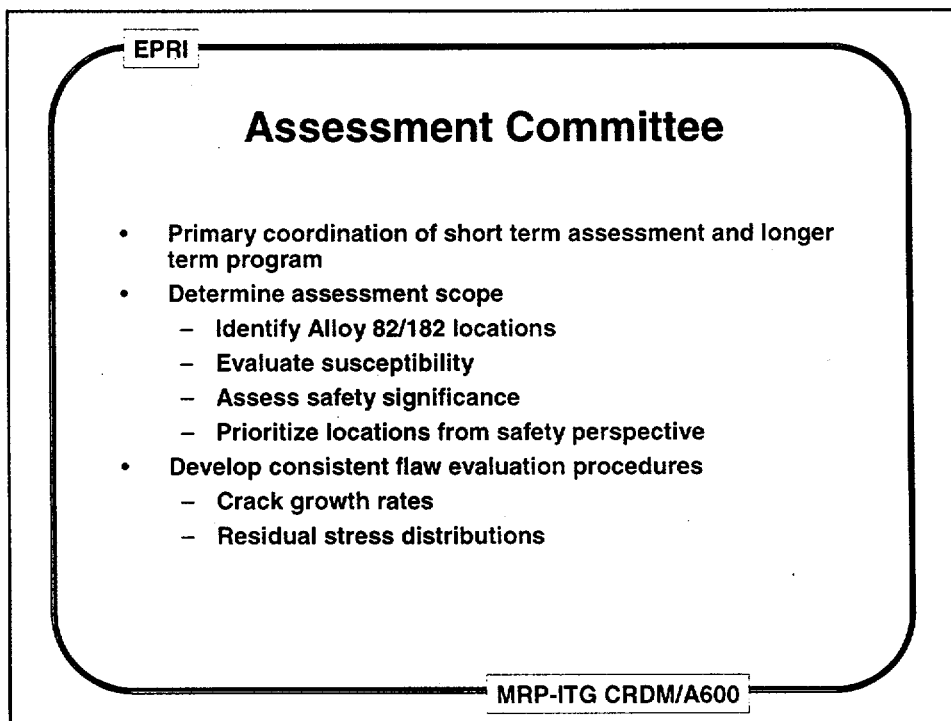
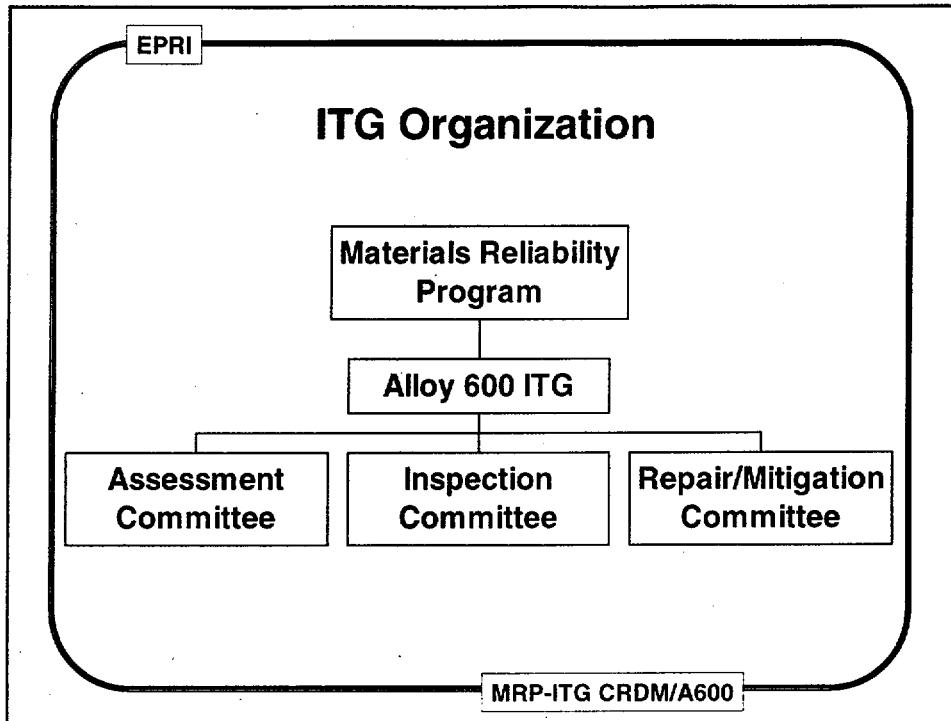
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## MRP Response to Weld Cracking Incidents

- Develop an industry plan
- MRP executive approval of plans and funding is being pursued
- The response plan will include:
  - Short term assessment to document that continued operation for Alloy 82/182 welds is acceptable
  - Longer term assessment of all Alloy 82/182 applications in PWR primary systems
  - Review and improvement of the inspection programs
  - Review of repair/mitigation methods
- The priority and schedule will be determined and conveyed to the NRC later

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## Assessment Committee (continued)

- **Assess research needs and oversee research tasks, e.g.:**
  - Crack growth tests
  - Additional use of Summer material
  - Worldwide data review and evaluation
  - Other material tests

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## Weld Safety Assessment

- Visual inspections per GL 88-05 requirements detected the leaks at Summer and Oconee before the integrity of the components was adversely affected
  - Confirmed by safety analyses
- Verifying these safety analyses are applicable to other plants and other Alloy 82/182 welds is the highest ITG priority

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## Weld Safety Assessment

- Like BWR Generic Safety Assessment for Shroud
  - Not as comprehensive as VIP-06, which covered ALL components inside nozzles, but should address all Alloy 82/182 welds
- Involves 3 NSSS vendors
  - Modeled after the industry response to GL 97-01
  - Assessment Committee establish generic evaluation approach
  - NSSS vendors perform assessments for their particular configurations
  - Responses coordinated and submitted as an Industry Safety Assessment

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## Weld Safety Assessment

### Include consideration of:

- Failure Margins - Axial and Circumferential
  - Fracture toughness
  - Crack Growth Rates and extent
- Impact on Leak Before Break
- Industry situation
  - Weld types and repair history (Cover ALL Alloy 82/182 welds)
  - NDE Results - Adequacy/uncertainty
    - » NDE used by vendors, past/present
    - » NDE results – Industry/Individual Plants
  - Leakage Monitoring
- Generic Stress Analysis
  - Axial and Circumferential
  - Base Cases – (as designed weld configurations)
  - Repair Cases – ID/OD, small and large
- Weld and Repair Materials
- Assessment of risk

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## Weld Safety Assessment

Some topics to be addressed include:

- Causes of PWSCC in Alloy 82/182 welds
- Analysis of crack orientation based on:
  - Stress analysis
  - Field observations
- Analysis demonstrating that safety is assured by Leak Before Break considering:
  - Maximum possible flaw size
  - Leak detection capability, including boron walkdowns
  - Fracture mechanics analysis
  - Boric acid corrosion of carbon steel components

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## Inspection Committee

- Background
  - VC Summer and Ocone leaks discovered by visual inspections for boric acid
  - UT and ET provided mixed results

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## Inspection Committee

- Provide input to Safety Assessment Committee
  - NDE capabilities and historical results
  - Acceptance criteria
  - Inspection frequency
- Committee to address NDE questions
  - NDE capability
  - Alternate NDE (if needed)
  - Leak detection capabilities
  - Qualification of techniques
- Impact on Risk Informed ISI (feedback of industry experience already part of RI-ISI)

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## Inspection Committee

- Coordinate near term outage recommendations, e.g.
  - Make inspections consistent
  - Take advantage of appropriate lessons learned
  - Enhanced awareness
- Evaluate boric acid walkdown adequacy
- Determine availability of mockups and tools
- Coordinate with vendors to define capabilities/limitations of coverage, development of alternate techniques
- Evaluate the "role" of alternate techniques
- Include lessons learned from domestic and foreign plants

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## Inspection Committee

- **Develop a Long Term Plan, including:**
  - Performance qualifications
  - Evaluate feasibility of alternate/new techniques
  - Provide training/expert help
- **Vendors will likely develop improved inspection and delivery methods with input from committee**
- **EPRI NDE Center will coordinate qualification/demonstration with PDI**
  - Similar to thermal fatigue and CRDM nozzle programs

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## Repair/Mitigation Committee

- **Summer and Oconee repairs were primarily manual methods**
- **Repairs were time consuming and dose intensive**
- **Need for repair/mitigation improvements depend on Assessment Committee and inspection findings**

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## Repair/Mitigation Committee

- **Prioritize from repair/mitigation/inspection perspective**
  - Likelihood/consequence of failure
  - Implementation difficulty
  - Cost and dose
  - Material availability
- **Create a repair/mitigation matrix**
  - Assess existing technology
  - Qualification and demonstration
  - Code and regulatory compliance/involvement

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## Near Term Actions

- **Review NRC staff feedback from today's meeting**
- **MRP Executive briefing of NRC management**
- **Committee activation**
  - **Begin safety assessment**
  - **Provide guidance for spring 2001 outages**
  - **Finalize action plan and schedule**
- **Schedule follow-up meetings with NRC staff**

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