



**U.S.NRC**

UNITED STATES NUCLEAR REGULATORY COMMISSION

*Protecting People and the Environment*

# **Subsequent License Renewal Research – Path to Success**

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# SLR Research Keys to Success

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- **Collaboration**
    - Selective technical areas – leverage resources
    - Industry – EPRI's LTO research
    - DOE – LWRS
  - **Technical Focus**
    - Relatively low knowledge, high susceptibility for degradation during SLR period
    - EMDA – identified areas
  - **Schedule and Timing**
    - Availability of data
    - Guidance development for regulatory assessment
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# SLR Research Focus

## EMDA

- **Major gap analysis related to reactor materials degradation**
- **Based on earlier 2007 work related to piping and reactor internals (PMDA)**
- **Extended the assessment to operation beyond 60 years**
- **Expanded the assessment to include reactor pressure vessel, concrete and cable aging**
- **Moderately successful with respect to the keys to success**

# Selected Key EMDA SLR Concerns – Metals

- **Reactor Pressure Vessel**
  - **Evaluation and prediction of thermal aging and neutron effects on fracture resistance (higher fluence during SLR)**
  - **Attenuation of embrittlement in the nozzle course vs. in the beltline**
  - **Code development and acceptance of direct fracture toughness measurements from surveillance samples**

# Selected Key EMDA SLR Concerns – Metals

- **Piping and Core Internals**
  - **High-fluence effects on lowering fracture resistance**
  - **High-fluence effects on SCC of austenitic stainless steels**
  - **Potential for distortion due to void swelling**
  - **Thermal aging embrittlement of cast austenitic stainless steels**
  - **Environmentally-assisted fatigue**

# Sample Projects Addressing SLR Concerns - Metals

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**NRC research programs are well-aligned with EMDA results**

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- **Reactor Pressure Vessel**
  - **Coordination with C&S bodies (ASME & ASTM)**
    - **Evaluate embrittlement trends in commercial surveillance relative to SLR concerns identified in EMDA**
    - **Develop predictive model based on 40+ years of NRC & industry data**
    - **Enable alignment between NRC predictive model and ASME/ASTM practices**

# Sample Projects Addressing SLR Concerns - Metals

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**NRC research programs are well-aligned with EMDA results**

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- **Piping and Core Internals**
  - **Evaluate high-fluence effects on austenitic SS core internals using materials from Zorita plant**
  - **Evaluate interacting effects of gamma heating and aging and neutron irradiation on cast austenitic stainless steels – fracture toughness and crack growth behavior**
  - **Coordinate sharing technical information with C&S committees**

## **Selected Key EMDA SLR Concerns – Non-Metals**

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- **Cable Aging**
  - **Estimation of activation energy under specific environment**
  - **Consequences of long-term wetting of both low- and medium-voltage cables**
  - **Effects of atmospheric oxygen concentration to consider in LOCA simulation**
- **Concrete**
  - **Irradiation effects for containment concrete**
  - **Creep of the post-tensioned concrete containment**



# Sample Projects Addressing SLR Concerns – Non-Metals

- **Cable Aging**
  - Evaluate naturally-aged safety-related cables from Zion NPP
  - Assess condition monitoring methods
  - Conduct LOCA testing to assess cable LOCA performance
- **Concrete**
  - Evaluate samples from biological shields and RPV supports of decommissioned NPP



Zion U2 Cable Spreading Room

# Prospects for SLR Research Success

- **Collaborative research on materials is high, mature, and well-established**
- **Potential for new collaboration, such as Zorita II**
- **Complementary research projects are underway in industry (EPRI) and DOE-LWRS on key SLR issues**
- **Potential major challenge includes schedule and timing of research results to support SLR application assessment**
- **Research success probability is estimated to be high – good coordination of NRC research with DOE (LWRS), EPRI (LTO) and other related international programs**

# Abbreviations

Abbreviation	Full Text
ASME	American Society for Mechanical Engineers
ASTM	American Society for Testing Materials
C&S	Codes and Standards
DOE	Department of Energy
EMDA	Expanded Materials Degradation Assessment
EPRI	Electric Power Research Institute
LOCA	Loss of Coolant Accident
LTO	Long Term Operation
LWRS	Light Water Reactor Sustainability Research
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
PMDA	Proactive Materials Degradation Assessment
RPV	Reactor Pressure Vessel
SCC	Stress Corrosion Cracking
SLR	Subsequent License Renewal