NRC Research to Support Regulatory Decisions Related to Subsequent License Renewal Periods

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"I never think of the future, it comes soon enough."

Albert Einstein

Global Age of NPPs

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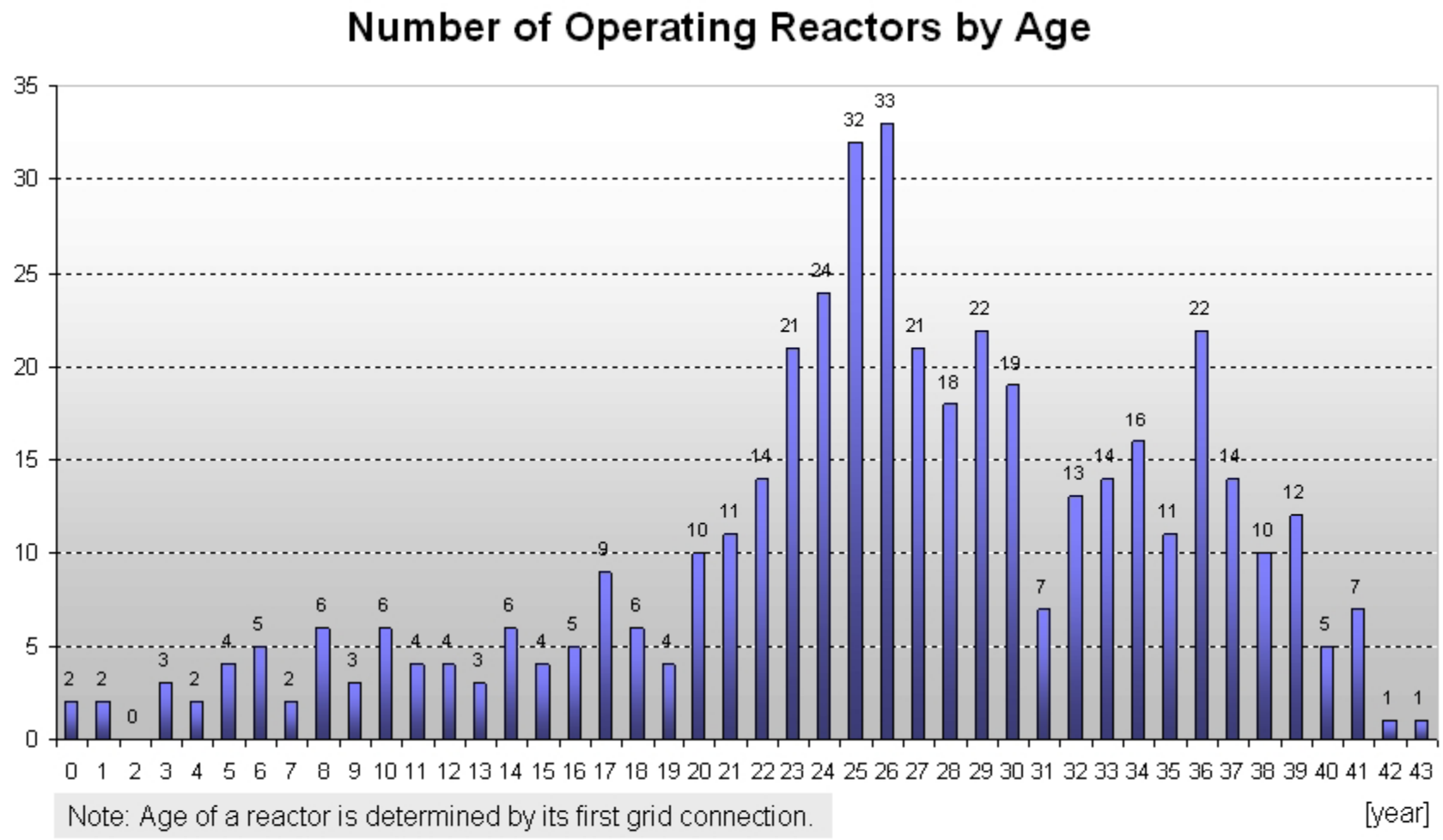

Source: International Atomic Energy Agency; http://www.iaea.or.at/programmes/a2/

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

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- Identify Degradation Scenarios Not Addressed in NUREG-1801, “Current 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

Aging R&D Areas

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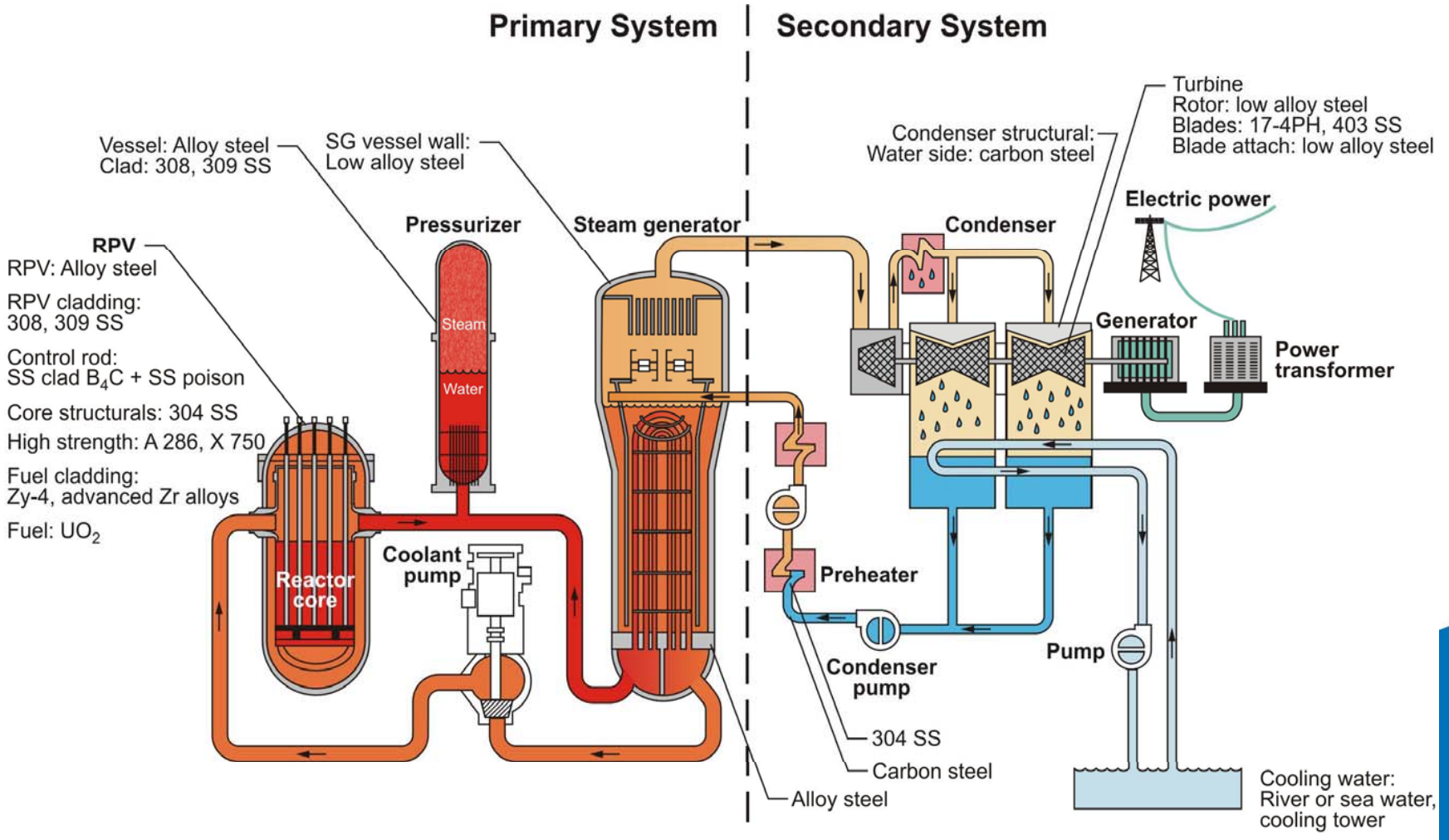

Aging Effects for Existing NPPs

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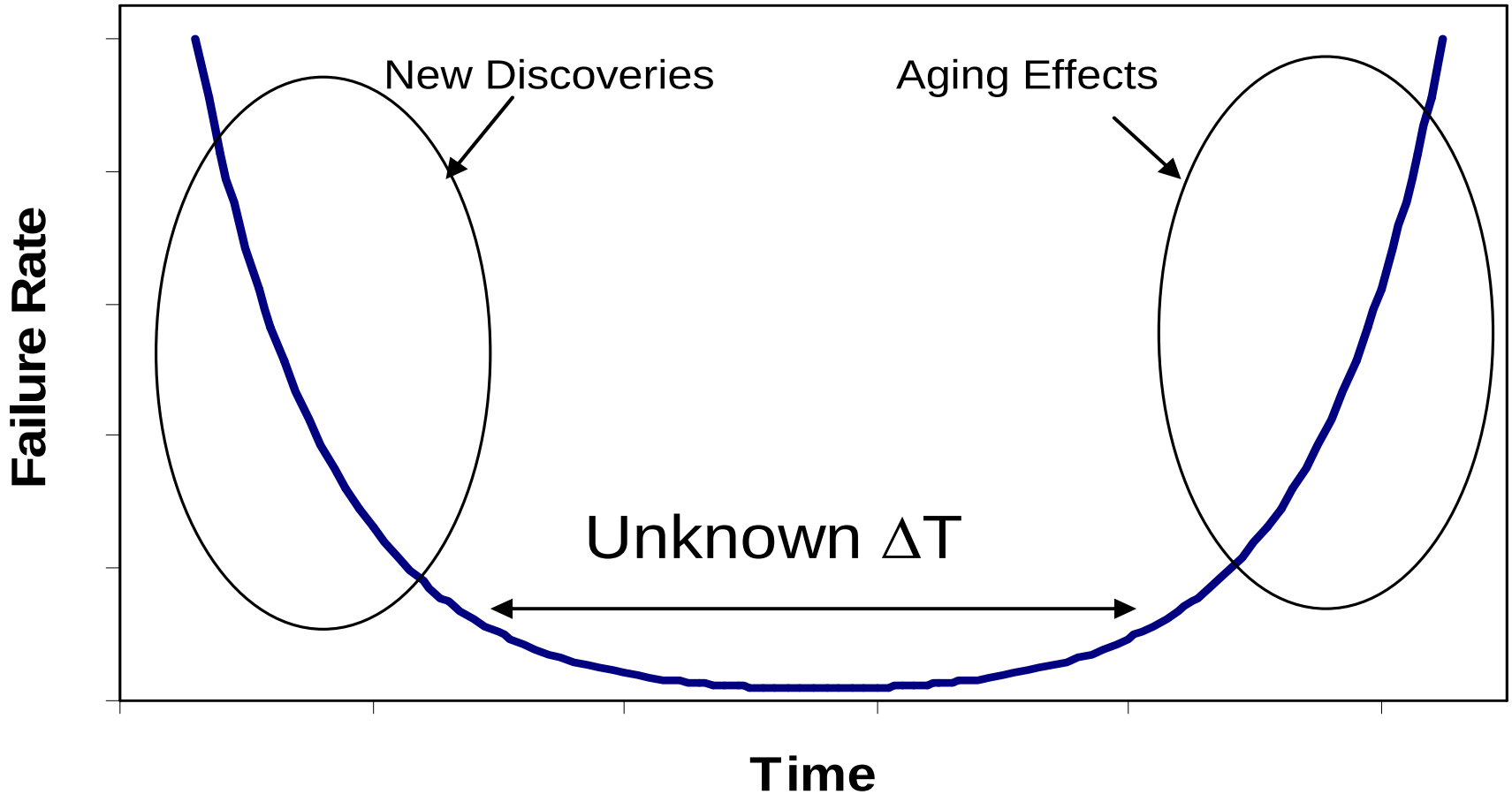
"Bathtub" Curve



Materials Degradation History

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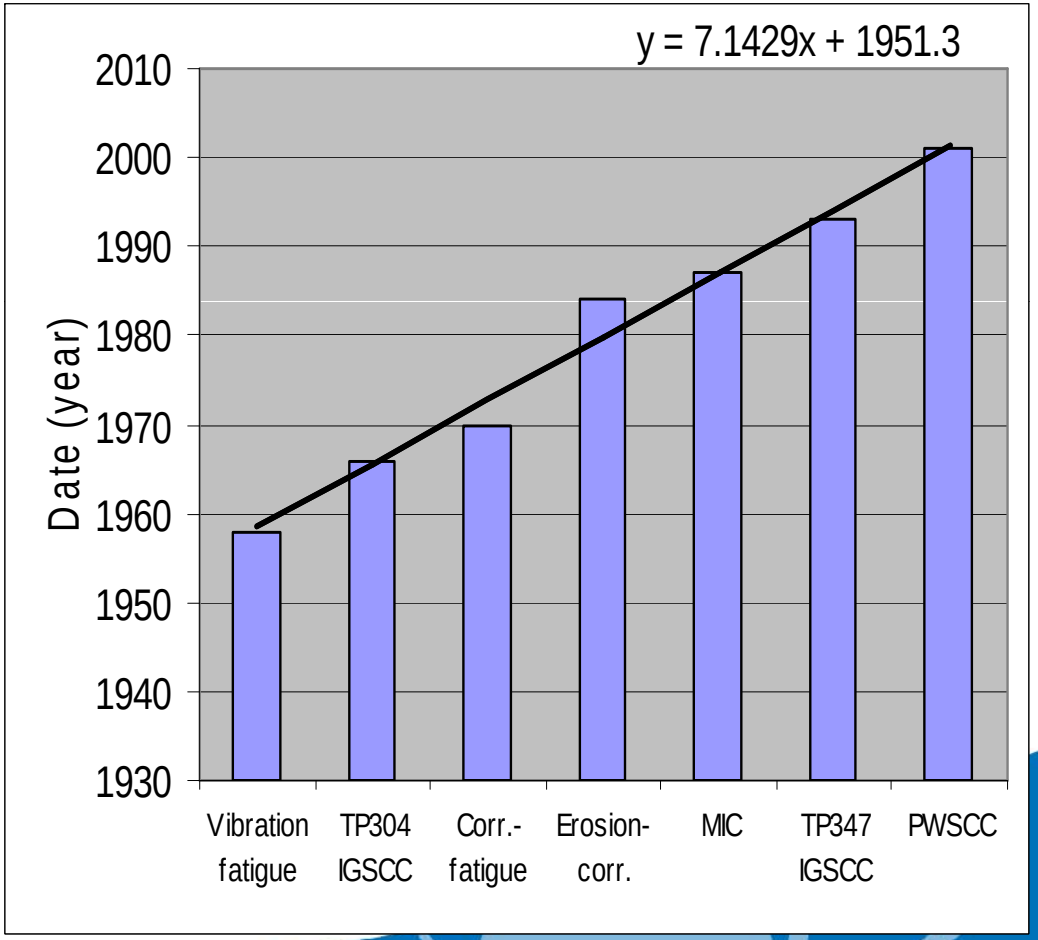
- 1958 - Vibration Fatigue
- 1966 - IGSCC in 304 SS
- 1970 - Corrosion Fatigue
- 1984 - Erosion Corrosion
- 1987 - Microbial-Induced Corrosion
- 1993 - IGSCC in TP347 Stainless Steel
- 2001 - PWSCC
- ?????



Proactive Management of Materials Degradation

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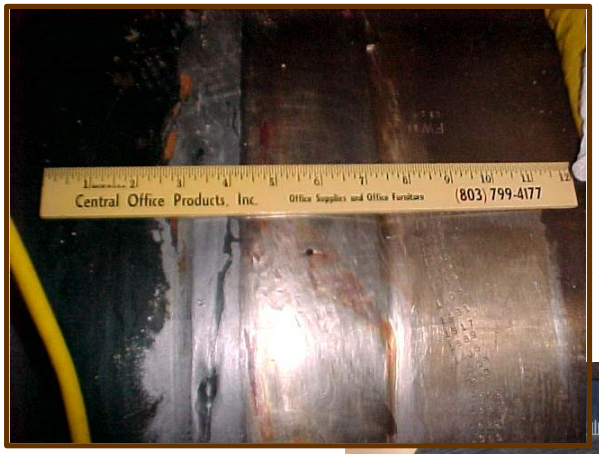
- Develop information
  - Materials behavior
  - Mitigation or repair
  - Inspection or monitoring
- Proactively address potential future degradation
  - Avoid failures
  - Maintain integrity and safety
- Increase cooperation
  - Prioritize PMMD research with industry
  - Pursue additional international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



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

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 to capture operating period beyond 60 years and to expand scope
  - 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 violate subcriticality 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, releases 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 of vessels and internal components
- Life-limiting factor for the reactor vessel and internals
- Compiling a comprehensive database of worldwide embrittlement information and conducting research on conditions to which reactor vessel internals are exposed

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 kinds of 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.

Conclusions

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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