U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

BACKGROUNDER

Office of Public Affairs
Phone: 301-415-8200
Email: opa@nrc.gov

Fire Protection for Nuclear Power Plants

Background

On March 22, 1975, a fire at the Browns Ferry Nuclear Power Plant, operating near Decatur, Ala., fundamentally changed the concept of fire protection and associated regulatory requirements for U.S. nuclear power plants. Plant workers were fixing leaks in the cable spreading room outside the reactor building. The workers used a candle to test seals for air leaks into the reactor building. The polyurethane foam seal, however, was not fire-rated. The flame from the candle ignited both the seal and the electrical cables that passed through it.

By the time firefighters extinguished the fire, it had burned for almost seven hours. More than 1600 electrical cables were affected, 628 of which were important to plant safety. The fire damaged electrical power, control systems, and instrumentation cables and impaired cooling systems for the reactor. Operators could not monitor the plant normally and had to perform emergency repairs on systems needed to shut the reactor down safely.

Investigations after the fire revealed deficiencies in the design of fire protection features at nuclear power plants and in the plant procedures for responding to a fire. Fire insurance companies, normally concerned with occupant safety and property protection, did not sufficiently consider nuclear safety issues. A fire in certain locations at a nuclear plant could cause redundant safety systems and components to fail, making it difficult to shut the reactor down safely.

Since the Browns Ferry incident, no fire at a U.S. commercial nuclear power plants has affected the safe operation of a reactor.

Fire Protection Regulations

After the Browns Ferry fire, the Nuclear Regulatory Commission revised its fire protection regulations to reduce the chances of a fire starting and the consequences should a fire occur. The regulations' bottom line is that each licensee must maintain the ability to shut down the reactor safely in the event of a fire.

The objectives of NRC's fire protection regulations are to:

(1) Minimize the potential for fires and explosions;
(2) Rapidly detect, control, and extinguish fires that do occur; and
(3) Ensure that operators can shut down the reactor safely despite a fire, and minimize the risk of significant radioactive releases to the environment.

Nuclear power plants today use multiple layers of fire protection features to keep fires from damaging plant safety systems. Some of these features include fire barriers such as insulation, fire detection systems, and fire suppression systems (such as sprinklers). If a required element of fire protection is not available, the licensee must compensate for it, often by placing dedicated personnel on a continuous fire watch. The NRC regularly inspects licensees' means of achieving and maintaining the reactor's safe shutdown capability in the event of a fire.
Today, licensees have two alternative regulatory approaches to manage their fire risk:

- **Deterministic fire protection** requirements seek to establish safety margins through the post-fire survival of the systems needed to shut down the reactor. These requirements, based on a set of postulated serious fires, were developed before the staff or the industry had the benefit of probabilistic risk assessments (PRAs) for fires and other recent technical advances. For example, we now do computer simulations of how fires spread. The NRC lists these requirements in 10 CFR 50.48(b) and Appendix R of 10 CFR 50.
- **Risk-informed fire protection** requirements consider risk insights as well as other factors to establish requirements that better focus attention on design and operational issues according to their importance to public health and safety. Performance-based regulations rely on a required outcome rather than requiring a specific process or technique to achieve the outcome. The NRC lists these requirements in 10 CFR 50.48(c).

The NRC approved the risk-informed and performance-based alternative regulation, 10 CFR 50.48(c) in July 2004, allowing licensees to focus their fire protection activities on the areas of greatest risk. The rule permits licensees to use the fire protection requirements contained in the National Fire Protection Association (NFPA) Standard 805, "Performance-Based Standard for Fire Protection for Light-Water Reactor Electric Generating Plants, 2001 Edition," with some exceptions. In order to help licensees making the transition from their current fire protection program to one based on NFPA 805, NRC staff issued Regulatory Guide 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants." The NRC guide also endorses the related Nuclear Energy Institute document NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program Under 10 CFR 50.48(c)" because, it provides methods acceptable to the NRC for implementing NFPA 805 and complies with regulations and regulatory positions outlined in the regulatory guide.

Current Fire Protection Activities for Operating Reactors

The NRC continues to oversee fire protection at nuclear power plants through inspection and oversight. In 2000, the NRC implemented the Reactor Oversight Process (ROP), which includes systematic quarterly, annual, and triennial fire protection inspections. The NRC evaluates fire protection findings through the significance determination process (SDP) during inspections. The process involves a series of qualitative and quantitative analyses for estimating the significance related to licensee performance deficiencies in meeting fire protection objectives. This process is based on methods in the NRC report, "Fire Dynamics Tools (FDTs): Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program" (NUREG-1805, Final Report).

In addition, the NRC works with international codes and standards organizations, nuclear industry representatives, professional societies and research organizations to address fire protection activities.

Alternate Fire Protection Rule Implementation The rule, 10 CFR 50.48(c), allows licensees to focus their fire protection activities on the areas of greatest risk. Two nuclear stations, Oconee and Shearon Harris, volunteered to be pilot plants for the transition to the new rule and NFPA 805. The staff kicked off

a pilot implementation in August 2005. To aid plants in their transition to the new rule, NRC staff and industry participated in pilot observation plant visits where they developed a process to capture the lessons learned and frequently asked questions and prepare staff responses to help remaining plants to complete this transition. By June 2008, operators of 47 reactors had sent letters of intent indicating their commitment to adopt NFPA 805.

Fire-Induced Circuit Faults In the past, inspectors discovered electrical circuits at particular plants that, if damaged by fire, could prevent critical equipment from working properly. The Commission directed the staff to work with stakeholders to develop a solution to address the circuit issue. The NRC is working with regional inspectors and industry representatives to clarify regulatory requirements for analyzing circuits needed to shut down a reactor after a fire.

Fire Barriers Fire barriers are fire-resistant materials that separate redundant series of fire safety equipment located within a fire area. Some of these fire barriers designed for nuclear plants are: Thermo-lag, Hemyc/MT, Kaowool and FP-60. Full-scale fire tests performed by the NRC revealed that materials used to protect cables did not perform as designed. In one test for Hemyc, it was found that the outer covering of the barrier could shrink during a fire, opening joints in the material and potentially allowing the fire to damage cables inside. The NRC contacted the licensees of the 11 plants using Hemyc and informed them about the test results, so the licensees could take appropriate compensatory actions. Subsequently, the NRC issued Generic Letter 2006-03 in April 2006 to ensure that the affected licensees would evaluate all fire barriers at their plants and take permanent corrective actions. All licensees have provided the information requested by the generic letter about the adequacy of their Hemyc and other fire barriers installed at their plants. The NRC has reviewed the responses, closed out the generic letter for all plants and considers these fire barrier issues have been addressed.

Post-Fire Operator Manual Actions Licensees are required to protect one set of plant equipment necessary to shut down the reactor safely using a combination of physical separation, barriers, and methods to detect and control or extinguish fires. Operator manual actions (OMAs), documented in plant procedures, can be used to recover other safe shutdown equipment that could be damaged during a fire. In some cases, OMAs were inappropriately used in place of fire protection features for one set of safe shutdown equipment. The agency provides more details of its expectations regarding OMAs in Regulatory Issue Summary RIS-06-10, “Regulatory Expectations with Appendix R Paragraph III.G.2 Operator Manual Actions.”

Source Documents

Documents related to fire protection are available on the NRC’s Web site at: http://www.nrc.gov/reactors/operating/ops-experience/fire-protection/regs-guides-comm.html. The NRC’s regulations for nuclear power plants can be found in Title 10 of the *Code of Federal Regulations* (10 CFR), available on the NRC’s Web site. Fire protection regulations are detailed in Section 50.48 of 10 CFR and Appendices A and R to Part 50.

Involved Industry Organizations

National Fire Protection Association (NFPA)
Nuclear Energy Institute (NEI)
Institute of Electrical and Electronics Engineers, Inc. (IEEE)
Electric Power Research Institute (EPRI)

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