Planning Meeting on International Cooperative Research Group and Program for Proactive Materials Degradation Assessment and Management

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Proactive Materials Degradation Assessment
Motivation

- Several unexpected materials degradation incidences have occurred in the recent past
- Regulators and industry have concluded that a proactive approach to materials degradation assessment and management is desirable
  - Develop a foundation for appropriate actions to keep materials degradation from adversely impacting component integrity and safety and avoid safety significant surprises

Proactive Materials Degradation Assessment
Scope

- What is proactive with respect to materials degradation management?
  - Predict and prevent or mitigate
  - Predict, monitor, and repair/replace in a timely manner
- Prediction is a critical aspect of PMDM
  - Proactive research allows us to manage the issue before it becomes safety-significant
  - Thousands of components need to be considered
- Consider risk importance of components susceptible to degradation
  - Prioritize research efforts
  - Develop regulatory guidance
- Roles
  - The industry develops methods
  - The regulator confirms their effectiveness
  - These roles can share the same research

Proactive Materials Degradation Assessment
Approach

- First step is to identify materials and locations where degradation can reasonably be expected in the future, and determine the risk significance
- Next step is to organize an international cooperative research program for the components and degradation of interest that will address:
  - Inservice inspection and continuous monitoring techniques for the detection, characterization, and evaluation of degradation
  - Materials and degradation mechanisms
  - Techniques to ameliorate stressors for mitigation or prevention of expected degradation
  - Repair and replacement materials and techniques
  - Post-repair and fabrication inspection techniques

Proactive Materials Degradation Assessment
Identify Susceptible Components and Knowledge level

- Three activities to accomplish the first step
  - Conduct Phenomena Identification and Ranking Table (PIRT) process to identify plant components susceptible to future degradation
    - Study has been completed; identified susceptible components and assessed level of knowledge
  - Use existing information to identify components that have experienced degradation
    - Input for evaluation of inservice inspection effectiveness
  - Recognize risk significance of component failure
    - This work is ongoing
    - First approach is to assume safety related components and reactor coolant pressure boundary are risk significant

Proactive Materials Degradation Assessment
Susceptible Components and Knowledge (Cont.)

- Hundreds of components with medium-to-high susceptibility to future degradation were identified
  - To be discussed during "break-out" session
- PMDA PIRT includes forward thinking with respect to time related aging phenomena and changing conditions
  - Ex. 1: Accumulation of chloride on the exterior of piping at seaside plants
  - Ex. 2: PWR operation at end of fuel cycles with practically zero boric acid in the primary coolant
    - Potential for lithium hydroxide accumulation in crevices without buffering effect of boric acid which could lead to stress corrosion cracking (pressurizer heater sleeves?)

Proactive Materials Degradation Assessment
Susceptible Components and Knowledge (Cont.)

- PMDA PIRT includes "what-if" exercise
  - Used to brainstorm non-component specific scenarios that could lead to degradation not previously seen
    - Pb SCC, particularly for Alloy 690
      - Laboratory observations
    - Does IGSCC of LAS/CS imply a new and/or faster SCC degradation mode? (Point Lepreau)
    - Issue of high CGR in nickel-base HAZs and application to other materials
    - Validity of K_{IC} values, air versus environment
    - Lack of predictability of thermal fatigue due to complex TH and FEM in unanalyzed lines
    - Corrosion events under slow-evolving deposits and changing composition of metal surfaces
    - Low-temperature sensitization

Proactive Materials Degradation Assessment
International Cooperative Research Group

- To accomplish the second step, an international research group and program will be assembled
- Technical experts and sponsoring organizations
- Together develop a broad-based research program plan
  - Materials and degradation mechanisms
  - Mitigation
  - Repair and replacement
  - Nondestructive examination and monitoring techniques
- Through cooperative agreement, sponsor, implement, and share research results
- Meetings to develop program plan and cooperative agreement:
  - USA, Europe, Japan

THE INTERNATIONAL COOPERATIVE GROUP AND RESEARCH PROGRAM FOR PROACTIVE MATERIALS DEGRADATION MANAGEMENT

Planning and Coordination

- Implementation of PMDM programs for components and degradation of interest will require an extensive technology base and new research
  - No one organization alone can accomplish
  - Feasible through international cooperation
  - We need to think, plan, and act together beyond our individual every day interests and responsibilities
- Success in PMDM will require the support and commitment of the reactor community, while recognizing industry's and regulators' roles
  - Regulators, Industry, Sponsoring Organizations, Laboratories, Universities

Planning and Coordination (Cont.)

- Develop a broad-based research program plan, conduct the research, and share the results through a cooperative agreement
  - Materials and Degradation Mechanisms
  - In-service Inspection and continuous monitoring (regulator verifies)
  - Mitigation, repair, and replacement (regulator verifies)

Planning and Coordination (Cont.)

Examples of Research Topics

- Materials and degradation mechanisms
  - Quantitative treatment of microcrack initiation, coalescence followed by short crack propagation
  - Mechanistic understanding of crack growth and quantitative evaluation of important variables and interactions
  - Definition of “corrosion system” parameters that control the kinetics of EAC
  - Effects of cold work and hardening
  - Low temperature crack propagation
- NDE and monitoring
  - New inspection technology
  - Continuous monitoring – additional validation
- Mitigation, repair, and replacement
  - Validation of evolving mitigation methods/fixes
  - Study of fabrication parameters to optimize microstructures and residual stresses

Planning and Coordination (Cont.)

- Approximately 3 working meetings in the USA, Japan, and Europe
  - Begin by identifying the broad-based research needed and assemble the research plan
  - Review and identify appropriate ongoing research work that participants are willing to share
  - Identify additional new research and possible sponsors
  - Discuss and agree on Agreement language and conditions
- Introductory meeting held at Snowbird, UT (8/05)

Planning and Coordination - Japan Meeting (Cont.)

- First working meeting held in Tokyo, Japan (11/05)
  - Obtained input for the broad-based plan
  - Expressions of intent to participate from several organizations
  - Discussed a model for cooperation
- Participant can be a single organization or a consortium
- Participant provides value in kind research of 3 person-year per year during the cooperation
  - Less for countries with small nuclear power programs
- Model for cooperation is not fixed
  - Other suggestions are welcome
  - Flexibility to allow widest participation possible

Planning and Coordination – Japan Meeting (Cont.)
Summary of Materials and degradation Discussion

- SCC of non-sensitized stainless steels
- Cold work effects on low alloy steels, stainless steels, and high nickel alloys
- Lead effects on Alloy 690
- Fracture toughness of welds at low temperatures as affected by environments
- Capacity to predict long term performance of Alloys 800 and 690
- Long term aging effects on alloy properties including especially grain boundaries
- SCC of dissimilar metal welds
- Modeling environmentally affected fatigue
- Integrate the materials behavior in BWR and PWR for mutual benefit

Planning and Coordination – Japan Meeting (Cont.)
Summary of NDE Discussion

- General consensus that improvements in NDE and monitoring are needed in order to manage degradation
- On-line monitoring, validation
- Identify those components and degradation processes where NDE/ISI is not effective at managing
  - Develop better ISI methods: Detection, Length and Depth Sizing
  - Coarse grained materials
- NDE methods for directly measuring material properties, especially radiation embrittlement
- Better NDE methods for wall thinning measurements
- More effective loose part monitoring techniques- Including AE

Planning and Coordination – Japan Meeting (Cont.)
Summary of Mitigation, Repair, Replacement Discussion

- Fundamental research in this area is more feasible for the cooperation since there will be a reluctance to share commercial “know-how”
- Validation research methodology for new mitigation, repair, and replacement technology should be conducted with world wide consensus
  - Emphasis placed on Development of guidance to provide the criteria

Planning and Coordination (Cont.)
Post – Japan Meeting

- Based partly on discussions at the Japan meeting, a number of short overview papers on research issues and needs were written
  - Initiation and propagation of SCC in cold worked stainless steel and Alloys 600 and 690: Fundamental assessments of crack tips
  - Measurement of accumulation of Pb, as well as S^{y-} in line contact crevices of steam generators
  - Reduction of high valence sulfur species to lower valence species
  - Long term LPSCC of Alloy 690TT
  - SCC and mitigation for Alloy 600TT and 690TT in Pb^{-} and S^{y-} contaminated solutions
  - Scaling of Alloy 690 TT in Pb-containing environments

Planning and Coordination
Post – Japan Meeting (Cont.)

- Establishing and updating recommended ECP/pH zone for minimizing SG tube degradation
- Determine factors controlling the SG tube degradation initiation and propagation
- Assess local chemistry conditions under SG conditions
- Factors affecting effectiveness of SG inspection
- SCC of welds and cold worked stainless steel in high temperature water
- Investigation of metallurgical variables affecting the low temperature creep cracking of carbon steel piping
- New nondestructive testing techniques for precise detection and evaluation of early stage materials degradation

Planning and Coordination (Cont.)
Charleston Working/Planning Meeting

- Participate in one of three focus groups
- Continue technical discussions of research issues and needs
- Continue development of overview papers for the broad research program plan for the cooperation
- Discuss approaches for collaboration (one type has been presented)
- Take away– Intent to participate e-mail to Dr. Jennifer Uhle jxu1@nrc.gov AND Dr. Joseph Muscara (jxm8@nrc.gov)
- Future discussions with interested parties will establish the type of collaboration used for PMDM research