NRC Aging Management Program Including Long Term Operation (LTO)

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Global Age of NPPs

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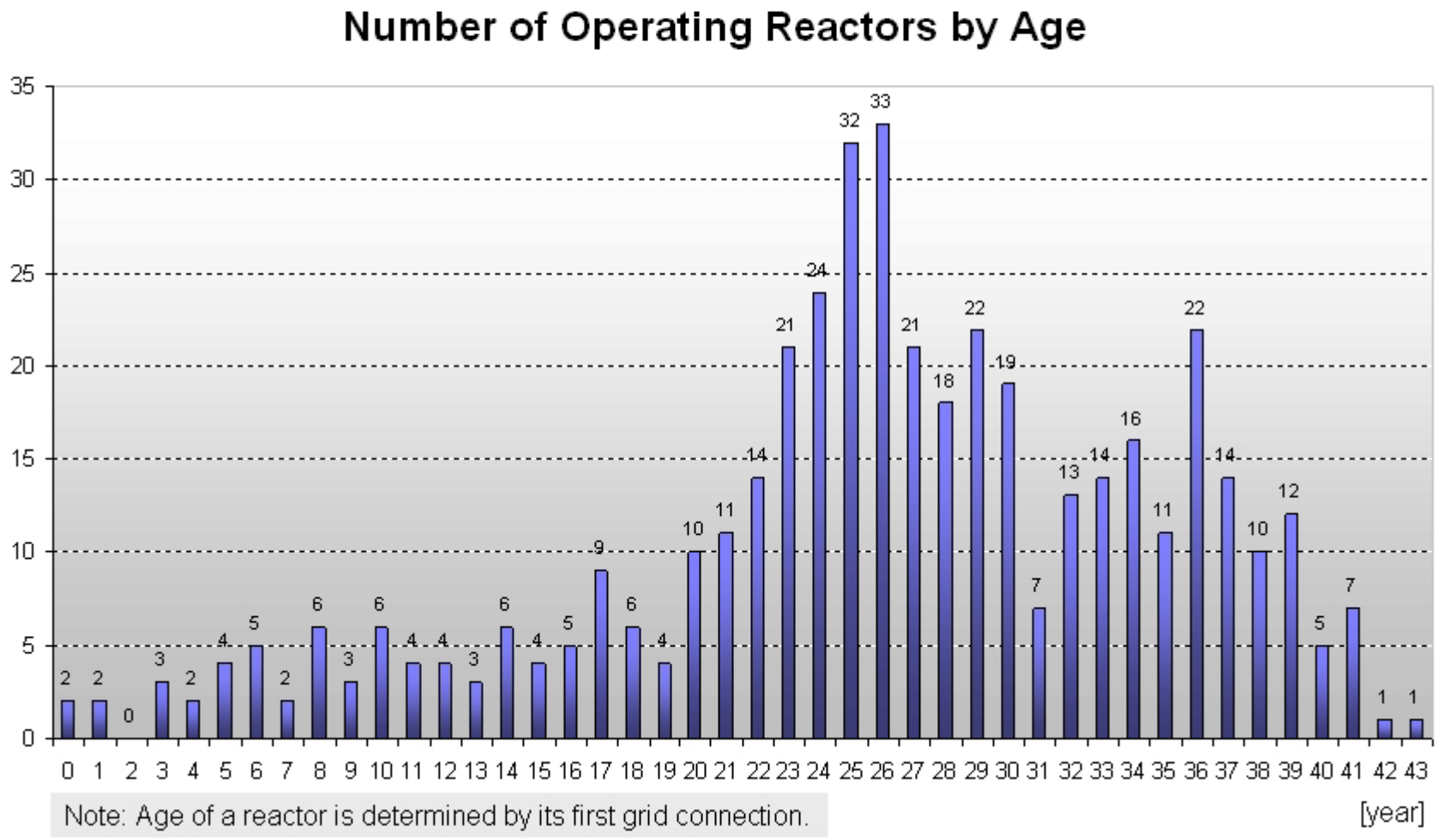

Source: International Atomic Energy Agency; http://www.iaea.or.at/programmes/a2/

Integration of Domestic Nuclear Research Programs

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INDUSTRY	NRC	DOE
• **Profit motive / shareholder perspective**	• **Public health and safety protection perspective**	• **Long term national interest perspectives**
• **Short term research addressing known problems and managing costs / downtime**	• **Confirmatory research addressing known safety issues**	• **Long term research addressing predictive and improvement opportunities**
• **Ex: IASCC – Better, faster weld repairs needed for reliability and reduce field repair times**	• **Ex: Better testing and repair integrity assurance methods needed**	• **Ex: Crack precursors and irradiation damage need to be understood for better predictions and future material selection**
Long Term Operability Program	*Life Beyond 60 Program*	*LWR Sustainability Program*

Individually, each program addresses a specific perspective; collectively, they address the majority of issues that need to be answered for safe extended operations.

NRC Aging Management Research Approach

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- **Identify Degradation Scenarios Not Addressed in NUREG-1801, "Generic Aging Lessons Learned (GALL) Report"**
  - Identify Inspection and Monitoring Programs and Associated Requirements for Highly Likely Degradation Scenarios
- **Assess Results from Implementation of License Renewal Aging Management Programs and Recommend Improvements for Subsequent License Renewal Periods**
- **Develop Domestic and International Partnerships to Share Expertise, Capabilities and Resources Related To Aging Management Research**

Materials Degradation Issues Key

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- **Extending safe operating life of NPPs will require comparing known modes of materials degradation, and identifying emerging degradation mechanisms, with expected service life to identify potential issues**
  - Materials degradation can lead to increased maintenance, increased downtime, and increased risk
- **Materials issues must be resolved for:**
  - Reactor Pressure Vessels and Primary Piping
  - Core Internals
  - Secondary Systems
  - Weldments
  - Concrete
  - Cable insulation
  - Buried Piping

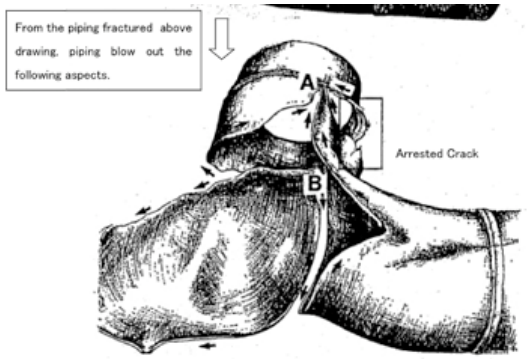

Fig.3 Detail Drawing of the Breaking Portion

Aging R&D Areas

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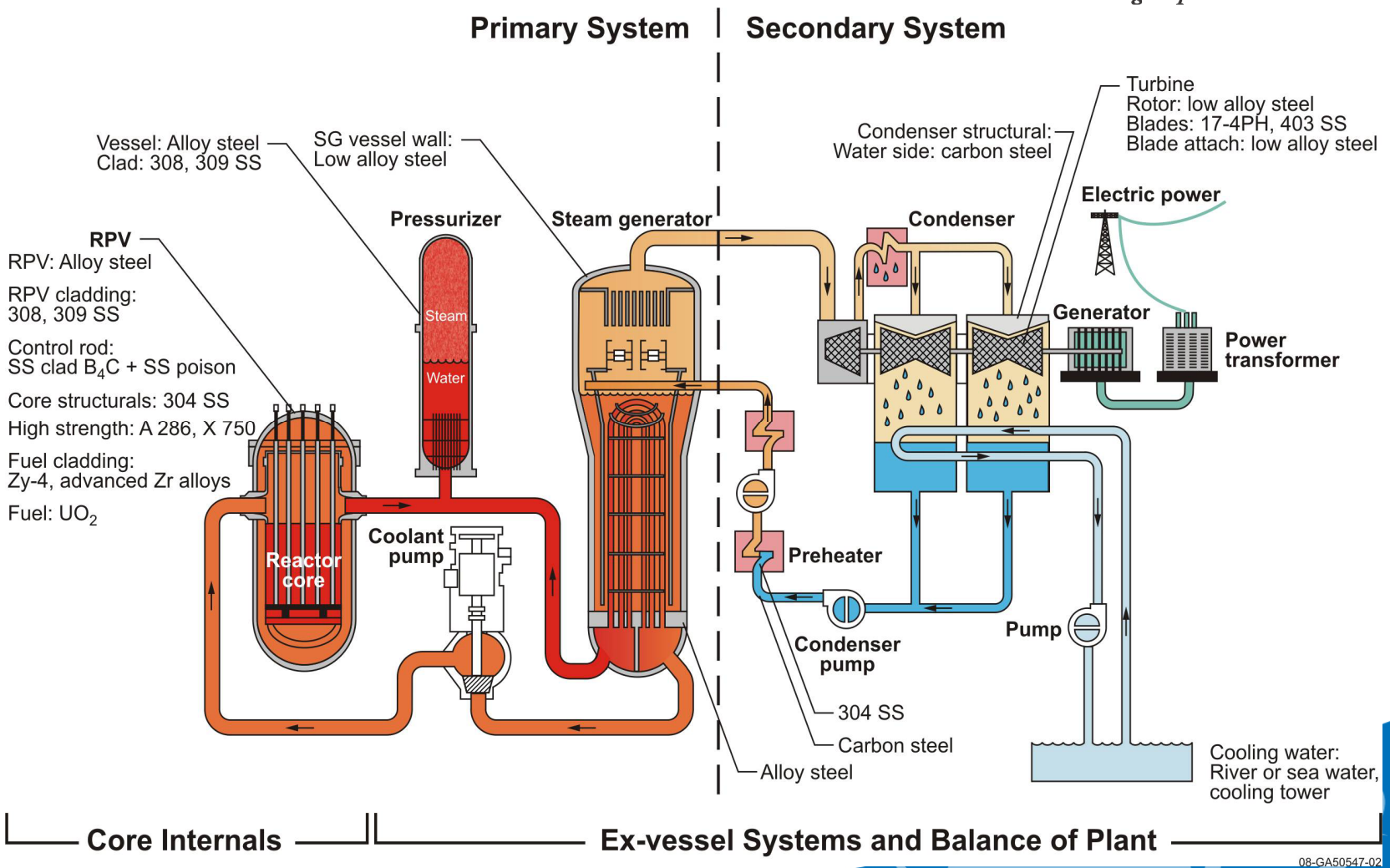

Aging Effects for Existing NPPs

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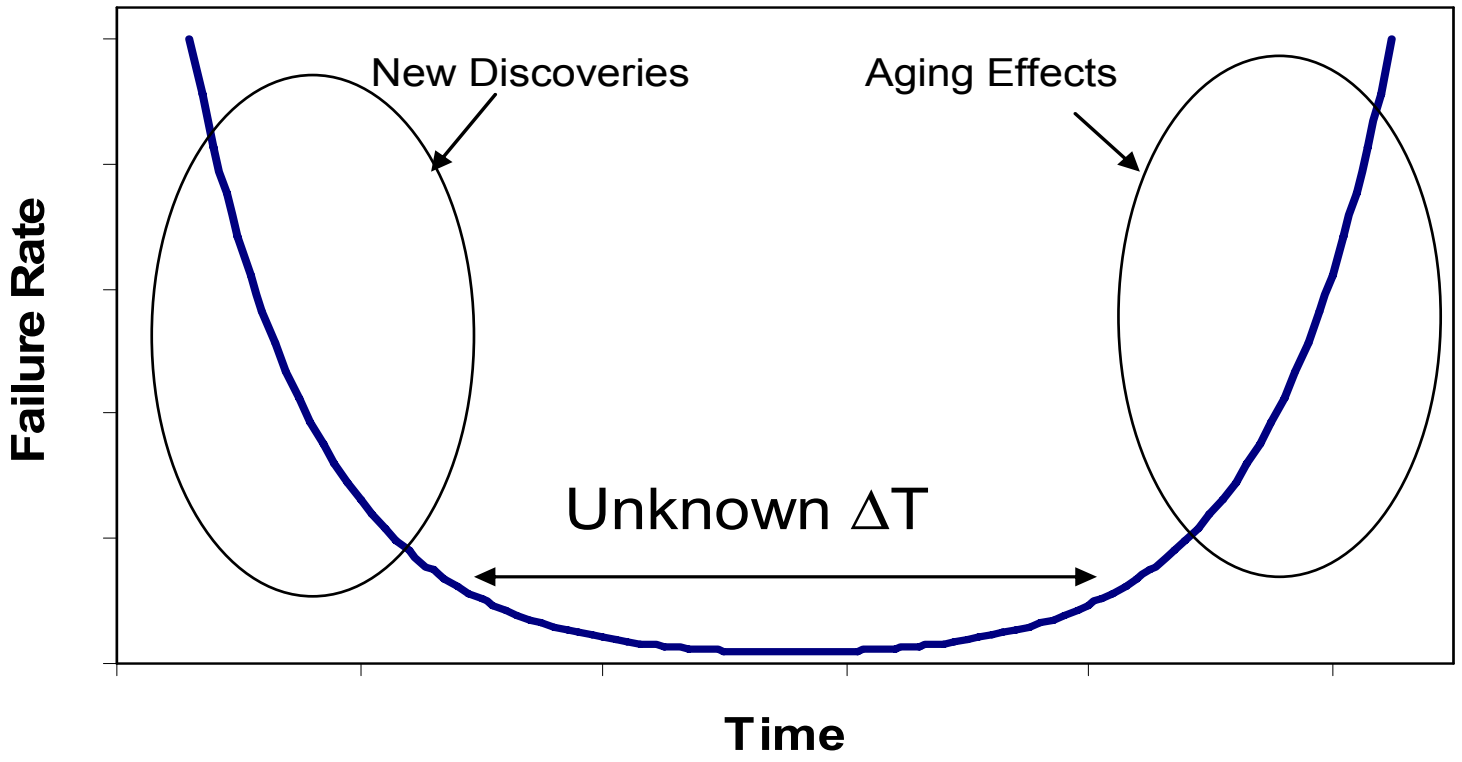
"Bathtub" Curve



Materials Degradation History

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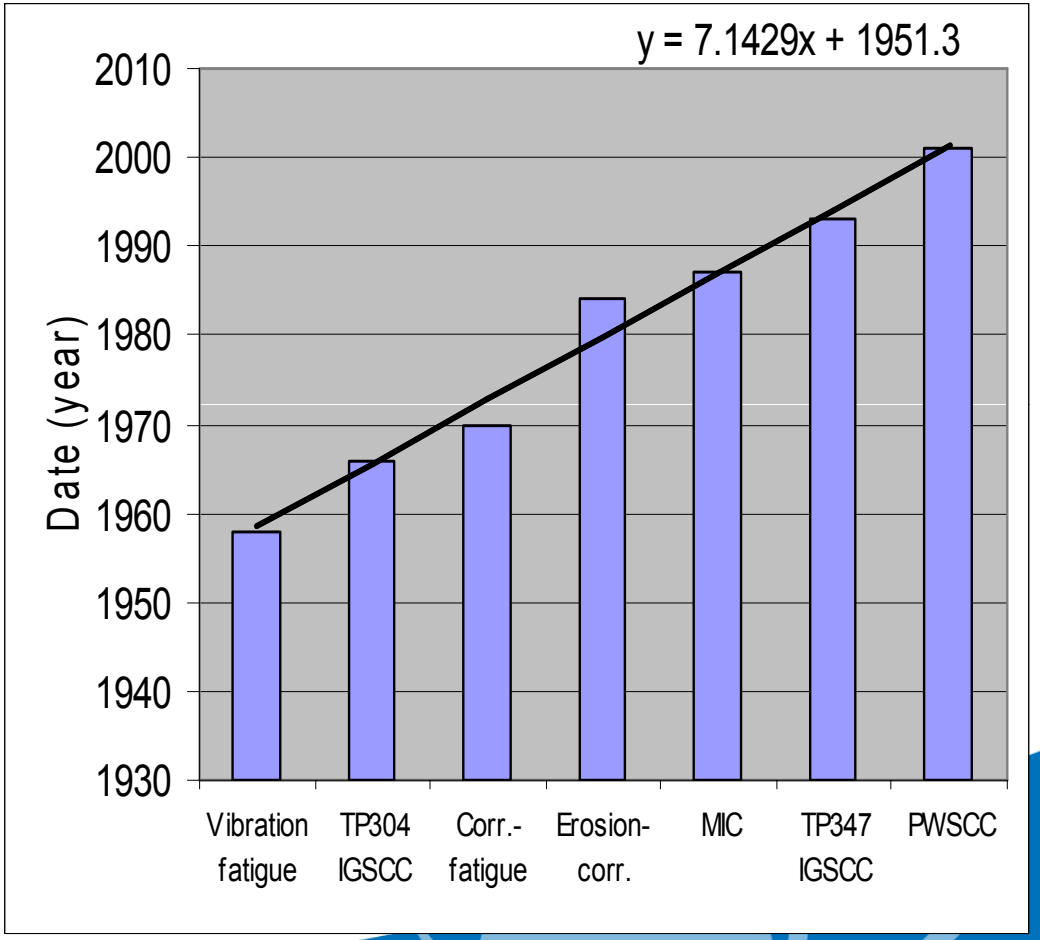
- 1958 - Vibration Fatigue
- 1966 - IGSCC in 304 SS
- 1970 - Corrosion Fatigue
- 1984 - Erosion Corrosion
- 1987 - Microbial-Induced Corrosion
- 1993 - IGSCC in TP347 Stainless Steel
- 2001 - PWSCC
- ?????



Proactive Management of Materials Degradation

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- Develop information
  - Materials behavior
  - Mitigation or repair
  - Inspection or monitoring
- Proactively address potential future degradation
  - Avoid failures
  - Maintain integrity and safety
- Increase cooperation
  - Prioritize PMMD research with industry
  - Pursue additional international collaborations
- Evaluate existing requirements
  - Integrity of susceptible components
  - Inspection and monitoring regulations

Avoid Surprises e.g. V.C. Summer And Davis Besse

Proactive Management of Materials Degradation

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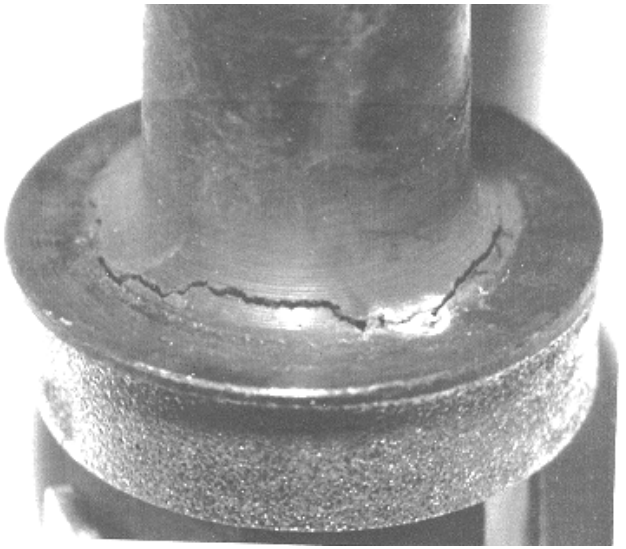
➢ **Extension of service life may cause new challenges for materials service**

- Increased lifetime leads to increased exposures
  - Time at temperature
  - Stress
  - Coolant
  - Neutrons
- Extending reactor life to 40, 60 years or beyond will likely increase susceptibility and severity of known forms of degradation
- New mechanisms of materials degradation are possible



➔ The motivation of several Department of Energy, Nuclear Regulatory Commission and Electric Power Research Institute projects is to provide improved understanding of degradation under extended service and provide alternative mitigation strategies.

Organized PMDA Approach

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- **Research must also identify other or new topics before they become life-limiting**
  - ➔ "Knowing the unknowns" is a difficult problem that must be addressed.
  - ➔ Difficult issue for such a complex and varied material/environment system.
- **Together with the DOE - LWRS program, USNRC is working to expand the initial PMDA activity (*NUREG 6923)* to encompass broader systems and longer lifetimes.**
  - ➔ Core internals and primary piping
  - ➔ Pressure Vessel
  - ➔ Concrete
  - ➔ Cabling
- **NRC updating and expanding PMDA to capture operating period beyond 60 years and to expand scope**

Expanded PMDA

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- **NRC Developed NUREG/CR-6923, "Expert Panel Report on Proactive Materials Degradation Assessment"**
  - Published February 2007
  - Scope encompassed passive components in primary, secondary and some tertiary systems of BWRs and PWRs, the failure of which could lead to a release of radioactivity or affect functionality of safety systems
- **NRC updating and expanding PMDA scope to capture operating period beyond 60 years**
  - EMDA will ascertain gaps in present level of understanding of materials degradation during subsequent license renewal periods
    - ➔ EMDA will look at materials in passive, long-lived systems, structures and components (e.g., RPV steels, concrete, cables, underground piping, etc.)
  - NRC and DOE LWRSP collaborating on developing EMDA

Metal Fatigue

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- **Analysis methodology could yield non-conservative results**
- **Potential delay in implementation of planned corrective actions to address aging**
- **Requiring license renewal applicants to demonstrate that their analysis results are conservative**

Submerged Electrical Cables

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- Cables not designed for continuous submerged service in electrical manholes
- Cable failure can disable safety systems
- Revised inspection procedures and program guidance to increase and expand inspection and test frequencies

Electric Cable Insulation

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- Cable failures worldwide increasing with plant age
- Cables provide power needed to operate equipment and transmit signals to and from the various controllers
- Research to confirm whether requirements for electrical equipment are being met through an extended period

Steel Containment and Liner Plate Degradation

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- Corrosion due to water leakage or contact with wood or foreign objects
- Potential impacts on structural integrity and leak tightness
- Obtained applicant commitments for additional inspections and increased maintenance; issuing advisory to other licensees

Neutron Absorber Degradation

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- Long-term use of neutron absorbers in spent fuel pools leads to deformation and degradation of the materials
- Potentially reduce safety margins and may violate sub-criticality requirement
- Developed new aging management program for neutron absorbing materials degradation

Refueling Cavity/Spent Fuel Pool Leakage

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- Concerns regarding the impacts of historical water leakage from concrete walls and floors
- Potential effect on structural integrity and leak tightness
- Obtained commitments from license renewal applicants

Buried Piping

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- Corrosion on soil side of piping
- Potential effects on system safety and release of hazardous material
- Enhanced agency guidance to increase inspections and focus on key preventive measures

Prolonged Concrete Exposure to High Temperature and Radiation

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- Prolonged exposure to elevated temperatures and radiation facilitates chemical interactions and induces strains
- Compromise concrete performance
- Research on sufficiency of current methods to evaluate effects and the effects themselves

Reactor Vessel and Internals

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- **Irradiation embrittlement is the life-limiting factor for the reactor vessel and core internal components**

- **NRC RES is actively pursuing**
  - **to compile and prepare a comprehensive database of all the information on irradiation embrittlement of reactor vessel and core internal components**
  - **to conduct confirmatory research on IASCC, neutron embrittlement and void swelling in LWR reactor core internals**

AMP Assessments

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- **Staff is preparing to assess the ability of Licensees' Aging Management Programs to successfully detect and manage aging degradation of safety-related systems, structures and components**

International Forum for Reactor Aging Management

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- **IFRAM promotes worldwide cooperation to address NPP aging management issues**
  - Cooperation includes sharing of data and specimens as well as facilitating joint research agendas and promoting work that addresses high priority issues and concerns.
- **Participation in IFRAM provides an extended pool of resources and expertise to work on common problems**
  - Promote global cooperation on management of reactor aging
  - IFRAM does not replace any existing cooperative efforts
- **IFRAM's rationale is that:**
  - Organizations worldwide share common challenges
  - Magnitude and scope of these challenges is beyond what any one organization can accomplish with their limited time and resources
  - Cooperation is a powerful tool to economize resources, save time, and minimize needless duplication of efforts in addressing these challenges

Concept Behind IFRAM

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- **IFRAM will consolidate available information, coordinate cooperation on activities, facilitate information exchange and provide opportunities to bring together different national and regional views on topics and, where appropriate, harmonize agreed-upon best practices**
- **IFRAM will cooperate with many parties and cut across numerous boundaries but it will not replace any cooperation efforts that currently exist**
  - **Its basic role is to facilitate research and information sharing**
- **IFRAM is not intended to be an NRC-led (or regulatory-led, utility-led, university-led, or research organization-led) entity**
  - **Since membership in IFRAM is open to all organizations, leadership roles will be given those members willing to support IFRAM's goals.**

Third International Conference on NPP Life Management for Long Term Operation

14-18 May 2012

Salt Lake City, Utah

Conclusion

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- **Research is necessary to establish basis for long-term operation of existing nuclear plants beyond 60 years, and this research will:**
  - **Answer safety questions on aging, reliability, and long-term operability of systems, structures and components**
- **Industry has lead role to drive the process and identify issue resolutions**
  - **Ultimately, life extension is utility business decision**
- **NRC ensures that safety-significant issues are identified and resolved in a timely manner**
  - **It is not NRC's responsibility to resolve any potential aging issues that may impact continued safe operation of existing fleet**
  - **NRC seeking to cooperate/collaborate with DOE, domestic industry and international partners in an integrated, holistic program to ensure long-term safety**