



# Historical Applications of PFM for Materials Topics

Industry/NRC Materials Technical Exchange Meeting



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# Purpose and Contents

- The purpose of this presentation is to provide a historical review of PFM applications to provide context for discussion of future expectations for future uses of PFM
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  - BWR RPV Circumferential Weld Inspection Relief
  - WOG RI-ISI for Piping Method
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# PWR RCP Flywheel Inspection Interval Extension

- Extends inspection interval for PWR RCP flywheels required by RG 1.14
- PFM analysis performed using RPFWPROF software which is based on the Westinghouse Structural Reliability and Risk Assessment (SRRA) Code
- Deterministic structural evaluation also performed per RG 1.14
- PRA not used
  - RCP flywheel failure frequency = CDF = LERF
  - Risk goal is change in LERF  $< 1E-7$  from RG 1.174
- WCAP- 14535A – SE issued 1996 – 40 months extended to 10 years
- WCAP-15666-A, R1 – SE issued 2003 – 10 years extended to 20 years
- PWROG-17011 – SE issued 2019 – Extends applicability to 80 years
- Regulatory Guide 1.174 principles explicitly addressed
- Performance monitoring addressed by continued inspections on 20-year intervals and other indicators of flywheel degradation, such as vibration

# BWR RPV Circumferential Weld Inspection Relief

- Eliminates inspection of BWR RPV circumferential shell welds required by ASME Section XI
- BWRVIP-05 – PFM using VIPER Code – SE issued 1998
- BWRVIP-329 – PFM using FAVOR Code – SE issued 2021 – Addresses extended operations
- Implemented by all U.S. BWRs
- No use of the PRA
  - Risk goal is  $5E-6$  failures/yr in BWRVIP-05
  - Risk goal is  $1E-6$  failures/yr in BWRVIP-329
- Regulatory Guide 1.174 not addressed
- Performance monitoring addressed through continued inspection of RPV axial shell welds

# WOG RI-ISI for Piping Method

- Risk informed approach to Section XI piping inspections utilizing SRRA PFM code to calculate individual piping segment failure probabilities
- WCAP-14572, Revision 1-NP-A – SE issued 1998
- Plant-specific PRA values used in conjunction with plant-specific PFM results to perform risk-ranking of piping segments
- Risk goals are consistent with Regulatory Guide 1.174 change-in-risk criteria
- Regulatory Guide 1.174 principles explicitly addressed
- Performance monitoring addressed through statistical modeling, living program, continuation of pressure test, etc.

# PWR RPV ISI Interval Extension

- Extends inspection interval of PWR RPV shell welds (Categories B-A and B-D) required by Section XI from 10 to 20 years
- PFM using a modified version of the FAVOR Code
- WCAP-16168 – SE Issued 2008
- Implemented by most U.S. PWRs
- PRA not used
  - RPV failure frequency = CDF = LERF
  - Risk goal is change in LERF  $< 1E-7$  from RG 1.174
- Regulatory Guide 1.174 principles explicitly addressed
- Performance monitoring addressed through a coordinated implementation plan and inspections still being performed on a 20-year interval

# BWR RPV Nozzle-to-Shell Weld Inspection Relief

- Reduces population of BWR recirculation inlet and outlet nozzle weld inspections required by ASME Section XI (Category B-D) from 100% to 25%
- First implemented in Code Case N-702 and later in IWB-2500(f)
- Technical bases developed using VIPER-NOZ PFM Code contained in:
  - BWRVIP-108 – SE issued 2007
  - BWRVIP-241 – SE issued 2013
- Code Case N-702 first conditionally approved by NRC in RG 1.174, Revision 17 (2014)
- No use of the PRA – Risk goal is  $5E-6$  failures/yr
- Regulatory Guide 1.174 not addressed
- Performance monitoring addressed through continued inspection of 25% of welds

**An update to address extended operations and feedwater nozzles is currently being considered by ASME Section XI committees**



# Summary and Conclusions

- PFM has been used successfully for over 25 years to address materials management topics, particularly modification of ISI requirements
- Almost all applications do not make use of PRA
- Applications have had varied acceptance criteria/risk goals
  - Some based on absolute criteria using different values
  - Some based on change-in-risk or change-in-failure probability
- Regulatory Guide 1.174 principles have not been addressed in all applications
- Performance monitoring has been addressed in all historical applications, although methods and rigor have varied





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