



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