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Fire Protection for Nuclear Power Plants

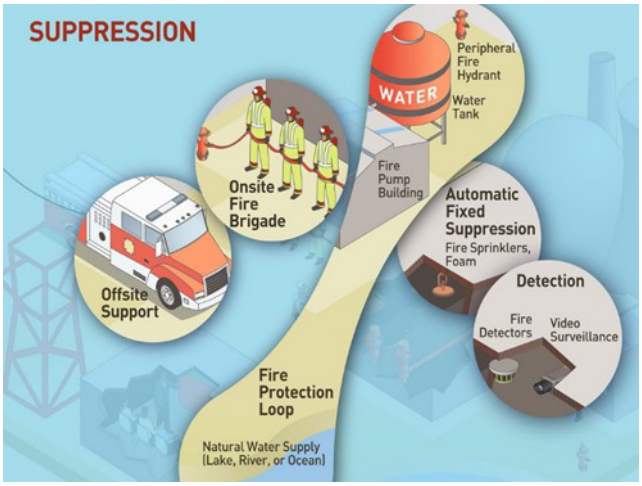
Background

The March 22, 1975, fire at the Browns Ferry Nuclear Power Plant (near Decatur, Ala.) fundamentally changed how the NRC dealt with fire protection at U.S. nuclear power plants. Plant workers accidentally started the fire when checking fire barrier penetration seals for leaks in the room where electric cables entered the reactor building. The workers used a lit candle to check for air leaks. An air leak caused the candle flame to ignite both seal material and the cables passing through it.

Firefighters extinguished the fire almost seven hours later. More than 1,600 electrical cables were affected, 628 of which were important to plant safety. The fire damaged cables for power, control systems and instrumentation, affecting reactor safety systems. The fire-damaged cables prevented operators from monitoring the plant normally. Operators had to perform emergency repairs on fire-affected systems in order to shut the reactor down safely.

Investigations after the fire revealed shortcomings in both the plant's fire protection designs and its procedures for responding to a fire. The event demonstrated that a fire in certain locations at a nuclear plant could damage redundant safety systems and components, making it difficult to shut the reactor down safely.

Fire Protection Regulations



Today, the NRC's fire protection regulations reasonably ensure a reactor can safely shut down in the event of a fire by:

- Minimizing the potential for fires and explosions;
- Rapidly detecting, controlling and extinguishing fires that do occur; and
- Ensuring that plant operators have redundant shutdown equipment available despite a fire, minimizing the risk of significant radioactive releases to the environment.

Nuclear power plants use multiple layers of fire protection for their safety systems. These layers include fire barriers (such as insulation) and fire detection/suppression systems (such as smoke detectors

and sprinklers). Every plant must have a fire protection plan outlining the fire protection program, installed fire protection systems, and the means to assure the reactor can be safely shutdown in the event of a fire. The NRC lists these requirements in 10 CFR Part 50.48(a). The NRC regularly inspects how plants achieve and maintain the reactor's safe shutdown capability in the event of a fire.

Today, nuclear plants have two approaches for managing fire safety:

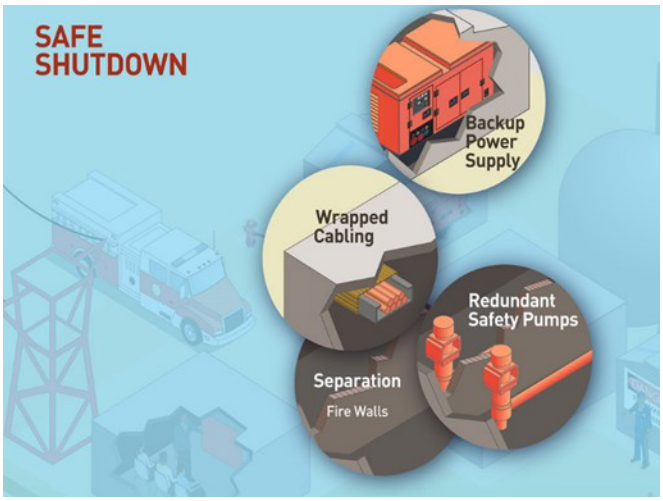
- **Deterministic fire protection** ensures reactor shutdown systems will survive an assumed serious fire. The NRC developed this approach when the best fire risk tools available to staff and the industry looked at an entire system. The NRC lists deterministic requirements in 10 CFR 50.48(b) and Appendix R of 10 CFR Part 50. Regulatory Guide 1.189 provides plants an acceptable approach to meeting these requirements.
- **Risk-informed, performance-based fire protection** considers risk insights down to the individual component level, as well as other factors, to better focus attention and resources on design and operational issues according to their safety importance. This approach relies on a required outcome rather than requiring a specific process or technique to achieve that outcome. The NRC lists these requirements in 10 CFR 50.48(c).

The NRC approved the risk-informed and performance-based fire protection rule in July 2004. The regulation incorporates National Fire Protection Association (NFPA) Standard 805, with some exceptions. NRC staff issued Regulatory Guide 1.205 to help licensees move to an NFPA 805-based fire protection program. The NRC guide also endorses the Nuclear Energy Institute's NEI 04-02 document, because its methods acceptably implement NFPA 805 and comply with the regulatory guide. The staff issued Revision 2 to RG 1.205 in May 2021.

The NRC first approved risk-informed fire protection for the Shearon Harris plant in North Carolina in June 2010. The agency has approved 26 additional NFPA 805-based programs since then, with no additional plants expected to apply for transition to the risk-informed standard.

Significant Fire Protection Issues for Operating Reactors

The NRC oversees nuclear power plant fire protection through the Reactor Oversight Process. This includes routine fire protection inspections once a quarter, as well as more intensive inspections once a year and once every three years. The NRC analyzes these findings to determine where a plant can improve its fire protection performance.



Fire Barrier Testing: These fire-resistant materials separate redundant series of fire safety equipment located within a fire area. Nuclear plant fire barriers include: Thermo-lag,

Hemyc/MT, Kaowool and FP-60. The NRC tested these materials in full-scale fires; the materials used to protect cables did not perform as designed. One Hemyc test found the barrier's outer covering could shrink during a fire, opening joints in the material and potentially allowing the fire to damage cables inside. The NRC contacted 11 plants using Hemyc so the licensees could take appropriate compensatory actions. The NRC's Generic Letter 2006-03 asked the affected plants several questions requiring both evaluation of all their fire barriers and permanent corrective actions. All the plants' responses described the adequacy of their Hemyc and other fire barriers installed at their plants. The NRC's review of the responses concluded these fire barrier issues have been accounted for, closing out the generic letter.

Post-Fire Operator Manual Actions: Plants must protect at least one set of plant safe shutdown equipment from fires using a combination of physical separation, barriers, and methods to detect and control or extinguish fires. Plant procedures can list operator manual actions to recover other safe shutdown equipment that could be damaged during a fire. In some cases, however, plants inappropriately substituted manual actions for fire protection features on one set of safe shutdown equipment. The agency clarified its expectations on manual actions in Regulatory Issue Summary RIS-2006-10.

Fire Protection for New Reactors

The NRC ensures fire safety at new reactors by applying lessons from currently licensed reactors. In Regulatory Guide 1.189, new reactor design fire protection criteria exceed current standards, as approved by the Commission, by assuming that a fire in any one area will disable all the equipment there. The agency's draft proposed Part 53 rulemaking, "Risk-Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors," includes fire protection guidance for both light-water cooled and non-light-water reactors. Both Part 53 and the ongoing advanced reactor content of application project and the technology-inclusive content of application project will continue developing fire protection guidance for future applications, in accordance with the Commission-approved enhanced criteria for new reactor designs.

Source Documents

More information on fire protection is available on the NRC's website . The NRC's regulations for nuclear power plants can be found in Title 10 of the Code of Federal Regulations . 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
Nuclear Energy Institute
Institute of Electrical and Electronics Engineers, Inc.
Electric Power Research Institute

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