International Collaboration on Materials Research at the NRC

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Nuclear Regulatory Commission

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Nuclear Regulatory Commission Headquarters
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Committee on the Safety of Nuclear Installations Activities

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- Objective
  - Assist member countries in maintaining and further developing the scientific and technical knowledge base required to assess the safety of nuclear reactors and fuel cycle facilities.
- Structure
  - Main Committee (B. Sheron, NRC/RES, Chairman)
  - Program Review Group (S. West, NRC/RES)
  - Six working groups
    - Working Group on the Integrity of Components and Structures
    - Metals, concrete, and seismic subgroups
  - Working groups meet yearly to review existing projects, propose new projects, and discuss operational experience
- Participants
  - 21 countries from Europe, Americas, and Asia
  - Regulatory agencies, technical support organizations, industry

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- Metals-related activities
  - **Leak-before-break (LBB)**
  - **Long-term operations (LTO)**
  - **Component operational experience, degradation and aging program (CODAP)**
  - Benchmark on the analytical evaluation of the fracture mechanics parameters K and J
  - Environmental fatigue
  - Probabilistic structural integrity of a PWR reactor pressure vessel (PROSIR)
  - Hydro-proof pressure test requirements
  - Metallic component margins under high seismic loads (MECOS)
- Typical deliverables
  - Databases, state-of-the-art reports, benchmarking and round-robin analytical results, workshops
- Schedule
  - Programs typically last from 1 – 3 years

CSNI LBB Project

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- Objectives: To identify technical areas of mutual interest related to
  1. Evaluation of structural integrity of piping systems using deterministic and/or probabilistic methods
  2. Demonstration that flaws in piping systems will exhibit LBB
- Scope
  - Primary pressure boundary piping
- Participants: Principally regulatory agencies and representatives
  - Belgium, Canada, Czech Republic, Finland Germany, Japan, Netherlands, Slovakia, Sweden, Switzerland, United States, & JRC
- Program description
  - Phase I: Conduct survey
    - Identify current regulatory and technical requirements used for LBB
    - Identify technical and regulatory concerns related to the aging degradation in LBB systems
  - Phase II: Evaluate LBB benchmark problems
    - Develop and solve problems of common interest (PWSCC)
    - Use approved methods for each country or more advanced methods

CSNI LBB Project

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- Project status
  - Survey (Phase I) has been completed and documented
  - Benchmark evaluation (Phase II) is beginning in 2015
- Principal deliverables
  - Report summarizing current requirements in each country and technical and regulatory concerns (Phase I)
  - Report on benchmark evaluations (Phase II)
- Milestone schedule
  - Summer 2015 – Publish working level CSNI report
  - September 2015 - Develop detailed project plan
  - December 2015 – Finalize participation of interested countries
  - April 2016 – Develop specific benchmark problems

CSNI LTO Project

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- Objectives
  1. Identify technical areas of mutual interest related to age-related degradation of materials in safety-related systems, structures, components (SSCs) during long-term operation (i.e., > 60 years)
  2. Capture operating experience and regulatory treatment associated with degradation in buried tanks and piping (BTP)
- Scope
  - Safety significant SSCs; barriers/shields that protect against exposure
  - Metals, concrete, cables, instrumentation and control systems
- Participants: Principally regulatory agencies and representatives
  - Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Netherlands, Slovakia, Slovenia, Sweden, Switzerland, United States, & JRC
- Program description
  - Conduct survey to identify common regulatory and technical concerns associated with LTO
  - Conduct survey to document each country's regulatory treatment and technical concerns associated with BTP

CSNI LTO Project

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- Project status
  - Both LTO and BTP surveys have been completed
  - LTO report has been finalized and is awaiting CSNI approval
  - Report summarizing BTP survey responses is being prepared
- Principal deliverables
  - Working level report summarizing regulatory treatment and technical concerns in each country associated with BTP
  - CSNI report summarizing LTO plans, research activities, and issues
- Milestone schedule
  - Summer 2015 – Publish LTO report
  - December 2015 – Complete draft of BTP report
  - April 2016 – Finish BTP report
- Possible follow-on work
  - Identify joint projects related to concrete aging, cable aging, fatigue, PWSCC, RPV integrity, ISI requirements for internals and BMI nozzles

CODAP

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- Objective
  - Capture international materials degradation events and general knowledge of various degradation mechanisms, in a web-based format
- Scope
  - Degradation of pressure boundary passive components
  - Piping, control rod drive housing, instrumentation tubes, etc.
- Participants
  - OECD/NEA,
  - Regulatory agencies and representatives from United States, Canada, Chinese Taipei, Czech Republic, France, Germany, Japan, Korea, Slovak Republic, Spain, Switzerland
- Program description
  - Participating countries submit operating experience on findings of material degradation
  - Resulting international database is searchable on important physical and operational attributes of each finding

CODAP

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- Status
  - Last agreement was completed in 2014
  - New 3-year agreement initiated in 2015
- Principal deliverables
  - Improved user interface and searching capabilities
  - Updated event database
  - Topical reports
    - Flow Accelerated Corrosion (FAC) of carbon steel & low alloy steel piping in commercial Nuclear Power Plants
    - Operating Experience Insights on Pipe Failures in Electro-hydraulic Control & Instrument Air Systems
- Schedule
  - Operating experience is updated continuously
  - Topical reports are developed approximately every year
  - Schedule for user interface improvements is under development

International Forum for Reactor Aging Management (IFRAM)

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- Objective
  - Strengthen regional, and build global, networks to facilitate appropriate exchange of information among those organizations that are presently, or are planning to, addressing issues related to aging management of nuclear power plant systems, structures and components (SSCs)
- Scope
  - Facilitate sharing of information and best practices
  - Identify joint research/demonstration projects
  - Leverage resources to accomplish technical and operational objectives
- Key participants
  - NRC, EPRI, DOE, Joint Research Council (JRC), Institute of Metals, Chinese Academy of Sciences, Canadian Nuclear Safety Commission (CNSC), NICHe, Tohoku University, Korean Advanced Institute of Science and Technology (representing PRIMA-NET), Iowa State University

International Forum for Reactor Aging Management (IFRAM)

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- Status
  - IFRAM informally began August 2011
  - Creating a handbook on reactor aging management – lead by Korea
  - Developing Memorandum of Understanding (MOU) for formal IFRAM participation – target completion in summer 2015
- Initial deliverables
  - Develop a living quantified listing of
    - Test facilities and their capabilities,
    - Regional subject matter experts
    - Proposed/on-going research by organization
  - Develop and implement a virtual framework to get regulators, industry (utilities & vendors), academia, and TSOs to share information and cooperate on aging management activities

Halden Reactor Project

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- Objectives
  - Provide a fundamental understanding of irradiation-assisted stress corrosion cracking (IASCC) and predict the cracking rate in irradiated materials
  - Evaluate irradiation-assisted creep and stress relaxation in-situ
  - Develop new methods to characterize RPV embrittlement
- Scope
  - Aging and performance of reactor vessel internal and RPV materials in LWR environments
- Participants
  - 29 organizations (including NRC and EPRI) from 19 countries
- Program description
  - Use Halden reactor for irradiation of unirradiated and ex-plant materials
  - Conduct in-pile IASCC, creep, and stress relaxation testing
  - Use separate loops for IASCC testing
- Status
  - NRC has been a project member since 1958
  - The program is renewed on a 3 year basis
  - Current 3-year program started in Jan. 2015

Halden Reactor Project

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- Principal deliverables
  - Periodic reports
  - Annual review and planning meeting for materials research
- Schedule
  - Jan. 2015: Adoption of agreement for current program and start of technical work
  - Feb. 2015: Final technical reports for last program
- Work during current program:
  - Evaluate weld and HAZ crack growth rate and fracture toughness for as-received Zorita core barrel materials (1 – 2 dpa) under LWR conditions
  - Perform additional irradiation on Zorita core barrel weld and HAZ materials (up to 8 dpa)
  - Remove specimens yearly and measure crack growth rate and fracture toughness under LWR conditions

Zorita Internals Research Project

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- Objective:
  - Harvest ex-plant RPV internals from a decommissioned Spanish PWR to study radiation effects
- Scope:
  - Reactor vessel internal components exposed to high fluences – baffle and former plates
- Participants:
  - CSN (Spain), EPRI (US), MHI/Japanese utilities (Japan), NOK (Switzerland), Ringhals (Sweden), Tractebel (Belgium), UNESA/ENRESA (Spain), SSM (Sweden), USNRC
- Program Description:
  - Plate materials harvested and tested for IASCC initiation and growth rates, fracture toughness, tensile properties, and microstructural characterization
  - Program management is being provided by EPRI
  - NRC participates as a funding partner and member of the project steering committee

Zorita Internals Research Project

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- Status
  - SOCOIN completed temperature/radiation analysis
  - Material harvesting and retrieval has been completed
  - Studsvik is conducting testing
    - Tensile testing is complete
    - Fracture toughness, crack growth rate, & crack initiation testing are underway
- Principal deliverables
  - Information on IASCC resistance, mechanical properties, and microstructure of materials irradiated under in-service conditions
- Schedule
  - Testing completed and final technical report anticipated by 2016
- Related work
  - Weld and HAZ testing of Zorita core barrel without further irradiation at Studsvik planned for 2015-2017
  - Weld and HAZ testing of Zorita core barrel with further irradiation at Halden

Probabilistic Analysis as a Regulatory Tool for Risk-Informed Decision Guidance (PARTRIDGE)

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- Objectives
  - Further develop the PRO-LOCA PFM code
  - Support xLPR code development through international participation
- Scope
  - Probabilistic analysis of primary pressure boundary piping systems
- Participants:
  - Sweden (SSM), Canada (CNSC, CANDU Owners Group), South Korea (KINS, KHNP, KEPCO), Taiwan (INER), US (NRC)
- Program description
  - Update PRO-LOCA by incorporating latest deterministic models as they become available
  - Evaluate PRO-LOCA through sensitivity analyses and benchmarking
- Principal deliverables
  - PRO-LOCA 4.1.9, GUI
  - PRO-LOCA Users Manual

PARTRIDGE

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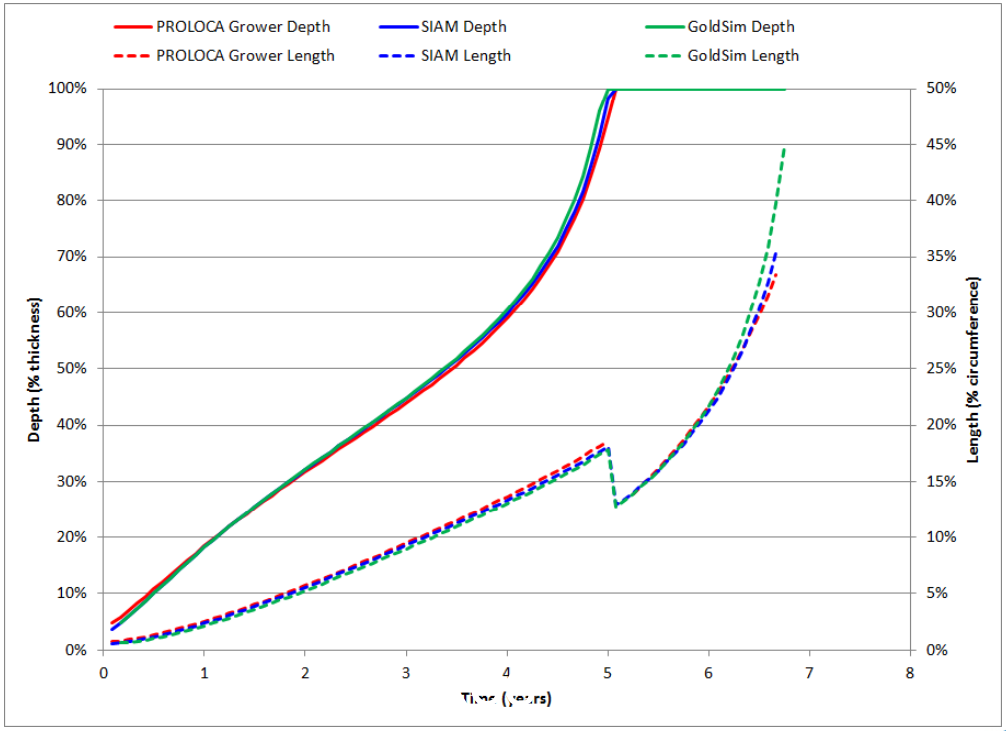
- Status
  - Program has been completed
  - Finalizing scope and participants for PARTRIDGE II
- Proposed future work (start in 2015)
  - Maintain PRO-LOCA sharepoint for users group
  - Update PRO-LOCA, GUI, User and Theory manuals
  - Provide continued international support of xLPR
  - Identify critical variables through sensitivity study
  - Update software tools and databases
  - Revise Pipe Fracture Encyclopedia
  - Enhance post-processing capabilities

Benchmarking PRO-LOCA with xLPR V1.0



PARENT Program

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- Objectives
  - Evaluate the ability of more than 10 different NDE techniques to detect and characterize PWSCC in nickel alloy components and welds
  - Evaluate the effectiveness of open and blind inspections using more than 20 test teams
- Scope
  - Ten large bore dissimilar metal welds: ~90 cm diameter
  - Ten small bore dissimilar metal welds ~40 cm diameter
  - Nine bottom mounted instrumentation penetrations
- Key participants:
  - US NRC and PNNL contracting US NDE Industry Representatives
  - Organizations from Japan (JNES, JPEIC, Tohoku University, MHI, KEPCO), Korea (KINS, KAERI, Doosan, KHNP, KPS, Sungkyunkwan University), Sweden (SSM, SQC), Finland (VTT, Aalto University), Switzerland (ENSI, PSI, and SVTI)

PARENT Program

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- Program description
  - Evaluate commercially-used inspection techniques using blind round robin testing (RRT)
  - Evaluate emerging NDE techniques using open RRT
- Principal deliverables:
  - Two TLR and NUREG/CR reports with open and blind RRT results
  - Atlas Information Technology Tool
- Schedule:
  - Complete NUREG/CR reports for NRC review – June 2015
  - Complete initial Atlas development – Sept. 2015
- Possible future work (pending agreement by participants)
  A. Summarize round-robin testing results from previous 20-30 years
  B. Conduct round-robin testing of CASS components
  C. Explore effects of human factors (e.g., inspection and review speed) on POD
  D. Conduct round-robin testing on pre-mitigation inspections for PWSCC
  E. Enhance ATLAS with PWSCC crack morphology