

# AMP XI.M5, BWR Feedwater Nozzle

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**NRC Meeting on Draft SLR  
Guidance Documents**

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## Issue Background

- BWR Feedwater nozzle inner radius cracking was identified in 1974
- GE performed extensive studies to understand the phenomenon
- GE, NRC and industry had multiple meetings
- GE produced NEDO-21821 as a result
- NRC produced NUREG-0619 and included their comments on NEDO-21821 in the NUREG
- Final NRC positions were identified in GL 81-11
  - Provided flow controller options
  - Plants to show 0.25” flaw would not exceed 1” in 40 years

# Aging Management History

- Plants responded with a variety of actions including clad removal, sparger replacement, installation of new feedwater controllers, revised procedures on feedwater operations, etc.
- Removing spargers to perform PT exams was undesirable
  - Concerns over damaging feedwater nozzle
  - High personnel dose to perform exams
- In developing NUREG-0619, NRC intended for liquid penetrant (PT) examinations to cease when ultrasonic examinations (UT) were adequate.
- Topical Report GE-NE-523-A71-0594-A, Revision 1 was developed by industry and approved by NRC.
- The topical report provided the basis for eliminating PT examinations
- BWRVIP-74, which addresses license renewal for RPVs, incorporated the topical as an acceptable aging management tool, was approved by NRC October 18, 2001

## NDE status

- GE-NE-523-A71-0594-A, Revision 1 did pre-date full implementation of Section XI, Appendix VIII
- UT methods were to be demonstrated to show detection of a 0.25” flaw
- In modifying the topical report to incorporate the NRC safety evaluation in 1999, the BWROG noted that the 1989 Edition of ASME Section XI (containing Appendix VIII) was endorsed in 10CFR50.55a
- As plants incorporated the 1989 Edition of Section XI into their ISI programs, implementation of Appendix VIII would be required by law
- Code Case N-552, “Qualification for Nozzle Inside Radius Section from the Outside Surface,” was endorsed by the NRC (64FR183) September 22, 1999.
- Examinations of the RPV nozzle inner radius to the requirements of Appendix VIII, Supplement 5 became mandatory November 22, 2002.
- Thus, it is expected that all plants either use Appendix VIII for UT examination of feedwater nozzles or have NRC-approved alternatives

# Fracture Mechanics History

- The initial NUREG-0619 requirement was for plants to show that an assumed 0.25” flaw would not grow beyond 1” in 40 years
- The GE-NE-523-A71-0594-A, Revision 1 fracture mechanics evaluation (FME) used conservative leakage assumptions to assess how long it would take a flaw to reach code allowable maximum depth if a flaw of 0.25” due to high-cycle fatigue were to occur in the inner radius
- The most limiting time to reach a code allowable flaw was 33 years
- Inspection frequencies were set based on the FME analysis and type of UT used (manual, automated, etc.)
- Regardless the calculated time to maximum depth, the inspection frequency could not exceed 10 years (same as Section XI)
- A 2006 survey revealed 266 examinations meeting the topical report and / or Appendix VIII had been completed – no flaws detected
- In the intervening 10 years additional examinations have been conducted with no flaws detected

# Conclusion

- A 2006 survey revealed 266 examinations meeting the topical report and / or Appendix VIII had been completed – no flaws detected
- In the intervening 10 years additional examinations have been conducted with no flaws detected
- There has been no inner radius cracking for any sparger type since operation of low-flow feedwater controllers was changed (30 years)
- There is a significant margin from the time a flaw initiates until it reaches its allowable limit
- Every time an examination is conducted and the nozzles are shown to be flaw free, the clock resets in regard to time for a flaw to reach its maximum depth (examinations at year 40 combined with FME analysis might technically justify only one more examination before year 80)
- After 30+ years of no cracking, it is logical to conclude that the feedwater control changes implemented in the early 1980s eliminated the source of inner radius cracking for all sparger types – not an aging effect
- Appendix VIII is fully integrated into ISI programs
- Use of NUREG-0619 and GE-NE-523-A71-0594-A, Revision 1 as an aging management program is no longer necessary
- Use of the ASME Section XI ISI is sufficient

