Structural Metallic Materials

Longer Term Operations

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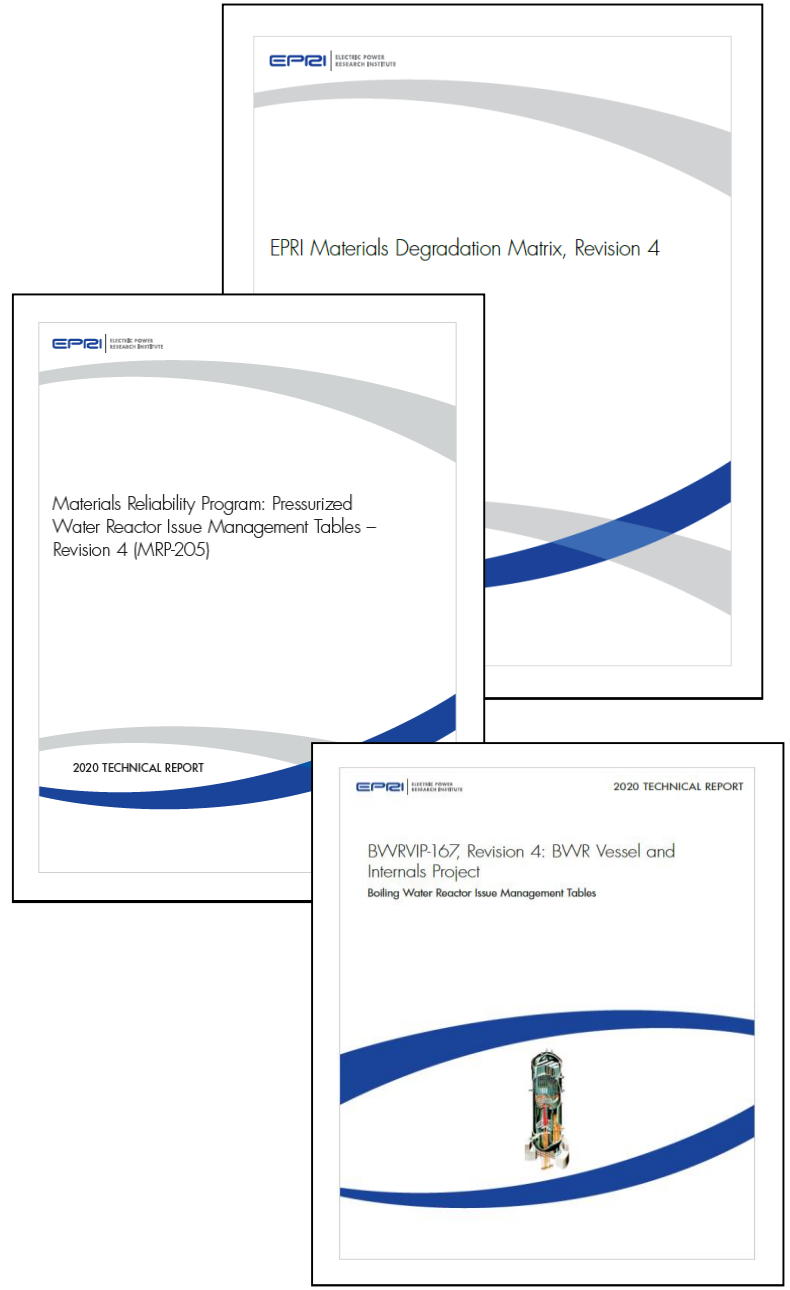
EPRI Approach Toward Operation Beyond 80 years for LWRs

- Unless specifically stated, materials aging management guidance is ***independent of service life***
- Guidance requirements and conditions for use are based on parameters relevant to aging management (e.g., neutron fluence is the key parameter relevant to managing irradiation-assisted stress corrosion cracking)
- Each owner / licensee then confirms that their plant satisfies any conditions for use
- EPRI technical work performed to address operation beyond 60 years (SLR) also addresses operation beyond 80 years…

Structural Metallic Materials

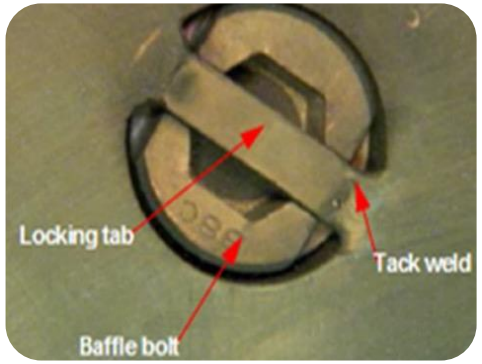
- EPRI built on our initial contribution to the EMDA to maintain and update our Issue Management Tables for BWRs and PWRs
  - PWR MRP-205 and BWRVIP-167 - Revisions 4 issued in 2020
- EPRI Materials Degradation Matrix (MDM) is maintained as the state-of-the-art knowledge of materials aging effects in LWR components
- EPRI Issue Management Tables identify gaps in aging management knowledge
  - Compares knowledge needed for effective management vs. available products from research
  - "Expected Material Conditions" (**not number of years**) are now the criteria for aging management decisions
  - Issue Management Tables compare the knowledge needed to resolve issues arising from operating experience and the present results of relevant research (and development and implementation) activities
  - Issue Management Tables considerations are now expanded to include the progression of aging effects beyond 60 years
- EPRI Issue Management Tables consider
  - Knowledge gaps in technical basis of aging management
  - Status of operating experience
  - Status of related technical research
  - Recommendations for actions
  - Prioritization of technical gaps – need for immediate research
- Future considerations will include extent/severity of aging to 80 years and beyond



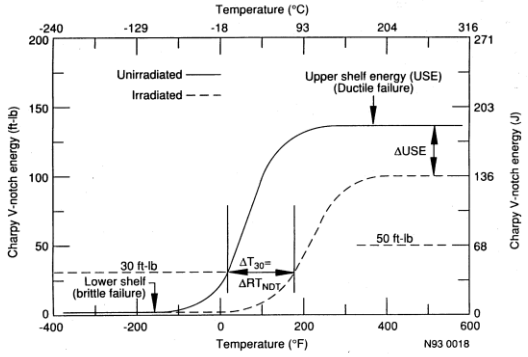
Aging Management Activities for Structural Metallic Materials

Based on the four categories of IMT gaps…

Inspection / Monitoring → **Assessment / Evaluation** → **Mitigation / Modernization** → **Repair/ Replacement**

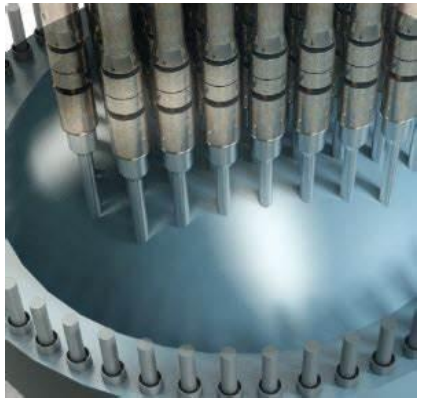


Visual and UT examinations of internals monitor the condition of Baffle Bolting



"Surveillance Capsule" testing provides an assessment of the post-irradiation toughness in RPV steels

Water-jet and laser peening provide improved surface stresses to mitigate against SCC



Replacement of Alloy 600 tubed PWR RPV heads by Alloy 690 tubed heads increases confidence in long lives

Aging management activities for beyond 80 will similarly build off IMT identified technology gaps

BWRVIP Reports Applicable to Operation Beyond 80

- BWRVIP-315, Reactor Internals Aging Management Evaluation for Extended Operations
  - Documents a technical evaluation of the adequacy of the BWRVIP guidance to continue managing age-related degradation of BWR reactor internals for operating periods exceeding 60 years
  - Where needed, identifies revisions to BWRVIP guidance for reactor internals needed to address extended operations
- BWRVIP-329, Probabilistic Fracture Mechanics Analysis of BWR RPV Welds to Address Extended Operations
  - Provides a technical basis for continued relief from ASME Section XI RPV weld examination requirements. Criteria for use are specified in terms of end-of-life reference temperature values.
- BWRVIP-316, Reactor Vessel Aging Management Evaluation for Extended Operations
  - Similar to BWRVIP-315 but addresses the RPV as opposed to the reactor internals

- BWRVIP-315 and BWRVIP-329 are currently being reviewed by NRC
- BWRVIP-316 will be completed & submitted to NRC for review & approval in 2021

PWR Reactor Vessel Internals – Reports Applicable to Beyond 80

- EPRI Guidance Documentation coverage extended from 40 to 60 years (SLR)
  - MRP-211 - PWR Internals Age-Related Material Properties, Degradation Mechanisms, Models, and Basis Data—State of Knowledge → Updated materials testing results
  - MRP 135 - Materials Reliability Program Development of Material Constitutive Model for Irradiated Austenitic Stainless Steels → Improved modeling and extended fluence regimes
  - MRP 227 - Pressurized Water Reactor Internals Inspection and Evaluation Guidelines → Extends the PWR reactor internals inspection and evaluation (I&E) guidance to 60-years of plant operation (SLR)
  - MRP-229 - Functionality Analysis for B&W Representative PWR Internals → Incorporates extended life fluence levels and temperature exposures
  - MRP-230 Functionality Analysis for Westinghouse and Combustion Engineering Representative PWR Internals → Incorporates extended life fluence levels and temperature exposures with updated IRADSS module
- MRP-227 Revision 2 provides updated technical basis support for SLR applications

EPRI anticipates similar extension of guidance for beyond 80

PWR Reactor Pressure Vessel & Low Alloy Steel Structures - Projects Applicable to Beyond 80

- Coordinated PWR Reactor Vessel Surveillance Program (CRVSP)
  - Continuing monitoring of RPV surveillance capsule data
  - Updating “Trending Analyses” based on values from most recent capsules
  - Revising capsule fluence values
  - Supporting coordination of long-life capsule pull schedules
  - Continuing to plan for pull and testing of PSSP capsules at Farley 1 and Shearon Harris
- Exploring potential for assessment of spare capsules and samples from RPVs of retired plants
- Extension of Low Alloy Steel aging activities to consider
  - Potential Irradiation Embrittlement of RPV supports
  - Potential Thermal Embrittlement of high temperature (pressurizer) exposed LAS
- EPRI will continue to consolidate data and continue to provide guidance to plants seeking extended operations of vessels

EPRI anticipates similar extension of guidance for beyond 80

EPRI Aging Management Guidance Summary

- EPRI will maintain and update its technical understanding of aging effects – the “Material Degradation Matrix”
- EPRI will continue to maintain its up-to-date record of key technical gaps and issues - “BWRVIP and MRP Issue Management Tables”
- EPRI will continue to extend the MRP-227 Process for guidance for aging management of Reactor Vessel Internals
- EPRI will maintain its efforts to monitor aging management of Reactor Pressure Vessels and Pressurizers
- EPRI will pursue Materials Harvesting from decommissioned plants to obtain improved quantitative information on materials property degradation
- EPRI research programs will continue to seek Mitigation and Repair & Replacement options for aging components