International Materials Research (IMR)

Program Update

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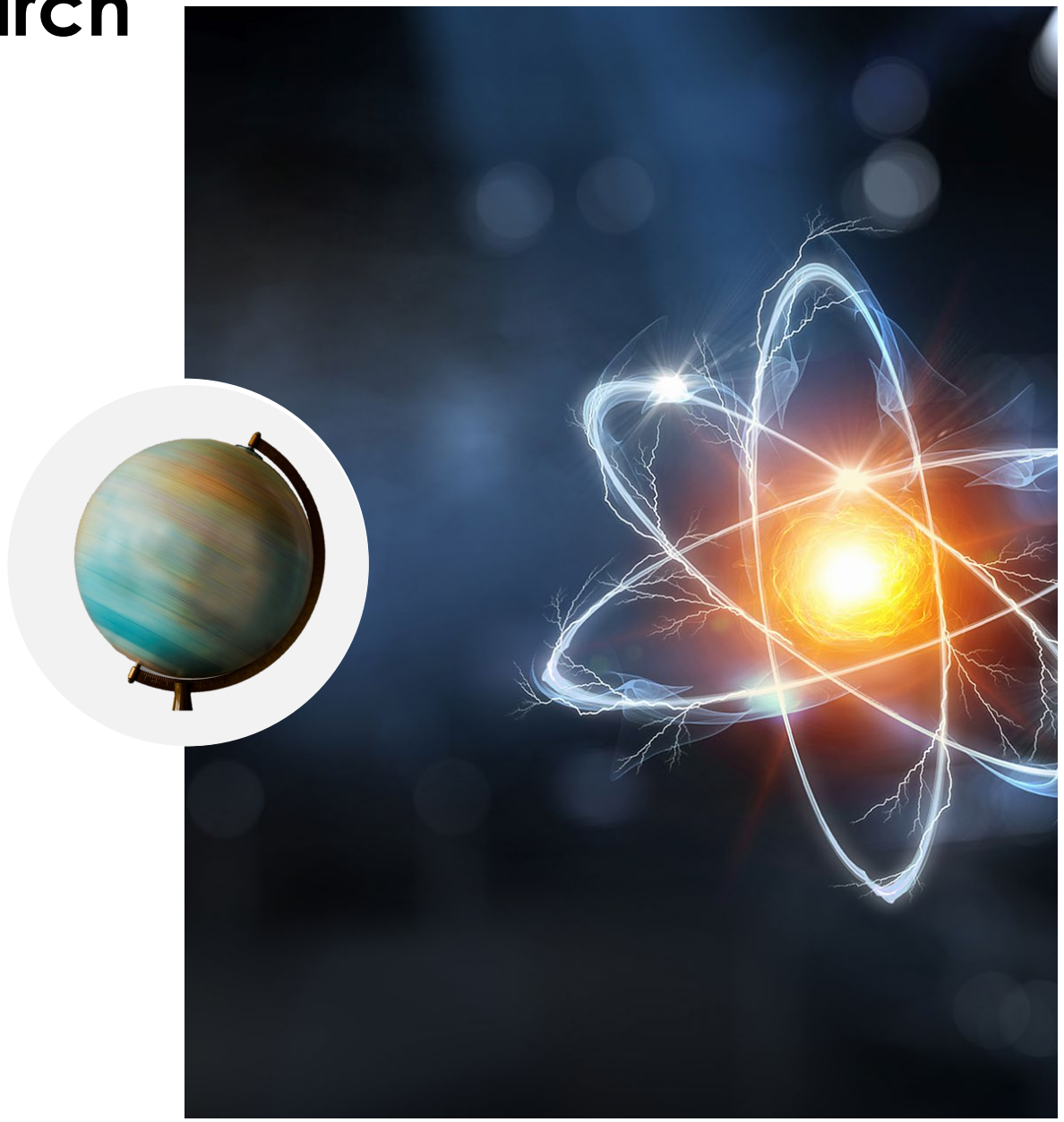
Topics

- IMR Objective
- The IMR Team
- IMR Technical Strategy Areas and Projects
  - Fundamental Research
  - Reactor Sustainability
  - International Reactors
  - Advanced Methods and Databases
- Interactions with NRC
- EPRI Materials Department References

International Materials Research

International Materials Research conducts research to enhance the understanding of the damage mechanisms in materials used in water-cooled reactors.

Research results lead to improved predictive models, provide inputs to aging management plans, and inform potential countermeasures that contribute to the safe, continued operation of plant components.



The IMR Team

- IMR technical staff have more than 100 years of combined experience in materials science, corrosion, chemistry
  - Experience in nuclear national labs, utilities, and NSSS vendors
  - Participate in industry forums, collaborative projects, advisory boards
- In addition to research projects, IMR staff support utilities with reviews of plant-related materials activities:
  - Causal analysis reports
  - Hot cell examination test plans and results
  - Metallurgical evaluation reports
  - New light-water reactor design material test plans

Santtu Huotilainen joined the IMR team in April as a Principal Technical Leader.

- Master's Degree in Mechanical Engineering from Aalto University and more than 15 years of experience in both nuclear fission and fusion.
- Originally from Loviisa, Finland, Santtu spent his summers interning at the nuclear power plant and went on to become the Team Manager for the Materials Engineering and Strength Analysis Specialist Team at Fortum.
- Santtu also worked as a research scientist at VTT; there he was responsible for experimental design, mechanical testing in air and fluid environments, and data analysis. Through his role at VTT, he was appointed to an international collaboration team for in-core materials test capability development for the Jules Horowitz Reactor (JHR) project at CEA in France.

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IMR Technical Strategy Areas and Projects

Fundamental Research

Reactor Sustainability

International Reactors

Advanced Methods and Databases

Fundamental Research

- Conduct derivative research to elucidate microstructural contributions to mechanical testing results
- Develop technologically-innovative approaches to support plant operations
- Perform advanced characterization of plant components to support utility component failure analyses

IASCC Initiation Testing Expert Panel and Round Robin

- The large scatter in historical IASCC initiation data is most likely a result of the inherent stochastic nature of IASCC initiation and the differences in test procedures previously utilized by labs.
- IASCC initiation data from EPRI and others has been collected and a statistical analysis has been performed to develop guidelines for IASCC initiation testing with the purpose of reducing the variability in test results.
- Future activities include developing a standard method of calculating Ys_{irr} from pre-aged material properties and evaluating candidate methods for creating plant-relevant oxides.
- A round robin using same-source materials is planned.

- Thermal Ageing of Austenitic Stainless Steel Weld Metal
- Thermal Ageing of Alloy 690 and Associated Weld Metals
- IASCC Initiation Testing Expert Panel and Round Robin
- Role of GB Carbides on Crack Initiation in Alloy 600 and Alloy 182
- EAF in KOH Water Chemistries

IMR Technical Strategy Areas and Projects

Fundamental Research

Reactor Sustainability

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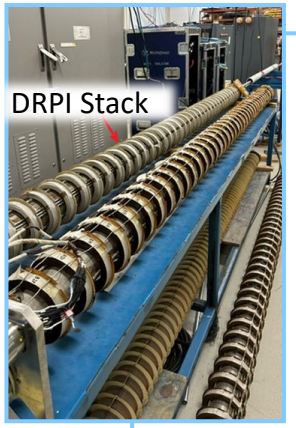
Reactor Sustainability

- Quantify time-dependent ageing mechanisms such as wear and fatigue
- Manage materials harvesting projects and testing of ex-plant materials
- Characterize the behavior of advance manufactured components in service environments



Evaluation of Potential Methods of Monitoring Drive Rod Vibration in Support of Assessing Latch Assembly Wear Susceptibility

- Unanticipated wear in the stationary grippers of control rod drive mechanism latch assemblies prompted industry to collect more data on extent of condition across fleet.
- Inspection methods are laborious and consume personnel dose, so an alternative mechanism was explored. Phased approach was used laboratory testing and site planning.
- Benchtop testing of simulated digital rod positioning indicator (DRPI) system was utilized to evaluate measurement feasibility during rod drop testing at startup.
- Feasibility analysis was performed for site work.

- EAF Component Test
- Planning of Plant Materials Extraction (Harvesting)
- Laser Annealing for Mitigation of IASCC Initiation
- Stress Corrosion Cracking and Fatigue Testing of DED Stainless Steel
- Development of a Deployable Welding System for Irradiated Stainless Steel

IMR Technical Strategy Areas and Projects

Fundamental Research

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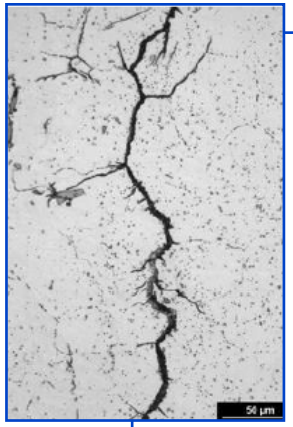
International Reactors

- Support the long-term operation of international reactor designs, including VVERs and CANDU reactors, in conjunction with developing reactor-agnostic technical bases for materials models that support these aging
- Participate in iGALL and other international ageing management programs



SCC Susceptibility of Titanium-Stabilized Stainless Steels in RCS Dead Legs

- High priority gap in VVER IMT, which was elevated in urgency following the operating experience from France; which has been evaluated for applicability to the VVER fleet.
- VVER titanium-stabilized stainless steel has generally seen good performance relative to SCC, with limited instances of cracking observed due to off-normal water chemistry.
- ASTM G30 U-bend SCC initiation tests will be performed in different water chemistries, including reactor startup with dissolved oxygen, pH excursions, and static (dead leg) conditions.
- Time-to-cracking data will be produced, supplemented with metallographic analysis and specimen characterization using both optical and electron microscopy.

- Prediction of Irradiation Effects on Stabilized Stainless Steels
- Mitigation of CANDU Calandria Relief Duct Cracking
- SCC Susceptibility of Titanium-Stabilized Stainless Steel in RCS Dead Legs
- Issue Management Tables for VVER and CANDU Reactors

IMR Technical Strategy Areas and Projects

Fundamental Research

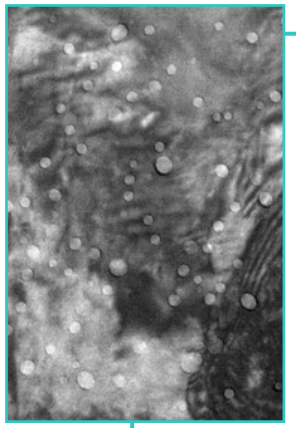
Reactor Sustainability

International Reactors

Advanced Methods and Databases

Advanced Methods and Databases

- Utilize advanced methods, such as machine learning and robust statistical analyses, to facilitate materials characterization and to manage data sets to ensure the success of future research projects and future fleet deployment
- Maintain Materials Department products such as the MDM, IMTs, and Materials Handbook.



Rapid Quantification of Irradiation-Induced Microstructures

- Electron microscopy techniques are widely used to identify defects, such as dislocation loops and cavities, in materials. The key challenge is to determine the number density and size distribution of each defect type.
- EPRI is employing machine/deep learning methods to develop a combined framework for automatic detection and analysis of nanocavities and estimate void swelling accurately.
- Current project on quantifying void swelling has resulted in very good size predictions with some underestimation of cavity density. However, overall swelling predictions are accurate.
- Applying same ML approach to a more rapid and standardized assessment of Pt particle size and distribution in BWRs.

- Rapid Quantification of Irradiation-Induced Microstructures by Deep Learning
- Assessment of Platinum Particle Size and Distribution in BWRs Using Machine Learning
- Materials Degradation Matrix and Issue Management Tables
- Annual Materials Handbook Revision/Interactive Materials Handbook

Interactions with NRC

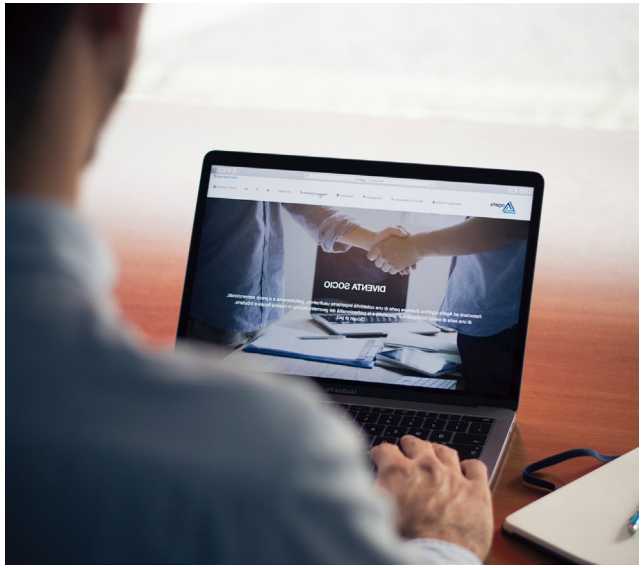
International Materials Research

Joint Meetings

- Monthly Materials Research Pathway meetings
  - NRC, DOE LWRS, EPRI
  - Discussions on long-term operation of the existing light water fleet
- NRC-DOE-EPRI ANLWR Materials, Chemistry, and Component Integrity (MCCI)
  - Share information, data, and knowledge of materials and component integrity research activities.
  - Enhance common understanding of technical issues impacting safety.
  - Address areas of potential knowledge gaps useful for engineering assessments.

Materials Harvesting

Discuss harvesting opportunities, ongoing projects, and prioritizations (includes SMILE/SMILE 2)



Nickel-Based Alloys

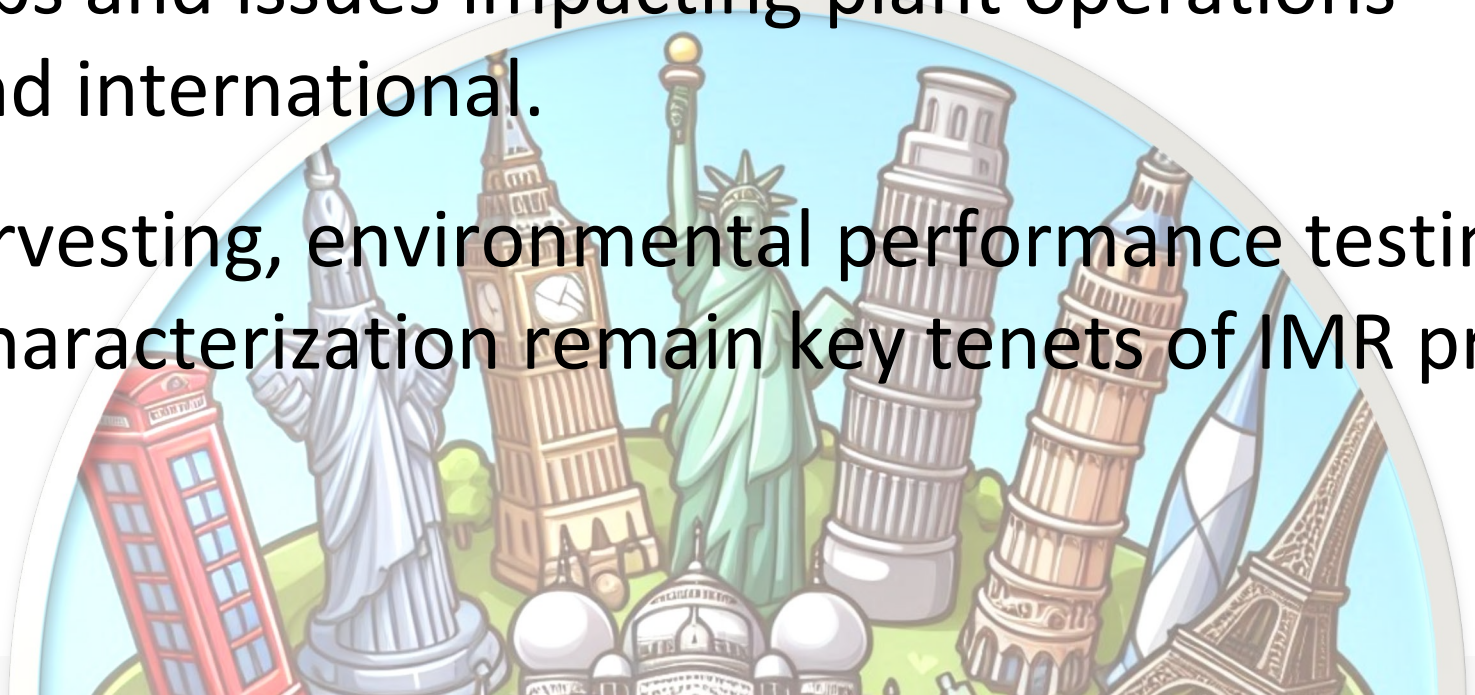
Regular interactions on joint projects related to long-term aging of nickel-based alloys

EPRI Materials Department References

All reports are available to download at no cost on EPRI.com

Summary

- IMR Program continues to provide a focus on materials issues pertinent to the global fleet of water-cooled reactors
- Materials degradation management is supported through fundamental research, with continued review and prioritization of research gaps and issues impacting plant operations – both domestic and international.
- Material harvesting, environmental performance testing, and advanced characterization remain key tenets of IMR project work.



Any Questions?

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