

Develop and apply methods for assessing fire safety in nuclear facilities

RES/DRA

The development of risk-informed, performance-based fire standards and regulations requires a sound understanding of fire phenomena and its contribution to overall nuclear power plant (NPP) risk. A fire research program has been developed and is being implemented to provide realistic solutions to complex issues associated with Fire Probabilistic Risk Assessment (PRA) and fire modeling to support risk-informed changes to these standards and regulations. The Office of Nuclear Regulatory Research (RES) is also performing specialized testing to support other NRC program offices.

The staff worked with the National Fire Protection Association (NFPA) to develop a performance-based, risk-informed fire protection standard (NFPA 805) for NPPs. NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," was issued in January 2001 and serves as the basis for the rule, 10 CFR 50.48(c). The NRC-RES and Electric Power Research Institute (EPRI) under a Memorandum of Understanding (MOU) have provided much of the technical basis for this implementation by developing tools critical to performing fire PRA and fire modeling. RES is conducting these activities at the request of a formal Office of Nuclear Reactor Regulation (NRR) User Need request.

In order to address the need for qualified fire PRA practitioners, RES and EPRI have recently conducted a detailed, hands-on fire PRA training course in August 2011 and have another training scheduled for November 2011. This training is based upon the jointly developed document, NUREG/CR-6850 (EPRI 1011989) "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," and will be very similar to the trainings offered by RES and EPRI in 2007, 2008, 2009, and 2010. One notable addition to the 2011 training is a new module on advanced fire modeling. Approximately 180 representatives from NRC (NRR, RES, and the Regions), and industry, as well as from foreign countries attended this concentrated training in 2010. RES and EPRI had previously conducted more general fire PRA workshops in 2005 and 2006, with the detailed training being developed at the request of both internal and external stakeholders who attended the joint workshops.

RES began a joint project in early 2008 with EPRI and National Institute of Standards and Technology (NIST) to provide guidance to users of mathematical fire modeling computer codes for NPP applications. This guidance will help ensure consistent and realistic application of fire modeling tools used in fire PRAs for NFPA 805 license transitions and other licensing and inspection actions. Draft NUREG-1934 (EPRI 1023259), NPP Fire Modeling Application Guide, was submitted for peer review in August 2009 and was issued for public comment in early 2010. Based on the large number of public comments, the report was revised and issued for a second public comment period in August 2011. The draft report is also being used as "textbook" for the Advanced Fire Modeling course being taught as part of the 2011 joint NRC/EPRI NUREG/CR-6850 training. Comments developed from the classroom sessions and the public will be used to revise the document as necessary. The final document is scheduled for release in early 2012.

RES is working jointly with EPRI to develop detailed guidance for performing quantitative human reliability analysis (HRA) for post-fire mitigative human actions modeled in a fire PRA. This guidance builds upon the existing information in NUREG/CR-6850 (EPRI 1011989) and takes into account the ASME/ANS PRA Standard (RA-Sa-2009). Draft NUREG-1921 (EPRI 1019196)

EPRI/NRC-RES Fire Human Reliability Analysis Guidelines was released for public comment in December of 2009. The NUREG is scheduled for release as a final report in December 2011. A module in fire HRA was added to the 2010 NRC-RES/EPRI Fire PRA workshop to provide training on this methodology, and was conducted in the August 2011 training also.

RES is supporting the NRR Circuit Analysis Resolution Program. RES previously performed the testing and provided the technical basis for RIS 2004-03 Bin 2 items. This RIS identified circuit issues to be inspected and other lower risk issues that possibly should be subjected to inspection but which needed additional tests and analyses for final determination. RES provided these additional tests and analyses with the Cable Response to Live Fire (CAROLFIRE) program, which was started in CY 2006 and published as the three-volume NUREG/CR-6931 in April, 2008.

RES is continuing to provide support to the NRR Circuit Analysis Resolution Program by conducting direct current (DC) circuit testing in collaboration with EPRI. This testing began in July 2009 and will be documented as a NUREG/CR report by December 2011. This testing program was requested by NRR based on the results of the limited number of DC circuit tests performed by Duke Energy in 2006. This testing indicated there is a potential for DC circuits to respond differently than alternating current (AC) circuits to the hot short phenomenon as previously thought. Several DC circuits in NPPs are of high risk significance and their unintended spurious operation resulting from fire damaged cable may have a significant impact on the plants' ability of achieving post-fire safe shutdown conditions. The principle purpose of this project is to determine the risk significance of DC circuits by conducting appropriate fire tests. The testing will provide a comparison of DC circuit failure likelihood relative to that of the AC circuits previously tested. RES will provide the results of this testing in a NUREG/CR report.

New, more realistic probability values relevant to circuit analyses will be developed from this AC and DC testing and analysis program. These values will be developed during an expert elicitation and Phenomena Identification and Ranking Table (PIRT) project, sponsored by RES which began late in CY2010. These advancements will be incorporated into the Fire PRA process, helping to reduce the uncertainty of predicting cable failure in fire PRA applications.

In 2010, RES completed an aspect of its support to NRR by assisting in the provision of interim solutions to the existing fire PRA questions in the NFPA 805 frequently asked questions (FAQ) program. EPRI supported RES in this endeavor since it participated in the development of these realistic solutions, given on our available knowledge, by proposing their own solutions and reviewing RES solutions. Fifteen fire PRA questions were posed by industry, and spanned many different aspects of fire PRA. All fire PRA FAQs to date were successfully resolved with new research arising from some of those technical questions. These fire PRA FAQ solutions were consolidated in NUREG/CR-6850 Supplement 1 (EPRI 1019259), which was published in September 2010.

RES also supported NRR by participating in the staff audit of the fire PRAs performed by the two pilot plants transitioning to 10 CFR 50.48(c). In these audits, the staff evaluated the conformance of pilots' fire PRAs to the fire portion of the ASME/ANS PRA Standard. RES has also provided support to NRR by attending earlier observation visits to these two pilot plants, by reviewing technical materials for those plants' transition, and by supporting the resolution to fire PRA frequently-asked-questions (FAQs) program. RES' role in these visits and reviews is to ensure that its technical documents are implemented properly, as well as to collect insights relevant to these technologies. RES continues to support the ongoing FAQ program.

RES issued Revision 2 of R.G. 1.200 in March of 2009. This regulatory guide documented the staff's position on the fire PRA portion of the ASME/ANS PRA Standard and on the NEI Fire PRA Peer Review Guidance. The ASME/ANS PRA standard is a part of the Commission's phased approach to PRA quality (SECY-04-0118), and will support implementation of the risk-informed, performance-based rule endorsing NFPA 805. The fire PRA Standard was originally developed under the auspices of the American Nuclear Society (ANS), but was integrated into the combined ASME/ANS PRA standard. Previously, RES provided substantial support to the Committee for drafting and reviewing the Standard.

RES in collaboration with EPRI has also initiated an update to the EPRI fire events database which was used in the development of NUREG/CR-6850. Data for fires occurring from 2001 to 2009 are being added to the database, and more current, realistic fire ignition frequencies established as identified in a fire NFPA 805 PRA frequently-asked-question (FAQ). RES and EPRI have planned for a joint report in CY2012 on this project. Furthermore, RES is evaluating fire protection metrics on 10CFR50.72/73 reportable fires and on fire protection findings, and issued reports in September 2009, April 2010, September 2010 and April 2011. Reports will be issued every six months to account for new events and findings. In addition to working with EPRI under the current memorandum of understanding (MOU) in order to expand the evaluation to include information regarding trending of long term compensatory measures.

As a part of its "knowledge management" activities, RES has issued a brochure on Fire Protection and Fire Research Knowledge Management (NUREG/CR-0465). RES has also issued a brochure that presents the history of NRC's fire safety research (NUREG/BR-0364), and a brochure that compiles facts and analyses related to the 1975 fire at the Browns Ferry Nuclear (BFN) Power Plant (NUREG/BR-0361). The fire safety research brochure covers the time period (1975-2008) when NRC was transforming fire regulation from a "deterministic" (non-quantitative) system to the present "risk-informed" (more quantitative) system. The BFN brochure preserves the history and impact of the BFN fire on fire regulations to educate future generations of fire safety professionals. The knowledge management brochure shares over 30 years of regulatory and scientific knowledge with our inspectors, licensees, reviewers, and other interested stakeholders, including fire related documents such as NUREGs, inspection procedures, generic letters, and information notices.

RES published NUREG-1924 in May 2010, which documents the history, issues and regulatory footprint and site specific use of electric raceway fire barrier systems (ERFBS) used in NPPs. The reports consolidates documentation regarding all known raceway fire barrier systems including their effectiveness, information regarding the fire endurance testing of the systems, and how the NRC achieved closure for any related open issues. NUREG-1924 is a complement to the GAO report issued in June 2008 titled, "Nuclear Safety – NRC's Oversight of Fire Protection at U.S. Commercial Nuclear Reactor Units Could Be Strengthened, GAO-08-0747."

RES supported the Office of Nuclear Materials Safety and Safeguards (NMSS) in several PRA and risk-informed studies, and in testing related to Fuel Cycle Facilities (FCF) and Transportation applications. These areas include:

- Risk-informed study of red oil explosions in the Mixed Oxide (MOX) Fuel Fabrication Facility (FFF) currently being constructed (letter report published on August 2009)
- Insights from analyses of events and inspection reports to support the development of Significant Determination Process Tools for the Fuel Cycle Oversight Process
- Support to NMSS in the development of the Integrated Safety Analysis (currently used for FCF) and Probabilistic Risk Assessment (currently used for NPPs)

- comparison paper (Completed in December 2010), and
- Spent fuel cask seal performance testing of transportation packages in beyond-design-basis fires to assess the possibility of environmental release of radioactive materials

Future work being planned includes risk assessment of cable fires and spurious operations in FCF and continued support to Fuel Cycle Oversight Process SDP Tools Development.

Selected Major Milestones and Schedules				
Major Milestones	Original Target Date	Revised Date	Completion Date	NRC Responsibility
Publish report on fire risk requantification, NUREG/CR-6850	September 2005		September 2005	RES/DRASP
Issue Final fire model verification and validation report NUREG-1824	January 2007		May 2007	RES/DRASP
Publish final CAROLFIRE NUREG/CR reports	March 2008	April 2008	April 2008	RES/DRA
Issue fire model users guide	February 2009	February 2012		RES/DRA
Issue fire portion of R.G. 1.200, rev 2.	March 2009		March 2009	RES/DRA
Risk Assessment of Red Oil Explosions in the Mixed Oxide Fuel Fabrication Facility	August 2009		August 2009	RES/DRA
Issue final NUREG/CR on DC circuit testing results	June 2010	December 2011		RES/DRA
Publish NUREG/CR-6850 Supplement 1 on Fire PRA FAQs	September 2010		September 2010	RES/DRA
Incorporate CAROLFIRE and DC circuit results into Fire PRA process	December 2010	December 2012		RES/DRA
Issue Electric Raceway Fire Barrier System NUREG	December 2010		May 2010	RES/DRA
Conduct fourth RES/EPRI detailed fire PRA course (2 sessions)	October 2010		October 2010	RES/DRA
Issue NUREG on Fire HRA	December 2010	December 2011		RES/DRA
Letter Report on Spent Fuel Cask Seal Performance Testing of Transportation Packages in beyond-design-basis fires	February 2011	November 2011		RES/DRA
Letter Report on Insights from Analyses of Events and Inspection Reports on Determining Risk Significance of Inspection Findings for Fuel Cycle Oversight Process	November 2011			RES/DRA
Conduct fifth RES/EPRI detailed fire PRA course (2 sessions)	November 2011			RES/DRA

Support NFPA 805 implementation (e.g. Unreviewed Analysis Methods)	Ongoing			RES/DRA
Bi-Annual Metrics Methodology Report evaluating fire protection metrics on 10CFR50.72/73 reportable fires and on fire protection findings	April / September 2011			RES/DRA