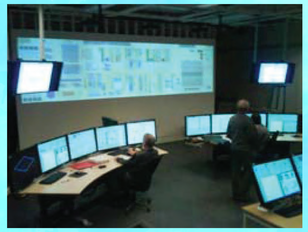
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Office of Nuclear Regulatory Research

Forward-Looking and Long-Term Research in Human and Materials Performance



Halden Human Machine Laboratory

USDA Field Site—Beltsville, Md

Pre-Fabricated Fiber-Reinforced Polymet Concrete Panel

Carbon Steel Piping Showing Corrosion Products Of Microbiologically Induced Corrosion

Forward-Looking Research is identified, as a matter of routine, as long-term research activities supporting potential longer term (within the next few years) regulatory needs. There are several projects in human and materials performance presently underway.

The program to assess **probabilistic pressure boundary safety** is developing a single, modular probabilistic fracture mechanics (PFM) code that can assess the failure probabilities associated with any materials degradation mechanism in any component, material, and geometry combination. In the past, individual PFM codes have been developed in reaction to materials degradation events. The new code will provide estimates of failure frequencies, and will also quantify the uncertainty in the knowledge of those estimates. This feature will permit sensitivity studies to determine which degradation mechanisms generate the most uncertainty.

Several research projects are addressing the anticipated need for regulatory guidance and knowledge in **digital instrumentation and controls** (DI&C). **Sustainability and obsolescence**: Due to rapid changes in software-based systems, the NRC expects that obsolescence of DI&C systems will occur more frequently than in analog systems. Frequent upgrades to hardware and software will introduce new volume and complexity to the regulatory review and inspection process. Also, the potential infiltration of low quality or counterfeit replacement parts is a concern. **Advanced Reactor Instrumentation, Controls, and Diagnostics/Prognostics**: Research is being performed to provide technical information for advanced reactor instrumentation, advanced reactor controls, and advanced diagnostics and prognostics. The goal is to develop the regulatory knowledge and guidance for reviewing the anticipated license applications for the next generation nuclear plant (NGNP). **Emerging Technologies**: This is an ongoing project that assesses the state-of-the-art in digital applications and developments which may be used in reactors in the future. This effort has been helpful in reducing the time it takes for emerging issues to reach a regulatory solution, thus improving regulatory efficiency and effectiveness. **Safety Assessment & Security Assurance of DI&C Systems**: NRC is collaborating with 13 Federal agencies on multiple aspects of DI&C lifecycle. **Harmonizing NRC Guidance with International Standards**: DI&C systems are increasingly using platforms sourced internationally and specifically designed for safety functions. This activity will harmonize guidance used by NRC and in the international community.

The increased use of solid-state and digital technology accentuates the need for the integrity of cable insulation because the low-voltage and low-current applications need high-resolution outputs. The purpose of the research in **cable aging and monitoring** is to identify the instrumentation and control (I&C) cables that have historically failed or degraded, and assess the significance of I&C cable aging in causing plant transients, causing plant trips, or disabling safety systems. The **National Institute of Standards and Technology Cable Testing** program performs fire tests on grouped electrical cables to better understand the fire hazard characteristics. Cable heat release rate and flame spread characteristics are the basic parameters desired. This type of quantitative information will be used to develop more realistic models of cable fires for use in fire PRA analyses. The NRC has entered into an agreement with the Organisation for Economic Cooperation and Development (OECD) and L'institut de Radioprotection et de Sûreté Nucléaire (IRSN) for the **Propagation d'un Incendie pour des Scénarios Multi-locaux Élémentaires** (PRISME) project to develop a set of fire experiments that will provide data related to electrical circuit failures during fires. The tests will be extensively instrumented to characterize the environmental conditions.

The **Valve-Regulated Lead-Acid Battery (VRLA) Service Life** program is being conducted because of industry-expressed interest in use in nuclear power plants. Research is required to verify the capability of VRLA batteries to support nuclear applications, and ensure that battery testing envelops the design, detects declining performance, and identifies early indications of end-of-life conditions. This research will involve assessing the adequacy of the current Institute of Electrical and Electronics Engineers criteria to ensure the capacity and capability of VRLA batteries, as well as the related criteria for battery maintenance and testing practices.

The Organisation for Economic Co-operation and Development/Nuclear Energy Agency **Halden Reactor Project** is a cooperatively funded international research and development project sponsored by 18 countries, including the United States. Halden's research programs address five areas of interest to the NRC: 1) nuclear fuels, 2) nuclear reactor materials performance, 3) human factors, 4) human reliability analysis (HRA), and 5) DI&C systems. Halden's Man, Technology, and Organization research program has numerous projects looking at control rooms of the future and associated technologies. This forward-looking work is expected to provide useful information to support NRC's reviews of control room upgrades and advanced reactor control rooms.

Estimating the likelihood of human error (particularly errors of commission) is extremely difficult, due in part to a lack of consensus in the HRA community regarding modeling approaches and a lack of quality empirical data to calibrate the models. NRC has taken a leading role in the **International HRA Empirical Study**, a project that benchmarks HRA model predictions against operating crew performance data developed by the Halden Reactor Project using their simulator. This project is expected to identify strengths and weaknesses of HRA models currently available for use in nuclear power plant PRAs.

The adequacy of data available for HRA is a concern for the credibility and consistency of human error probability estimates. To address this need, the NRC is developing the **Human Event Repository and Analysis** (HERA) system which will support both HRA and human factors. The objective of HERA is to make empirical and experimental human performance data from commercial nuclear power plants available in a format suitable for HRA.

The NRC's projection of future agency needs for the review and evaluation of environmental transport issues determine the projects in **environmental transport**. **Spatial Analysis and Decision Assistance (SADA)**: The SADA software implements an optimal surface-contamination sampling and survey protocol for guiding the sampling of surface contamination and is extending the protocol to handle subsurface contamination. **Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES)**: This framework enables modeling regulatory actions at complex sites through the use of environmental-pathway models appropriate for the complexity of the site and regulatory action, avoiding the tendency to force the problem to fit an overly restrictive simulation tool. **Long-Term Efficacy of Bioremediation for Uranium-Contaminated Ground Water**: A forward-looking project evaluated the technical basis for engineered in-situ bioremediation to precipitate uranium from ground water plumes. Subsequent licensee needs expanded the research to include experimental and modeling analysis of the behavior of uranium during and after bioremediation as oxygen returns to the system over an extended period of time.

Long-Term Research is research that is not already funded or otherwise being worked on that will provide the fundamental insights and technical information needed to address potential technical issues or identified gaps to support anticipated future (> 5 years) NRC needs. Projects in human and materials performance under this program are in place or planned for fiscal years 2009 and 2010.

FY 2009: A study of existing **integral effects test data for non-light-water reactors** to determine what, if any, new data are likely to be needed. A preparatory study of the **effectiveness of innovative sensors in nuclear facilities**.

FY 2010: A study to determine the **effectiveness of innovative sensor technology in nuclear applications** (continued from FY 2009). A study to identify safety issues associated with potential **nuclear power plant operation to 80 years**. A program to monitor external activities related to the development of **technologies (e.g., scavenging agents) for the capture and cleanup of potential nuclear plant releases** of radioactive material and the demonstration of the effectiveness for a variety of release and meteorological conditions. A review of **lessons-learned regarding the adoption of risk-informed and performance-based fire safety decisionmaking** and the availability of fire frequency databases.

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