

EPRI

Generic Industry Response Hot Leg Cracking Experience

Materials Reliability Program Alloy 600 Issue Task Group (ITG)

Larry Mathews, SNC

Chairman

Al McIlree, EPRI Project Manager

January 25, 2001

MRP-ITG CRDM/A600

EPRI

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 in³) of boric acid crystals at the point where the CRDM nozzle exits the vessel head

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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)

MRP-ITG CRDM/A600

EPRI

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

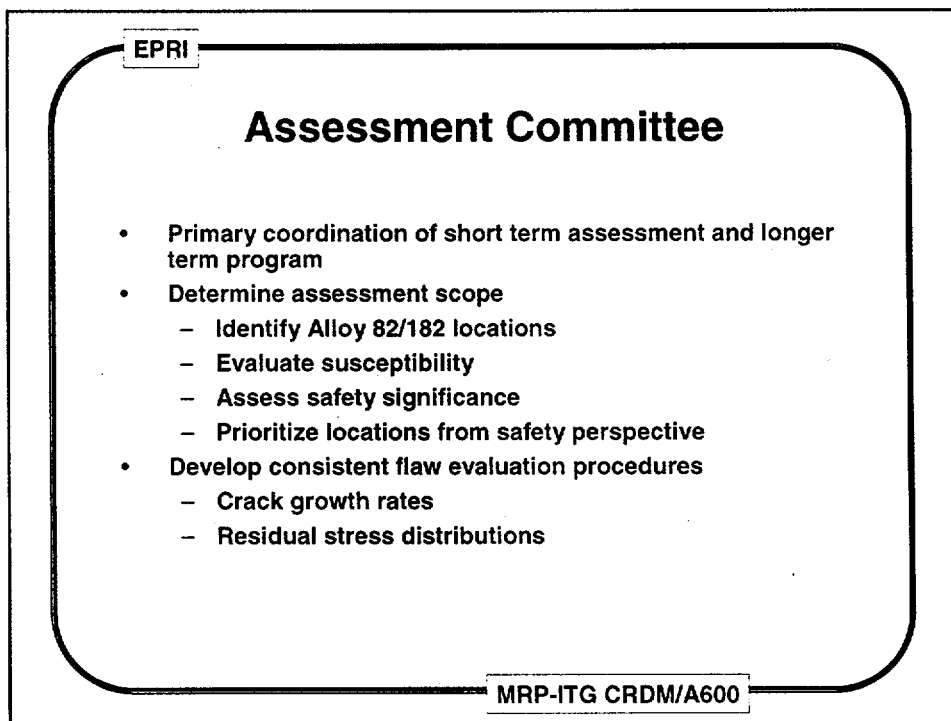
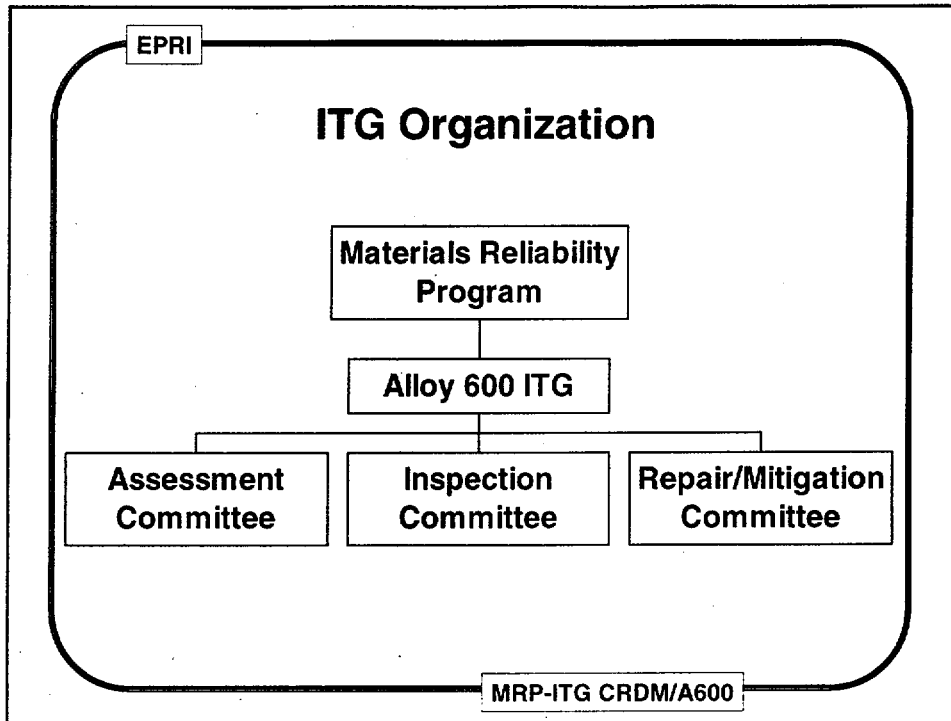
MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600



EPRI

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

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

Inspection Committee

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

MRP-ITG CRDM/A600

EPRI

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)

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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

MRP-ITG CRDM/A600

EPRI

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**

MRP-ITG CRDM/A600