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Overview of Industry Activities on Mitigation of PWSCC in Ni-Based RCS Components

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MRP/PWROG Briefing to NRC RES

Mitigation of PWSCC in Alloys 600/182/82: Background

- PWSCC is an important degradation mechanism in PWRs worldwide
- Replacement using resistant materials (e.g. Alloys 690/152/52) is ongoing
- Mitigation maintains plant safety and improves equipment reliability
- Additional mitigation methods desired to deal with all Alloy 600 and weld metal locations to
  - Prevent initiation of new cracks
  - Arrest or slow growth of existing cracks
- Extensive experience of IGSCC in BWRs suggests that both chemical and mechanical methods are beneficial. Both are being investigated for PWR plants.

BWR Mitigation Methodology

- Reduced Weld Inspection Frequencies
  - BWRVIP Technical Basis for Revisions to Generic Letter 88-01 Pipe Inspection Schedules (BWRVIP-75)
  - Specifies reduced inspection frequencies for IGSCC Susceptible Welds upon effective mechanical or chemical mitigation
    - Stress Improvement (MSIP or IHSI)
    - Weld overlay
    - Corrosion-resistant cladding/inlay
    - Hydrogen Water Chemistry

BWR Methodology (continued)

- NRC approval of technical reports that define effective mitigation requirements
  - "BWRVIP, Technical Basis for Inspection Relief for BWR Internal Components with Hydrogen Injection" (BWRVIP-62), December 1998
- Weld Overlay and MSIP accepted by NRC in GL 88-01

PWR Mitigation Plan

- Submit technical reports (e.g. MRP-169 for PWOL) that provide technical bases for qualification of mitigation technologies
  - Qualification program results
  - Any applicable field experience
  - Improvement for delaying crack initiation and for crack growth rate reductions
- Attain credit for mitigation
  - Reduced crack growth rate for flaw evaluation
  - Optimized inspection frequency
- Acceptable mechanical mitigation techniques addressed in MRP-139; chemical mitigation techniques will be addressed in revision to MRP-139

Mitigation of PWSCC in Alloys 600/182/82: Industry Approach to mitigation

- Industry approach is to use one or more of the following:
  - Chemical methods to alter environment
  - Mechanical methods to alter stress or rejuvenate damaged surface layer of base or weld metal
  - Replacement or isolation of susceptible materials

PWSCC Mitigation Technologies

- Chemical Mitigation
  - Elevated Hydrogen
  - Zinc Addition
- Mechanical Mitigation
  - Surface Remediation
  - Full Structural Weld Overlay
  - Optimized Weld Overlay (OWOL)
  - Weld Inlays
  - Surface Stress Improvement (Peening)
  - MSIP
  - Abrasive Water Jet Conditioning

Chemical Mitigation Specifics

- Mitigation Technologies
  - Elevated hydrogen
  - Zinc addition
- Address Crack Initiation and Crack Growth

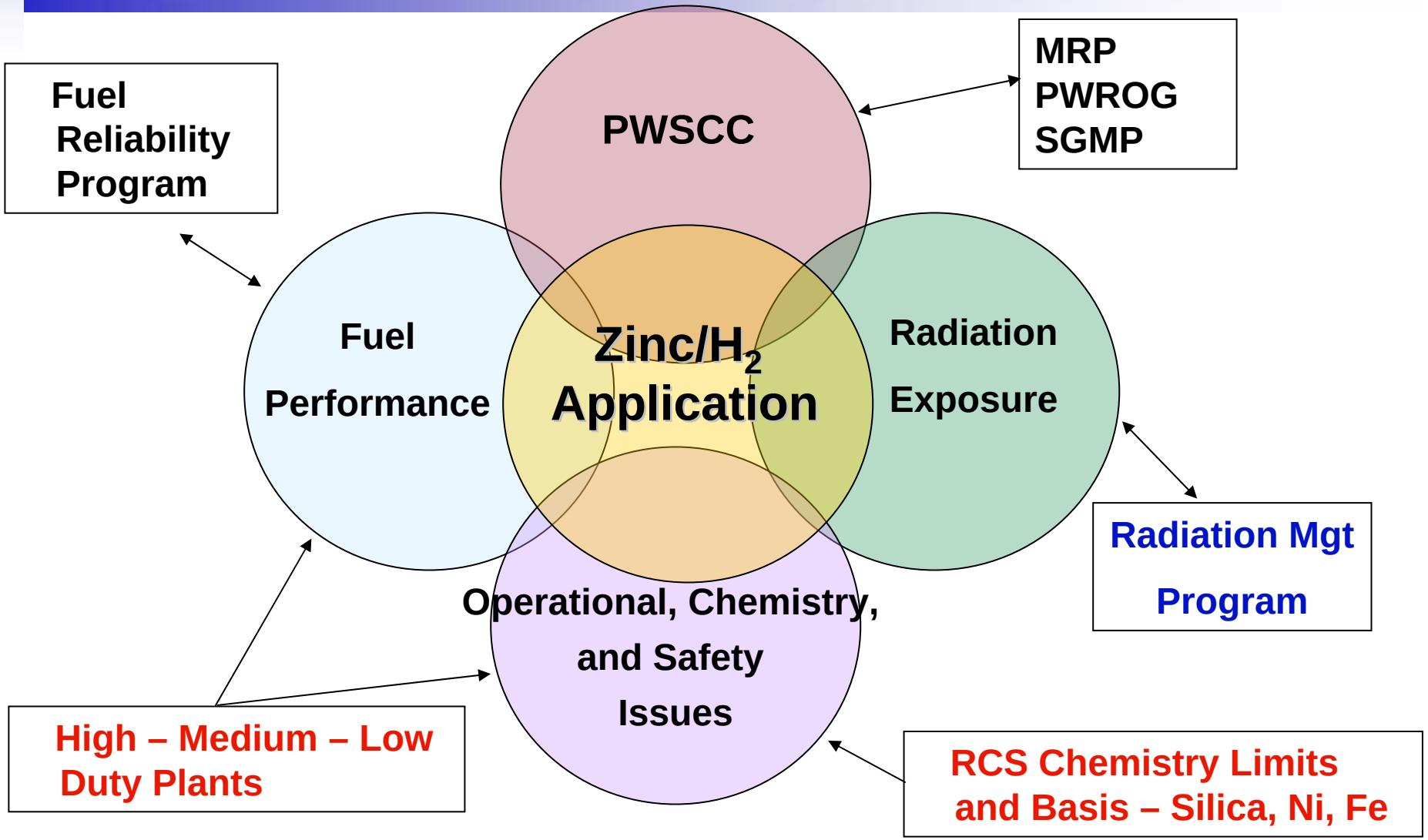
Mitigation of PWSCC in Alloys 600/182/82 by Chemical methods: Industry Program

- Objective: Demonstrate by testing chemical methods to mitigate SCC susceptibility of Alloy 600/182/82.
- Program is focused on:
  - Optimization of H_2 fugacity to avoid peak in growth rates
  - Zn additions to mitigate SCC
- A similar program is being carried out independently at EDF R&D labs. The MRP is participating in the EDF test program.
- All published test data (including work carried out in Naval Reactors program and further international results) will be considered in final evaluation

Mitigation of PWSCC in Alloys 600/182/82 by Chemical methods: MRP Program Schedule

- MRP testing to study effect of hydrogen and zinc began in 2003. This phase will conclude in 2008.
- Parallel evaluations in progress to determine and address any negative effects on plant safety/operability and fuel performance & cladding integrity
- Technical basis for extending inspection intervals based on test data (MRP, PWROG and others) and relevant field experience will be developed in 2008
- EPRI water chemistry guidelines will address chemical mitigation benefits in its subsequent revisions

PWR Chemical Mitigation Program Interactions



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Mechanical Mitigation Specifics

- Objective
  - Address crack initiation and growth by rejuvenating susceptible surface or altering stress
- Mechanical Mitigation Technologies
  - Surface Remediation
  - Preemptive Weld Overlay (PWOL)
    - Full structural
    - Optimized
  - Weld Inlays
  - Surface Stress Improvement (Peening)

Surface Remediation

- Technologies being considered:
  - SIMAT process from Westinghouse
  - *ReNew*™ process from GE
  - Surface treatment from AREVA
  - SCrP process (developed by EPRI)

Optimized Weld Overlay

- Overlay thickness optimization to alter stress at pipe ID
- Initial technical basis provided in MRP-169
- NRC RAIs received and are being addressed
- MEOG project to address inspection considerations

Weld Inlays

- PWSCC risk mitigation by inlay
- The application of corrosion resistant cladding / inlay has been successfully demonstrated in both BWR and PWR units
- Proactive PWROG and EPRI MRP/PDI programs to address application of mitigative and repair inlays in PWR RV primary nozzles

Surface Stress Improvement (Peening)

- Surface stress improvement technologies being investigated have been tested/analyzed and applied in nuclear plants in Japan (Multiple vendors)
- These technologies offer a potential PWSCC mitigation option for BMNs where alternatives are few and replacement is impractical; application to other locations to be considered later
- MRP effort is to “verify” these technologies for the US PWR fleet by utilizing Japanese data/experience supplemented by limited independent confirmation of critical parameters
- Demonstration/application for BMNs at a US PWR plant is anticipated