Mitigation of PWSCC by Peening

- Implementation and Status

Materials Reliability Program

Industry-NRC Materials R&D Tech Update

June 2-4, 2015

Rockville, MD

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Introduction

- **First peening applications in U.S. are now scheduled at 6 PWR units starting in spring 2016 through 2017**
  - Reactor vessel top head nozzles
  - Reactor vessel outlet and inlet nozzles
  - Bottom mounted nozzles (without inspection relief)
- **EPRI MRP is working to complete a dual track path to acceptance of peening mitigation:**
  - ASME Section XI code cases for peening inspection credit
    - Alloy 82/182 piping butt welds per Code Case N-770-4, approved by ASME May 7, 2014
    - The N-729-4 change for peening is approved at TG and currently out for Standards Ballot. Ballot closes June 7th. Alloy 690 change is also being Balloted on the same Ballot. Code approval anticipated in 2015.
  - U.S. NRC Safety Evaluation (SE) based on NRC review of MRP topical report MRP-335 Rev. 1
    - Submitted responses to NRC RAI questions on October 10, 2014, and June 1, 2015
    - Submit Revision 2 of MRP-335 to the NRC on August 15, 2015 *(anticipated)*
    - Complete the SE process in 4Q-2015 *(anticipated)*

Peening Process – Development to Implementation

PROCESS DEVELOPMENT / VALIDATION

DEVELOP PEENING TECHNICAL BASIS

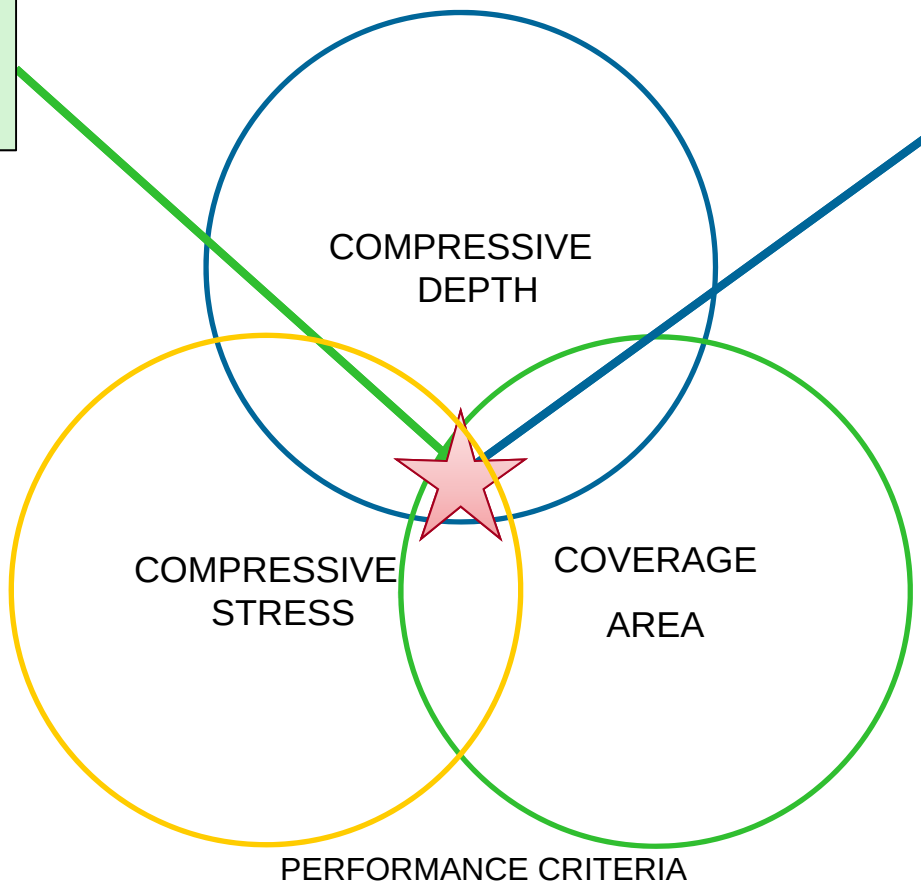
ESTABLISH PROCESS SPECIFIC ESSENTIAL VARIABLES

CONFIRM "PERFORMANCE CRITERIA" MET (i.e. PROCESS EFFECTIVE)

DEVELOP SPECIAL PROCESS CONTROLS / PROCEDURES

(10 CFR 50 APPENDIX B CRITERION IX)

LICENSEE REVIEWS / APPROVES PROCESS



INFIELD PROCESS IMPLEMENTATION

IMPLEMENT PEENING UNDER SPECIAL PROCESS CONTROLS

(10 CFR 50 APPENDIX B CRITERION IX)

QUALITY RECORDS VALIDATE PROCESS WITHIN ESSENTIAL VARIABLE LIMITS

LICENSEE REVIEWS / APPROVES PEENING EFFECTIVENESS

PROCESS / RESULTS SUBJECT TO NRC INSPECTION

Application of Appendix B

- **Specification** – Specify to meet the technical requirements of MRP-335 Rev 2, ASME Code Cases N-729-5 and N-770-4, ASME Section XI, and implementation of Appendix B Criterion IX Special Processes
- **Procurement** – Contracts will be Safety Related ensuring the use of Vendor's 10CFR50 Appendix B program
- **Oversight** – Will use contractor oversight procedure for Safety Related work
- **Controls and Management** – Vendor to manage critical parameters and supply documentation that demonstrates compliance to the specification

Peening Performance Parameters

Component	ASME Code Case	Surface Stress Magnitude	Nominal Compressive Residual Stress Depth	Coverage Zone
Peened Alloy 82/182 DMWs	N-770-4 Appendix I	Residual stress plus nominal operating stress on peened surface shall be compressive	at least 0.04 in. (1.0 mm)	Entire wetted surface of PWSCC susceptible material including the weld, butter, and base material, as applicable
Peened RPVHPNs	Draft N-729-5 Appendix II	Residual stress plus nominal operating stress on peened surface shall not exceed +10 ksi	*Nozzle ID*: at least 0.01 in. (0.25 mm) *Nozzle OD/weld*: at least 0.04 in. (1.0 mm)	Wetted surface of attachment weld, butter, and nozzle base material (OD and ID) that is susceptible to PWSCC

Process Qualification and Documentation

- Peening vendors will be required to meet stress magnitude and depth requirements, and peening coverage requirements
- Peening vendors will be required to establish and provide essential variables and associated ranges of acceptable application-specific values
  - Part of the controlled special process procedures submitted for licensee pre-implementation approval
  - Will ensure that specified stress and coverage requirements are met
  - Essential variables will be unique to the peening technology offered and specific to each vendor and type of component being peened
- Documented in Process Qualification and/or Relief Request, and Post-Implementation Reports

10 CFR 50.59 Implementation

- **Evaluation of peening application to RCS pressure boundary locations under 10 CFR 50.59 found:**
  - No analysis or procedure identified in the Safety Analysis Report is expected to be adversely affected
  - No accident condition or scenario in Safety Analysis Report is expected to be adversely affected
    - If anything, loss of pressure boundary conditions or scenarios are in a better safety position following the application of peening
- **Control of the Peening Process should be treated consistent with other maintenance and repair activities at the Site under 10 CFR 50 Appendix B Criterion IX. Control of Special Processes**
  - Other activities typically performed under this criterion include: Freeze Sealing, Welding, Soldering, Leak Stop Injection of Gasketed Joints
- **MRP members will implement peening using the 10CFR50.59 process**
  - ASME inquiry responses make clear that prohibitions on “peening” are for the type of heavy peening sometimes used for in-process welding distortion control, not the type of controlled peening used for surface stress improvement on finished parts
  - Therefore peening for surface stress improvement does not violate ASME Code
  - It is understood that obtaining inspection relief for peened locations will require a plant-specific technical alternative (relief request)

Anticipated Inspection Relief Request Process

- For initial peening applications in the US starting in 2016,
  - If seeking revised inspection requirements a relief request is required
  - NRC has expressed preference for receiving such requests as soon as possible
- Purpose of Relief Request: To obtain inspection relief commensurate with the reduction in susceptibility to SCC
- The Relief Request will reference the approved topical report and SE as the basis for the requested inspection relief
- Steps:
  - Licensee to request Relief Request pre-submittal meeting with NRC
  - MRP to draft generic Relief Request template/framework
  - Licensee and its peening vendor to insert application-specific details
    - Relief request to reference the process qualification report for the full details of the qualification effort, including the acceptable values of the essential variables
  - Anticipate NRC will respond to Relief Request with RAIs

Inspection Relief Request Framework

Draft Outline - for Industry-NRC Discussions

- ASME Code Component(s) Affected
- Applicable Code Edition and Addenda
- Applicable Code Requirement
  - ASME Code Cases N-729-1 and N-770-1 as Mandated by 10 CFR 50.55a(g)(6)(ii)(D) and (F), respectively
  - Acceptability of Peening for Stress Improvement
- Reason for Request
- Proposed Alternative and Basis for Use *(see next slide)*
- Duration of Proposed Alternative
- Precedent
- References
- Appendices

Inspection Relief Request Framework

Proposed Alternative and Basis for Use

- Introduction
  - Peening Mechanism for PWSCC Mitigation
  - General Industry Experience
  - LWR Experience
- Description of Application-Specific Process to be Implemented
  - Hardware Description
  - Process Description
  - Accessibility for Peening
  - Plant Interfaces and QA Requirements
  - Process Control
  - Pre-peening NDE
  - Summary of Process Implementation Documentation Including Procedures
  - In-Process and Post-Process Verification
  - Contingencies
  - Documentation of Peening Results
- Performance Criteria
  - Magnitude, Depth, and Coverage
  - Sustainability
  - Inspectability
  - No adverse Effects
- Summary of Qualification Program
  - Process Qualification as a Special Process per 10 CFR Appendix B (including reference to qualification report)
  - Pre-Implementation Approval by Licensee
  - Demonstration that Stress Improvement Parameters will be Met
    - Mockup Testing and Stress Measurements at Minimum Peening Conditions
    - Analyses to Consider Effect of Operating Stress
    - Testing and Analyses Demonstrating Long-Term Effectiveness
  - Corrosion Testing to Confirm Effectiveness for SCC (may include reference to MRP-267R1 and other EPRI reports)
  - Demonstration of No Adverse Effects at Maximum Peening Conditions (including summary of 50.59 analysis)
  - Process Essential Variables (with reference to qualification report for application-specific ranges)
  - Personnel Qualification
- Topical Report Basis for Inspection Requirements
- Conclusions

NRC SE Review Process

- Progress and Remaining Steps

- NRC Issued RAIs for MRP-335 Rev 1- April 2
- NRC-MRP Public Conference Call on RAIs - April 13
- MRP submitted written RAI Responses – June 1
- NRC-Industry Materials R&D Tech Update Public Meeting – June 2-4
  - Dialogue on Implementation by 50.59 and Inspection Relief Requests
- Possible Public Meeting on RAI Responses and Draft SE – July
- MRP submits MRP-335 Rev 2 incorporating revisions for RAIs – August 15
- NRC issues Draft SE for Review Comments – October 30
- NRC receives Review Comments on Draft SE – November 15
- NRC issues Final SE – December 16
- MRP submits MRP-335-2A incorporating Final SE – January 31, 2016

Summary of MRP RAI Responses

- Replies to 2nd RAI (dated April 2, 2015, ML15057A028) on topical report
- RAI response package:

Attachment 1: Table responding to 19 RAI questions	Attachment 3-5: Revised supporting deterministic and probabilistic analyses
Attachment 2: Revised examination requirements	Attachment 6: Investigation of tensile residual stress balancing peening stress

- RAI questions mostly focused on inputs, methods, and results of the analyses supporting the inspection methods and intervals of the topical report
  - All these supporting analyses (Alloys 82/182 Piping DMWs and Alloy 600 RPVHPNs) were revised to reflect the current range of available peening processes and the latest ASME Code performance criteria
- Section 4 of the topical report defining the NDE requirements including inspection credit for peening was completely reworked and revised
  - The revised requirements closely parallel N-770-4 and N-729-5p (final draft), except that some modest differences were necessary for the top heads to satisfy the probabilistic acceptance criteria and to address the potential for boric acid corrosion (the most significant differences affect only the four non-cold heads in U.S. that are candidates for peening)
- Additional analysis work was performed to address NRC questions regarding the peak magnitude of the tensile stress induced to balance the peening compressive stress
  - Concludes that the peak balancing tensile stresses are relatively small and that they do not affect conclusions regarding appropriate NDE intervals as the benefit of peening is to prevent initiation and arrest sufficiently shallow flaws, not slow growth

ASME Code and Standards

- Code Case N-770-4 integrated peening mitigation performance criteria appropriate for reduced inspection requirements
  - Performance criteria approach similar to that taken for MSIP was used
  - Japanese experience, Japanese JANTI VIP-03 and presentations by representatives of MHI and Hitachi provided International input for ASME
  - Technical basis provided through MRP-267 and MRP-335 and PVP papers
  - Peening performance criteria and pre- and post-peening examinations evaluated and approved through the consensus process

Approved by the ASME Code as Code Case N-770-4 on May 7, 2014

ASME Code and Standards

- Draft Code Case N-729-5 highlights:
  - Maintains the performance criteria approach used in Code Case N-770-4
  - Utilizes the same technical basis for the process with additional analysis specific to the impact of the RVH penetration inspection
  - Adjusts performance criteria where needed to account for different configurations of RVH penetrations
  - Presented to Standards Committee at April meeting, 4-week ballot vote period ends on June 7. Negatives and comments will be addressed and the CC will be presented again at the August Code meeting.

Approval by the ASME Code as Code Case N-729-5 anticipated in 2015

Conclusions

- First peening applications in U.S. are now scheduled at 6 PWR units starting in spring 2016 through 2017
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- EPRI MRP is working to complete a dual track path to acceptance of peening mitigation:
  - ASME Section XI code cases for peening inspection credit
    - Alloy 82/182 piping butt welds per Code Case N-770-4, approved by ASME May 7, 2014
    - Reactor vessel top head nozzles per a revised version of Code Case N-729-4, presented to Standards Committee at April 2015 meeting, 4-week ballot vote period will complete on June 7th. Negatives will be addressed and the case will be re-presented at the August Code meeting.
  - U.S. NRC Safety Evaluation based on NRC review of MRP topical report MRP-335 R1
    - Final SE anticipated in December 2015

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