



U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Fire Research Activities at the Nuclear Regulatory Commission

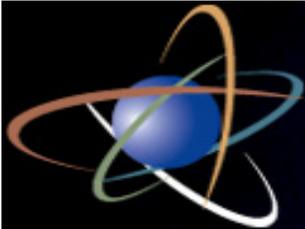
Department Of Energy 2008 Annual Fire
Protection Workshop



**Office of Nuclear
Regulatory Research**



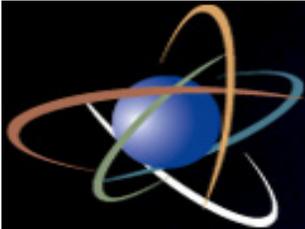
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Major Program Areas

- Fire Modeling for NPP Applications
- Fire PRA
- Operator Manual Actions
- Fire HRA
- Cable Response to Live Fire (CAROLFIRE)
- Fire Research Knowledge Base
- Collaboration with EPRI, NIST, EdF, U of MD
- Provide a overview on each major program

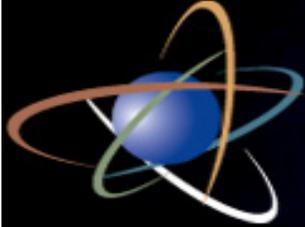




Fire Modeling Program Overview

- Four step process
- NUREG-1805 Introduction to Fire Dynamics in NPP applications
- NUREG-1824 Fire Model Verification & Validation (V&V)
- Fire Model Phenomena Identification Ranking Table (PIRT)
- Fire Model Users Guide for NPP applications
- Future Improvements

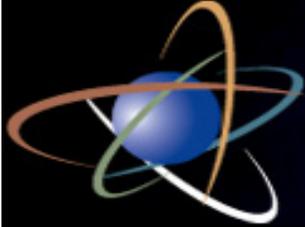




Fire Dynamic Tools (FDTs)

- NUREG-1805 “Fire Dynamic Tools (FDTs) Quantitative Fire Hazard Analysis Methods for the U.S. NRC Fire Protection Inspection Program” December 2004
- Introduction to Fire Dynamics for NRC Inspectors
- Specifically created for nuclear power plant fire modeling environment
- Contains Fire Dynamic Calculation Spreadsheets
- Currently developing additional spreadsheets





Fire Model V&V NUREG-1824/EPRI 1011999

- “Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications” May, 2007
- NFPA 805: “Fire models shall be verified and validated.”
Establish Regulatory Confidence
- Comparing 5 different models with experimental data to determine predictive capabilities
 - 2 Hand Calculation, 2 Zone Models, 1 CFD model
- Follow International Standard ASTM E 1355
- Partners: NIST, EPRI, EdF
- Dr. McGrattan (NIST) will provide detailed presentation





Fire Modeling PIRT

- Phenomena Identification and Ranking Table (PIRT)
- Structured expert elicitation process
- Focus on the dominant fire phenomena in important NPP fire scenarios
- Rank the phenomena in terms of importance and level of knowledge
- Use to prioritize future research
- Meetings completed Summer 2007
- Report issued early 2008

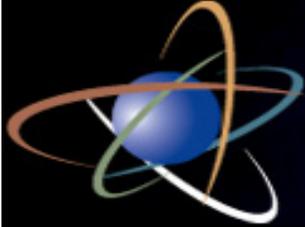




Fire Model User's Guide

- Provide expert insight
- Specific nuclear power plant fire modeling issues
- Provide guidance for model inputs and interpretation of model outputs
- Characterize the uncertainty of model outputs
- Draft for comment in December 2008
- Final report to be issued in 2009





Fire PRA: Implementation of NUREG/CR-6850

- NUREG/CR-6850 (EPRI 1011989) being used extensively in NFPA 805 pilot plant transitions
- RES/EPRI addressed implementation issues in NFPA 805 pilot program
 - RES and EPRI developed resolutions, adopted by NRR and industry, to several FAQs related to ignition source counting and fire frequency
 - Other FAQ resolutions in process by RES/EPRI team
- Fire PRA application beyond NUREG/CR-6850 guidance in several areas
 - Multiple Spurious Operations (MSOs) as required by Fire PRA Standard
 - Extent of instrumentation due to Standard implementation
 - Pilot experience valuable to fire PRA in these areas
- NUREG/CR-6850 remains best available overall fire PRA methodology
 - Refinements in knowledge expected from applications beyond 2005 publication





Fire PRA Training

RES/EPRI conducted two detailed fire PRA training courses in July and August of 2007 in Palo Alto

- Nearly 100 attendees; common feedback that course was highly valuable – also, exercises beneficial
- Modules conducted in fire, electric circuitry, and PRA
- RES/EPRI will be conducting the same courses two more times this fall in the Baltimore/Washington area.





Future Fire PRA Activities

- RES leading agency position on Fire PRA Standard and R.G. 1.200
 - General agreement with Fire PRA Standard
 - Review and endorse Fire PRA Standard
 - Review and endorse Industry Peer Review Guidance
- RES continued support to NRR for 805 pilot transition
- RES expects to conduct fire PRA training in 2008
- RES Projects under consideration
 - Long term HRA data collection effort to support fire PRA
 - Re-analysis of spurious actuation probabilities due to new data from CAROLFIRE, et al.

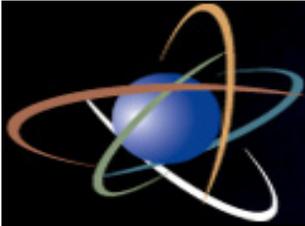




Operator Manual Actions NUREG - 1852

- Provides criteria and associated technical basis for evaluating the **feasibility** and **reliability** of post-fire OMAs implemented in NPPS
- Key criteria cited include:
 - Need for time-authenticated demonstrations of the manual actions
 - Adequate time available to complete the actions
- Final NUREG issued October 2007





Quantitative HRA Guidance

- Purpose: To develop detailed guidance for the performance of post-fire HRA for at power operations
- Extension of the work done in NUREG/CR-6850
- Ongoing joint RES/EPRI fire HRA program to produce quantitative approach tailored to fire
 - Enhance reproducibility and defensibility of analyses



CAROLFIRE Project Objectives

- Two areas of investigation:
 - Resolution of the 'Bin 2' circuit configurations:
 - Regulatory Issue Summary 2004-03, Rev 1 - "Risk-informed Approach For Post-Fire Safe-Shutdown Circuit Inspections"
 - Documents findings from a February 2004 NRC facilitated workshop puts cable/circuit configurations in one of three bins:
 - Bin 1: Configurations that are most likely to fail (e.g., leading to spurious operation)
 - **Bin 2: Configurations that need more research**
 - Bin 3: Configurations that are unlikely or least likely to fail (e.g., leading to spurious operation).
 - Fire Modeling Improvement
 - To reduce uncertainty associated with predictions of fire-induced cable damage





The 'Bin 2' Issues

- The Bin 2 issues:
 - A. Spurious actuations caused by Inter-cable shorting for thermoset cables
 - B. Spurious actuations caused by Inter-cable shorting between thermoplastic and thermoset cables
 - C. Concurrent spurious actuations associated with failures impacting three or more cables
 - D. Multiple spurious operations in control circuits with properly sized control power transformers (CPTs)
 - E. Fire-induced hot shorts lasting more than 20 minutes
- CAROLFIRE's goal:
 - Assess Bin 2 items A-E through experiments
 - Provide data to NRR for resolution





Cable Damage Fire Model

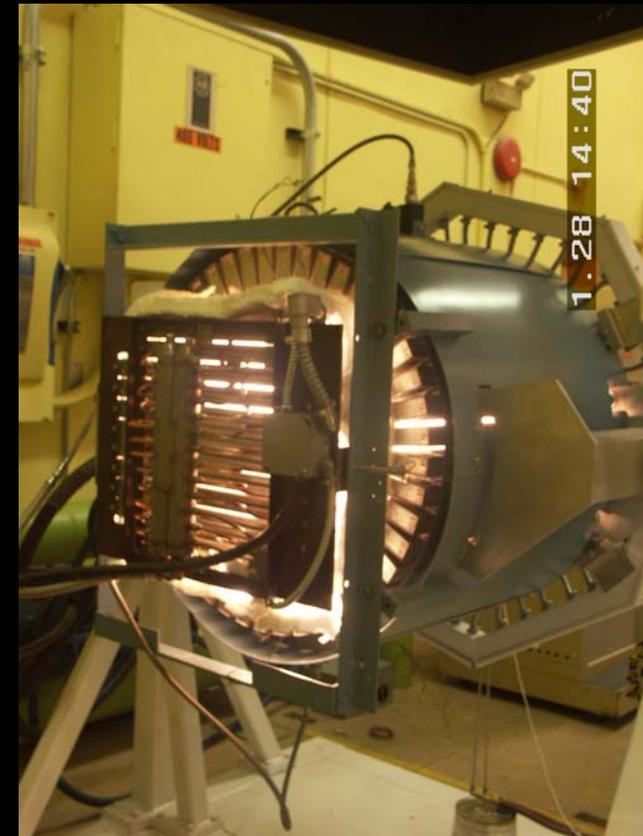
- RES has completed separate efforts for Verification and Validation of fire models (NUREG-1824)
 - CAROLFIRE compliments these efforts
- Data needed to:
 - Support improved cable thermal response and electrical failure fire modeling tools
 - Reduce modeling uncertainties
- Collaborative partners at NIST and UMd are leading the modeling efforts
- SNL did the testing
 - Extensive efforts to gather data that correlates thermal response to electrical response
 - Range of exposure conditions from simple to complex
 - Range of cable products
- Dr. McGrattan (NIST) will provide detailed presentation





Small Scale Tests

- **Penlight** heats target cables via grey-body radiation from a heated shroud
- Well controlled, well instrumented tests
- Allows for many experiments in a short time
- Thermal response and failure for single cables and small cable bundles (up to six cables)
- Cable trays, air drops, conduits

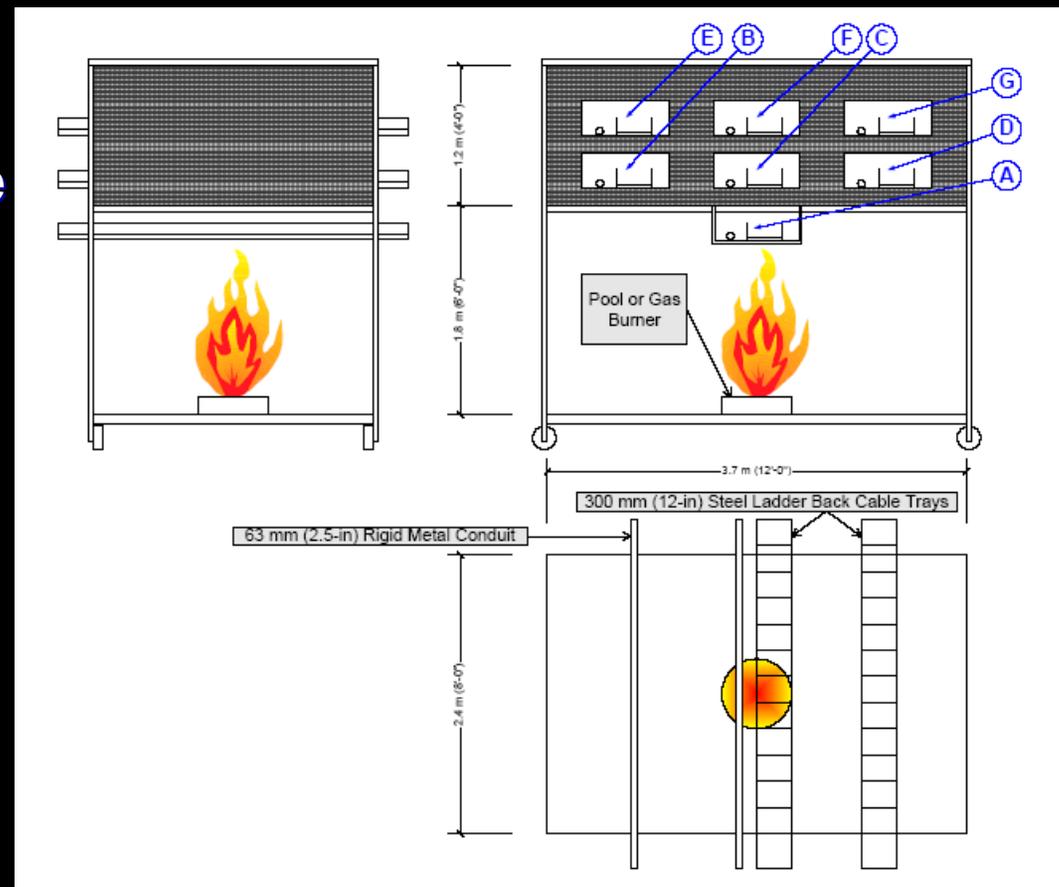




Intermediate-Scale Tests

Layout of the intermediate-scale test structure.

Structure was located within a larger test facility.





Intermediate-Scale Tests

- Less controlled, but a more realistic testing scale
- Hood is roughly the size of a typical ASTM E603 type room fire test facility (more open to allow for ready access)
- Propene (Propylene) burner fire source (200 kW typical)
- Cables in trays, conduits and air drop

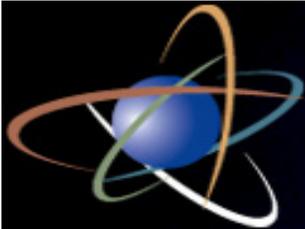




Instrumentation

- Cable thermal response (surface and interior)
- Raceway surface temperature
- Exposure environment
- Cable electrical Response via two monitoring systems
 - The SNL Insulation Resistance Measurement System
 - Surrogate Circuit Diagnostic Units (circuit simulators)





CAROLFIRE Status

- CAROLFIRE addressed need areas
 - Resolution of deferred spurious actuation circuit configurations
 - Improving the fire modeling of cable response and failure –
 - Status:
 - All testing has been completed
 - 3 Volume report in publication process:

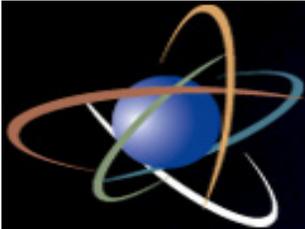




Fire Research/Regulation Knowledge Base

- Over 30 years of information
- Two Main Areas:
 - Regulations
 - Research
- Older reports were difficult to recover
 - Adding to Electronic Data Base
- Plan to Update & Expand annually





Future Work-Cable Testing

- Large stock of representative cable stored at NIST
- Data on HRR, flame spread for different cable types, configuration
- Validation data for new CAROLFIRE/NIST cable failure models
- Tests to be run in 2008/9





International Projects

- OECD Fire Events Data Base
- Fire Modeling
 - OECD PRISME
 - Int. Collaborative Fire Model Project
- Exploring High Energy Arcing Faults Project

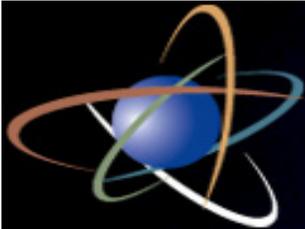




Other Projects Under Consideration

- Additional Fire Model Validation data?
- Additional AC Circuit data?
- DC Circuit performance?
- Digital I&C Fiber Optics Cable?





Conclusion

- NRC actively engaged in Fire Research
 - Research Products often support the broader Fire Protection Engineering Community
- NRC always willing to partner with other Agencies/Organizations to support similar safety missions.

- Questions?

