

### Summary

Fire poses significant risk to nuclear power plant safety. The Nuclear Regulatory Commission (NRC) estimates that the risk of reactor meltdown from fire hazards is roughly equal to the meltdown risk from *all* other hazards combined—even assuming that plants comply with fire protection regulations, which many do not.<sup>1</sup>

Because of this risk, the NRC established a set of fire safety regulations for nuclear plants in 1980 and an alternate set in 2004. **However, today—more than 30 years after those regulations went into effect—nearly half of U.S. operating nuclear reactors do not comply with either set of regulations.** (See list at end of report.)

Over those 30 years, the NRC has failed to enforce compliance with these regulations, and today continues its practice of giving plant owners extensions to come into compliance, despite the repeated failure of plants to do so in the past. Since 1995 there have been over 150 fires at U.S. nuclear plants.<sup>2</sup> Although the NRC has deemed almost all of them as minor, the potential consequences of a reactor meltdown and release of radioactivity to the environment—the human health costs, economic costs, and evacuation of large areas around the reactor—are too high for such lack of enforcement to continue.

The NRC is literally playing with fire, and with the safety of millions of citizens who live near these plants.

### Fire Safety and the 1980 Fire Protection Regulations

Nuclear power plant safety relies on redundancy and defense-in-depth: When a pump fails, a backup pump takes over; if a pipe breaks, an independent pipe is available. However, if primary and backup systems can both be disabled by a common cause, this approach to safety is ineffective.

A March 1975 fire at the Browns Ferry nuclear plant in Alabama dramatically illustrated this problem. Because of the plant's layout, the fire was able to destroy electric

### Key Issues

- The NRC estimates that the risk of reactor meltdown from fire hazards is roughly equal to the meltdown risk from all other hazards combined.
- The NRC created fire regulations in 1980 and 2004, yet today nearly half of U.S. nuclear reactors do not comply with either the 1980 or 2004 fire regulations.
- Only one reactor (Shearon Harris in NC) has come into compliance with the 2004 regulations, nearly a decade after the NRC created them in response to industry complaints about difficulties and costs of complying with the 1980 regulations.
- Many plants rely for fire safety on manual actions that have not been approved by the NRC.
- Many plants use interim compensatory measures for long periods of time—years in some cases—in lieu of repairing safety systems or retrofitting the plant as regulations require.
- Many plants continue to use insulating material on electric cables that does not meet the requirements of the 1980 fire regulations, rather than replacing these materials, or applying for formal exemptions and using approved compensatory measures.
- The NRC can fine plant owners up to \$140,000 per day per violation to induce them to take the steps needed to comply with fire regulations, but rarely uses this enforcement option.

cables for both primary and backup safety systems while damaging control systems and instrumentation cables, thereby knocking out all of the emergency cooling system pumps for Unit 1's reactor core. With no pumps to cool the reactor, water in the Unit 1 reactor boiled off and dropped nearly 13 feet—to within four feet of uncovering the reactor core. Emergency repairs and 15 hours of manual actions by plant workers finally restored the cooling systems and prevented a core meltdown.



*Burning insulation and sealant around electric cables at Browns Ferry in 1975. The fire started in a room located directly beneath the control rooms for the Unit 1 and 2 reactors. The cables connected controls and instruments in the control rooms with equipment throughout the plant.*

In response to this accident, the NRC developed fire regulations in 1980 that were intended to configure nuclear plants in ways to avoid problems like those at Browns Ferry. These regulations, referred to as *Appendix R*,<sup>3</sup> require reactors to have fire walls, automatic fire detection and suppression systems (e.g., water sprinklers or carbon dioxide discharges), and separation or insulation of electrical cables for primary safety systems and their backups. The goal is to keep a single fire from knocking out redundant systems of electrical cables, equipment, and emergency systems needed to safely shut down a nuclear reactor. Cables can either be physically separated (e.g., by keeping cables at least 20 feet apart) or if they are closer together one or both cables can be wrapped in a fire retardant material designed to protect against fire for one to three hours, depending on what other safety features are installed.

One concern is that fires can burn the insulation off cables allowing contact between the bare metal of adjacent cables. This can result in a short-circuit that causes equipment to malfunction, or, if an energized wire touches a previously de-energized wire, can cause equipment to run that is not supposed to be running, such as erroneously opening or closing a valve. The latter is called a *spurious actuation* or *spurious hot short*. Studies show that some situations can lead to multiple spurious actuations occurring simultaneously or in rapid succession.

The 1980 regulations require owners to consider discrete areas of their plant, postulate a fire in each area, and show that sufficient equipment or cables outside that area would survive to adequately cool the reactor. The postulated fire is assumed to damage all equipment and cables within a single area. The goal is to increase defense-in-depth at plants based on passive methods and measures that rely on automatic systems rather than requiring human interventions. A 2008 report by the Government Accountability Office (GAO) quotes NRC officials as saying “the agency prefers passive fire protection, such as fire barriers—including fire wraps—because such protection is more reliable than other forms of fire protection, for example, human actions for fire protection.”<sup>4</sup>

Yet, since 1980, many plants have not fully complied with these regulations and NRC has not forced them to do so.

## The 2004 Fire Protection Regulations

In 2004, the NRC added a second set of fire protection regulations, called the *NFPA 805 option*.<sup>5</sup> The 1980 regulations prescribe clear rules that apply to all plants. Under the NFPA 805 option, plant owners would instead use plant-specific information, such as the amount of combustible material in different areas of the plant and what fire detection and suppression systems are available, to conduct risk analyses. The risk analyses estimate how long it would take to detect and extinguish a fire in each area, what equipment would be disabled by the fire, and whether sufficient equipment remains intact to cool the reactor core. The goal is to determine what protection is needed in specific plant areas and reduce the costs of the one-size-fits-all approach of the 1980 regulations without reducing protection.

Studies beginning in the early 1990s showed that several types of material used as insulation for electric cables (called *fire wraps*) do not meet the requirements of the 1980 fire regulations. In particular, during tests some fire wraps intended to insulate for one or three hours failed in less time. In response, to compensate for the deficiencies in the fire wraps, many plant owners used measures that the NRC had not approved or authorized. These fixes relied largely on so-called *manual actions*. For example, if a fire damages cables for both primary and backup systems, the plant relies on workers running throughout the plant to manually turn on pumps, close valves, and take whatever

other steps are needed to compensate for the damaged cables.

NRC regulations permit manual actions, but only after they have been formally reviewed and approved by the NRC on a case-by-case basis. The NRC then grants the plant an exemption<sup>6</sup> from a specific fire regulation as long as the plant implements the approved manual action.

When the NRC began to crack down on the use of unapproved manual actions that reactor owners were using to compensate for deficient fire wraps, the nuclear industry threatened to submit hundreds if not thousands of exemption requests for all the unapproved manual actions. In response, the NRC developed the 2004 fire regulations to prevent being flooded with exemption requests.

The 2004 regulations still require plant owners to assess each area in a plant to ensure protection against fires. But rather than providing prescriptive measures like the 1980 regulations, the 2004 regulations consider relative timelines based on computer modeling of each plant. One timeline describes how long it would take a fire to damage important equipment based on the amount of combustible materials in that area. The other timeline describes how long a fire would burn in that area based on the location of fire detection sensors and fire suppression systems (e.g., sprinklers, CO<sub>2</sub>, Halon, or manual fire brigade with hoses). The plant owner complies with the regulations as long as postulated fires in all areas would be extinguished before damaging enough equipment to threaten systems needed to safely shut down the reactor. The 2004 regulations also codify when and under what conditions manual actions are acceptable.

While this kind of risk-informed approach offers advantages, it also creates concerns. Modeling fires accurately is challenging on many levels. Questions exist about the reliability of the risk-assessment methodology due to the complexity of such assessments, a lack of real-world data on reactor fires, and a lack of people with experience and expertise in fire modeling, risk assessment, and plant-specific issues. There is also concern about the cost of conducting the analysis, which can be millions of dollars. However, the analysis is likely to reduce the number of required plant modifications compared to the 1980 regulations, which would reduce costs.<sup>7</sup>

When it created the 2004 regulations, the NRC required plants to comply with either the 1980 or 2004 regulations.

In response, the owners of 51 reactors informed the NRC of their intent to comply with the 2004 regulations. These owners implicitly conceded that their facilities do not comply with the 1980 regulations, since otherwise it would have been an unwise business decision to spend millions of dollars to switch from complying with the 1980 regulations to complying with the 2004 regulations. (Four of these reactors have since stopped operating.)

To date, only one reactor (Shearon Harris in North Carolina) has successfully converted to the 2004 regulations, leaving 46 reactors at 28 plants still not in compliance with either the 1980 or 2004 regulations (see list at end). Shearon Harris and the Oconee plant in South Carolina intended to pilot the transition process for other plants, and the NRC approved both plants' license amendment requests. But in December 2012, Oconee's owner Duke Energy said it would not meet the year-end deadline for making safety upgrades required for the transition.<sup>8</sup> The NRC rejected its extension request in January 2013, and it remains out of compliance with both the 1980 and 2004 regulations.<sup>9</sup>

Today nearly half of U.S. operating nuclear reactors do not comply with NRC fire regulations.

## Longstanding Compliance Problems

The NRC must address several long-standing fire safety compliance issues.

**(1) Manual actions:** As discussed above, a plant owner can apply to the NRC for exemptions from specific requirements of the 1980 fire regulations if it believes plant modifications needed to meet those requirements are too difficult or costly, and if it can show that an alternative measure is equally effective. To grant an exemption, the NRC formally reviews and approves the alternatives on a case-by-case basis. Once an exemption is granted, the alternative measure allows the plant to comply with the fire regulations.

These alternative measures often consist of manual actions by plant workers. Manual actions approved by the NRC can maintain plant safety. However:

- NRC investigations have shown that many plant owners continue to rely on unapproved manual actions that are not allowed by specific exemptions,

and that many have employed an “extreme interpretation” of the rules for manual actions.<sup>10</sup>

- During an emergency, workers may have difficulty carrying out manual actions if the fire closes off access to parts of the plant.
- Relying on manual actions goes against the spirit of the 1980 fire regulations, which emphasizes passive systems such as physical separation and insulation of cables that are considered more reliable than active systems.

**(2) Inadequate fire wraps:** Despite knowing since the early 1990s that several types of wire-wrap material used to insulate electric cables do not meet the requirements of the

The NRC has for many years turned a blind eye to broad violations of its fire regulations.

1980 fire regulations, the NRC has not required plants to correct this problem or apply for formal exemptions and approved compensatory measures. While it developed the 2004 regula-

tions partially in response to this problem and has encouraged plants to transition to these regulations, that process has been very slow and many plants have not announced a decision to transition. In the meantime, many plants continue to operate out of compliance with both regulations.

**(3) Long-term use of compensatory measures:** The NRC allows nuclear plants to use *interim compensatory measures* to maintain fire protection when the equipment that usually provides that protection is being repaired or replaced. These measures are commonly manual actions, such as *fire watches* by plant workers—essentially workers checking for smoke in the plant. They do not require prior NRC approval, but are explicitly intended to be temporary. An NRC inspection document states that “a manual action is expected to be a temporary measure and to promptly end when the automatic action is corrected.”<sup>11</sup> While NRC regulations do not explicitly define how long plants may rely on interim compensatory measures, NRC policy is that “degraded and nonconforming conditions” at a plant should be resolved before the reactor is restarted after the next forced outage or refueling outage. **Since compensatory measures are meant to compensate for degraded and nonconforming conditions, this implies**

**that these measures should not be employed longer than the time until the next outage.**<sup>12</sup>

However, many plants have utilized compensatory measures for long periods of time—years in some cases—in lieu of repairing safety systems or retrofitting the plant as required by the regulations. The NRC has known about this practice and allowed it to continue.

In fact, NRC officials have told some plant owners that they can keep interim compensatory measures in place if they announce they are transitioning to the 2004 regulations. The argument is that these measures compensate for modifications required by the 1980 regulations that the plants have not made, but that the NRC believes are not important for safety. It believes a risk analysis will confirm that these modifications would not contribute significantly to safety, in which case neither the modifications nor the compensatory measures would be required under the risk-informed approach of the 2004 regulations.<sup>13</sup>

**(4) Uncited safety violations:** More recently, as an incentive for plant owners to transition to the 2004 safety regulations, the NRC is reportedly only citing plants for the most serious fire safety violations it finds during inspections as long as a plant owner agrees to announce its intention to transition to the 2004 regulations. However, it is unclear that using a carrot rather than a stick has been effective, since the NRC has continued to grant extensions for coming into compliance.<sup>14</sup>

This history appears to show that the NRC believes some of the steps required by its 1980 fire regulations can be ignored with low risk, and is therefore unwilling to enforce compliance, especially if plants are willing to state their intention to move to the 2004 regulations. But there are several problems with this approach.

First, by deciding that some regulations need not be enforced to maintain safety, the NRC is preempting the risk analysis required by the 2004 regulations. Once plant owners conduct this analysis they can be bound by the plant-specific requirements developed under the 2004 regulations. Until then, they are bound by the requirements of the 1980 regulations and should be held to them. If the NRC believes a safe, viable middle ground results from eliminating some of the 1980 regulations’ requirements, then it should demonstrate this and formally eliminate them.

Second, as noted above, at the same time that it is not enforcing the 1980 regulations, the NRC is continuing to offer extensions to plant owners transitioning to the 2004 regulations. For example, in May 2012 the NRC approved another one-year delay to the Browns Ferry nuclear plant's owner to transition to the 2004 regulations.<sup>15</sup> This means that the plant whose near-miss led to the fire protection regulations still violates them nearly 40 years later. In addition, the Arkansas Nuclear One Unit 1 and Beaver Valley reactors have requested extensions for submitting license amendment requests.<sup>16</sup> Whether the NRC's decision to deny an extension to Oconee indicates it is starting to enforce these deadlines more generally remains to be seen.

## Continuing NRC Lack of Enforcement

The NRC has for many years turned a blind eye to the broad use of unapproved manual actions and long-term use of compensatory measures. It has known for two decades about substandard insulation widely used to protect electric cables but has not corrected the situation.

Compounding this problem is the fact that the NRC reportedly does not have the information to take a comprehensive view of this issue. The 2008 GAO report states that "NRC has no comprehensive database of the operator manual actions or interim compensatory measures implemented at nuclear units ..., in addition to the hundreds of related licensing exemptions. NRC does not require units to report operator manual actions upon which they rely for safe shutdown."

The 2012 GAO fire safety report notes that a schedule exists for the 46 reactors planning to transition to the 2004 regulations. According to the schedule, these plants would submit requests for license amendments to allow this transition to occur by 2014, and the NRC would decide on all requests by 2016.<sup>17</sup> As the Oconee case shows, the timeline does not mean that these plants will be in compliance by 2016, since they may need to undertake safety upgrades after the license amendments are accepted. Moreover, the NRC appears willing to approve requests for delays.

## 46 Reactors at 28 Plants Out of Compliance with Fire Safety Regulations<sup>18</sup>

Arkansas Nuclear One Units 1, 2	Russellville, Arkansas
Beaver Valley Units 1, 2	Shippingport, Pennsylvania
Browns Ferry Units 1, 2, 3	Decatur, Alabama
Brunswick Units 1, 2	Southport, North Carolina
Callaway	Fulton, Missouri
Calvert Cliffs Units 1, 2	Lusby, Maryland
Catawba Units 1, 2	Rock Hill, South Carolina
Cooper	Brownville, Nebraska
Davis-Besse	Oak Harbor, Ohio
Diablo Canyon Units 1, 2	Avila Beach, California
Donald C. Cook Units 1, 2	Bridgman, Michigan
Duane Arnold	Palo, Iowa
Fort Calhoun Unit 1	Fort Calhoun, Nebraska
H. B. Robinson Unit 2	Hartsville, South Carolina
Joseph M. Farley Units 1, 2	Dothan, Alabama
McGuire Units 1, 2	Cornelius, North Carolina
Monticello	Monticello, Minnesota
Nine Mile Point Units 1, 2	Scriba, New York
Oconee Units 1, 2, 3	Seneca, South Carolina
Palisades	South Haven, Michigan
Perry	North Perry, Ohio
Point Beach Units 1, 2	Two Rivers, Wisconsin
Prairie Island Units 1, 2	Red Wing, Minnesota
R. E. Ginna	Ontario, New York
St. Lucie Unit 1, 2	Port St. Lucie, Florida
Turkey Point Units 3, 4	Homestead, Florida
Virgil C. Summer	Jenkinsville, South Carolina
Waterford	Killona, Louisiana

A schedule for transitioning is not meaningful if the NRC is unwilling to enforce it rather than continuing to grant extensions. Instead it should, for example, levy fines on the reactor owner for each day the reactor falls behind the

agreed schedule. Such fines are on the books—up to \$140,000 per day per violation—and would induce owners to place greater emphasis on correcting their fire protection shortcomings. However, the NRC rarely uses them.

It is not surprising that the nuclear industry does not feel compelled to comply with the NRC's fire regulations. For decades the NRC has been willing to accept actions that fall well short of the regulations. It continues to send the industry the message that it does not take fire in reactors seriously, so the industry does not need to either. **The NRC should enforce its fire protection regulations and compel nuclear plant owners to comply with regulations they currently violate.**

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<sup>1</sup> Jack Grobe, Associate Director for Engineering and Safety Systems, Nuclear Regulatory Commission, Transcript of Nuclear Regulatory Commission Briefing on Fire Protection Issues, July 17, 2008, page 58, states “Approximately one-half of the core damage risk at operating reactors results from accident sequences that initiate with fire events.”

<sup>2</sup> J. Sullivan, “NRC Waives Enforcement of Fire Rule at Nuclear Plants,” *ProPublica*, 11 May 2011, <http://www.propublica.org/article/nrc-waives-enforcement-of-fire-rules-at-nuclear-plants>

<sup>3</sup> Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix R, “Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979,” <http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/>

<sup>4</sup> GAO, “NRC’s Oversight of Fire Protection at U.S. Commercial Nuclear Reactor Units Could Be Strengthened,” GAO-08-747, 30 June 2008, p. 18, <http://www.gao.gov/products/GAO-08-747>

<sup>5</sup> National Fire Protection Association (NFPA) 805 option, <http://www.nrc.gov/reactors/operating/ops-experience/fire-protection/protection-rule.html>

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<sup>6</sup> Reactors licensed before January 1, 1979 are issued “exemptions” to NRC regulations, while those licensed after 1979 are issued “deviations” from conditions in their licenses. The term “exemption” is typically used to refer to both.

<sup>7</sup> GAO, “NRC’s Oversight of Fire Protection at U.S. Commercial Nuclear Reactor Units Could Be Strengthened,” June 2008, p.15, <http://www.gao.gov/new.items/d08747.pdf>

<sup>8</sup> IndependentMail.com, Anna Bard Brutzman “Oconee Nuclear Station set to miss fire controls deadline,” December 17, 2012, <http://www.independentmail.com/news/2012/dec/17/oconee-nuclear-station-set-miss-fire-controls-dead/>

<sup>9</sup> NRC, “Denial of Amendment Request,” January 15, 2013, <http://pbadupws.nrc.gov/docs/ML1234/ML12345A204.pdf>; NRC, “Apparent Violation of License Condition 3.D,” January 31, 2013,

<http://pbadupws.nrc.gov/docs/ML1301/ML13017A456.pdf>

<sup>10</sup> The Nuclear Regulatory Commission, *NRC Fire Protection Training Materials*, 2001; GAO, “NRC’s Oversight,” 2008, p.14.

<sup>11</sup> Part 9900 of the Nuclear Regulatory Commission Inspection Manual, “Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety,” April 16, 2008, page C-4.

<sup>12</sup> P. Gunter, J. Warren, and D. Lochbaum, “Fire When Not Ready,” p. 8, [http://www.ucsusa.org/assets/documents/nuclear\\_power/Fire-When-Not-Ready.pdf](http://www.ucsusa.org/assets/documents/nuclear_power/Fire-When-Not-Ready.pdf)

<sup>13</sup> GAO, “NRC’s Oversight,” 2008, p.17.

<sup>14</sup> J. Sullivan, “NRC Waives Enforcement,” *ProPublica*, 2011.

<sup>15</sup> NRC Confirmatory Order, May 18, 2012, <http://pbadupws.nrc.gov/docs/ML1205/ML12053A188.pdf>

<sup>16</sup> GAO, “Oversight and Status of Implementing a Risk-Informed Approach to Fire Safety,” October 2012, p. 33, <http://www.gao.gov/assets/650/649658.pdf>

<sup>17</sup> GAO, “Oversight and Status,” 2012, p. 11.

<sup>18</sup> GAO, “Oversight and Status,” 2012, p. 32. Since that report was published, the Kewaunee, Crystal River, and San Onofre plants have been shut down.

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June 2013