Extended Proactive Materials Degradation Analysis

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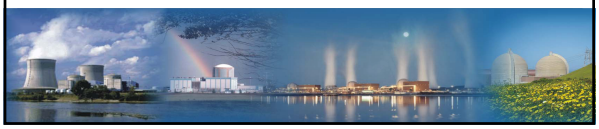
Light Water Reactor Sustainability R&D Program



Materials issues are a key concern for the existing nuclear reactor fleet

- Materials research is already a key need for the existing nuclear reactor fleet
- 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 System
  - Weldments
  - Concrete
  - Cabling
  - Buried Piping

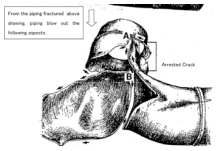
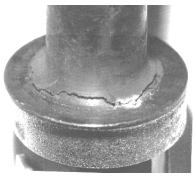


Fig.3 Detail Drawing of the Breaking Portion

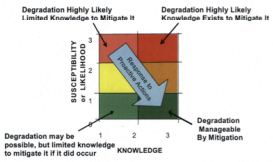
Extension of service life may cause new challenges for materials service

- 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.



In addition to other tasks, research must also identify other or new topics before they become life-limiting

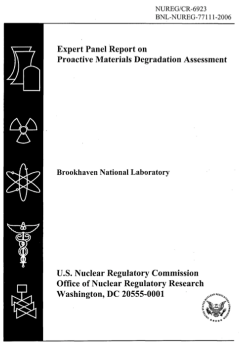
- "Knowing the unknowns" is a difficult problem that must be addressed.
- This is a particularly difficult issue for such a complex and varied material/environment system.
- An organized PMDA approach is being employed.
- Together with the USNRC, the LWRS program is working to expand the initial PMDA activity (*NUREG 6923)* to encompass broader systems and longer lifetimes
  - Core internals and primary piping
  - Pressure Vessel
  - Concrete
  - Cabling



Proactive Materials Degradation Assessment Matrix

The US NRC and LWRS are co-funding the EPMDA

- Both sides are contributing ~$750k in FY10/FY11
- *NUREG 6923* is being expanded beyond initial scope
  - *Longer lifetimes*
  - *Additional systems*
- Same PIRT process and expert panels are being employed.
- Product is complementary to EPRI's MDM


NUREG/CR-6923
BNL-NUREG-77111-2006

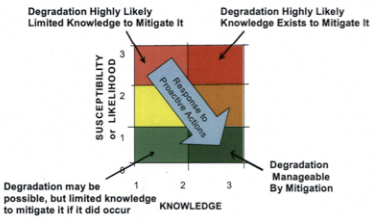
Expert Panel Report on
Proactive Materials Degradation Assessment

Brookhaven National Laboratory

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

A Phenomena Identification and Ranking Table process will be employed

- A systematic review of degradation modes, susceptibility and knowledge is performed for each material in each environment (component by component)



Each panelist provide scores for materials in given conditions for degradation modes

Susceptibility Factor – can significant material degradation develop given plausible conditions?

0 = not considered to be an issue
1 = conceptual basis for concern from data, or potential occurrences under unusual operating conditions, etc.
2 = strong basis for concern or known but limited plant occurrence
3 = demonstrated, compelling evidence for occurrence, or multiple plant observations.

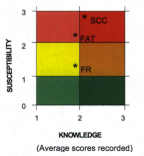
Confidence Level - personal confidence in the judgment of susceptibility

1 = low confidence, little known about phenomenon;
2 = moderate confidence
3 = high confidence, compelling evidence, existing occurrences
Note: "3" is assumed if Susceptibility Factor is "0."

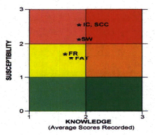
Knowledge Factor – extent to which the relevant dependencies have been quantified

1 = poor understanding, little and/or low-confidence data;
2 = some reasonable basis to know dependencies qualitatively or semi-quantitatively from data or extrapolation in similar "systems";
3 = extensive, consistent data covering all dependencies relevant to the component, perhaps with models; should provide clear insights into mitigation or management of problem.

The PIRT process can identify key areas of concern (high susceptibility and low knowledge)



Average scores of the panel members for degradation mechanisms of Alloy 182/82 welds in PWR primary side environments. The average confidence values for the damage susceptibility are indicated at the right of the diagram.



Average scores of the panel members for degradation mechanisms of high-strength baffle bolts in PWR pressure vessel internals at dpa>0.5. The average confidence values for the damage susceptibility are indicated at the right.

Expanded PMDA relies on a diverse set of expertise and perspective

- **For each assessment, an expert panel has been assembled. This panel must include a diverse body of experts.**
  - At least one member from regulatory bodies
  - At least two members representing industry (EPRI, vendors, etc.)
  - At least one member from the US national laboratories
  - At least one member from academia
  - At least two members from outside the US
- **In addition, most members of the original PMDA were involved**
- **EPRI's MDM has been considered as part of this process**

Panelists have been identified and confirmed

Internals/Primary Piping	Secondary Piping	RPV	Concrete	Cables
J. Busby (ORNL)	S. Bruemmer (PNNL)	R. Nanstad (ORNL)	D. Naus (ORNL)	R. Bernstein (SNL)
A. Hull (NRC)	G. Carpenter (NRC)	M. Kirk (NRC)	H. Graves (NRC)	S. Ray (NRC)
R. Dyle (EPRI)	K. Arioka (INSS)	B. Server (Consult)	J. Wall (EPRI)	G. Toman (EPRI)
P. Andresen (GE)	R. Staehle (Consult)	B. Odette (UCSB)	J. Rashid (Anatech)	K. Simmons (PNNL)
K. Gott (SSI)	G. Was (UM)	N. Soneda (CRIEPI)	Y. Le Pape (EdF)	K. Gillen (Consult)
P. Ford (Consult)	M. Wright (AECL)	B. Burgos (Westinghouse)	V. Sauma (UC)	

Successful conclusion of the Expanded PMDA will be beneficial to all stakeholders

- May help "know" some of the current "unknowns"
- Involves input from a wide range of perspectives
- This systematic analysis will provide a firm foundation for task prioritization and research needs for regulators, industry, and researchers
- Additional efforts on visualization of results may provide a concise presentation of risks and needs to other sponsors

Acronyms

- PIRT: Phenomena Identification Ranking Table
- LWRS: Light Water Reactor Sustainability
- MDM: Materials Degradation Matrix
- PMDA: Proactive Materials Degradation Analysis