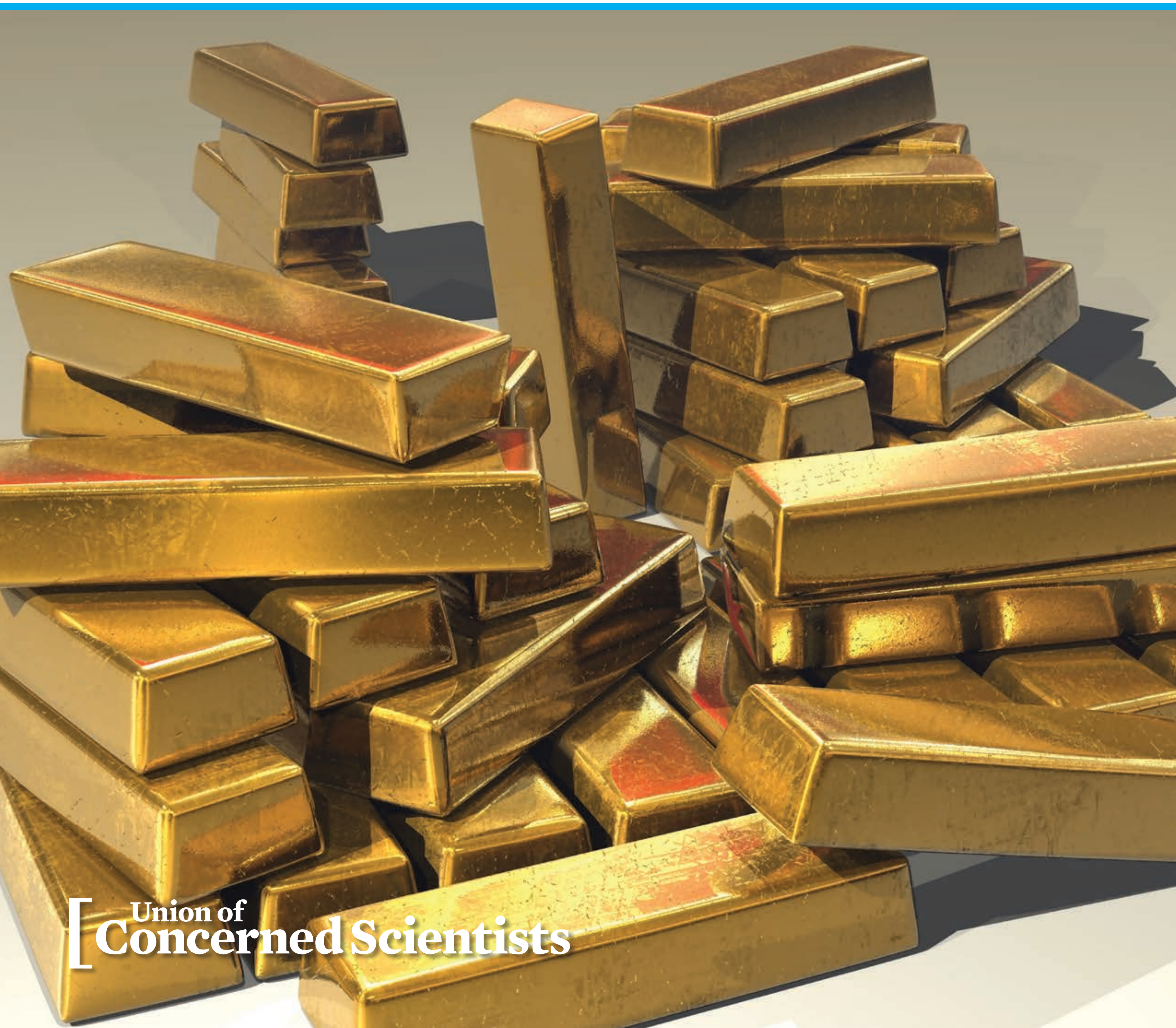
The NRC and Nuclear Power Plant Safety in 2014

Tarnished Gold Standard



Union of Concerned Scientists

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Union of Concerned Scientists

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The Union of Concerned Scientists (UCS) is the leading science-based nonprofit working for a healthy environment and a safer world. UCS combines independent scientific research and citizen action to develop innovative, practical solutions and to secure responsible changes in government policy, corporate practices, and consumer choices.

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[ACKNOWLEDGMENTS]

The author greatly appreciates the peer reviews of the draft report conducted by Paul Blanch, an electrical engineer who retired from the nuclear industry after a long and distinguished career; Lucas W Hixson, the Editor in Chief of *Enformable Nuclear News* (*www.enformable.com*); Tim Judson, Executive Director of the Nuclear Information and Resource Service (*www.nirs.org*); and one anonymous industry colleague. The technical editing by Teri Grimwood, program researcher at the Union of Concerned Scientists, was extremely helpful and much appreciated. Trudy E. Bell did a great job with the meticulously helpful final editing as she had done with last two year's report in this series. And Bryan Wadsworth and Cynthia Derocco of UCS deserve much credit for facilitating the editing and layout of the report on a very tight schedule.

The author has the privilege and pleasure of working with many citizens around the country on nuclear power plant safety issues. The vast majority receive no compensation for their long hours and challenging efforts other than the satisfaction from working unselfishly to make their communities safer for their families and neighbors. Often frustrated by not obtaining the desired outcome, they may not appreciate the tangible benefits of steps taken in that direction; steps less likely to have been taken but for their efforts. The author acknowledges, and greatly appreciates, their achievements that have made his job much easier and—more importantly—their communities much safer.

The opinions expressed herein do not necessarily reflect those of the organizations that funded the work or the individuals who reviewed it. The Union of Concerned Scientists bears sole responsibility for the report's content.

The Nuclear Regulatory Commission (NRC) often claims to represent the gold standard for nuclear power plant safety regulation and oversight (Macfarlane 2013; Magwood 2013). Ample evidence, including the summaries of positive outcomes achieved by the NRC in this series of annual reports, suggests much validity to these claims.

One cannot count the number of nuclear disasters averted by the NRC's effective regulatory performance, but one can generally count on the NRC to be an effective regulator. The NRC has done much to earn the gold standard label.

Chapter 4 of this report describes how the NRC conducted two extensive reassessments of its reactor oversight process—not in response to an accident demonstrating its inadequacy or to criticism suggesting an inadequacy, but as a proactive measure aimed at enhancing the effectiveness and efficiency of the existing process. Chapter 4 also describes how a decade ago the NRC recognized it had an aging work force and developed formal programs to retain as much tribal knowledge as possible before its retirees hit the golf courses and beaches in their golden years. Such proactive actions enable the NRC to retain the gold standard label.

Chapters 2 and 3 of this report describe how the number and severity of near misses at nuclear power plants have been steadily declining since 2010, again consistent with the NRC being an effective regulator.

But Chapter 5 reveals the gold standard to be tarnished. For the past decade, the NRC has been improperly withholding documents, including many about safety problems. By doing so, the NRC deprived the public of legal rights for regulatory decision-making and painted a misleading picture of nuclear safety. Chapter 5 also describes how two NRC engineers who did their duties and voiced safety concerns were subjected to repeated investigations of alleged but unsubstantiated wrongdoing, sending a very clear message throughout the agency that "silence is golden." Finally, Chapter 5 explains how the NRC has been using nonuniform answer keys to grade standardized tests administered via its reactor oversight process, yielding numerical outcomes less predictable than fluctuating gold prices. By improperly withholding many safety problem reports and jiggling the grading of other safety problems, the improving trends may be more fabrication than fact. If the NRC truly is the gold standard of nuclear regulators, it must restore the luster by removing this tarnish and preventing it from recurring.

[***One cannot count the number of nuclear disasters averted by the NRC's effective regulatory performance.***]

[CHAPTER 1]

The Cop on the Nuclear Beat

The U.S. Nuclear Regulatory Commission (NRC) is to owners of nuclear reactors what local law enforcement is to a community. Both are tasked with enforcing safety regulations to protect people from harm. A local police force would let a community down if it investigated only murder cases while tolerating burglaries, traffic violations, and vandalism. The NRC must similarly be the cop on the nuclear beat, actively monitoring reactors to ensure that they are operating within regulations, and aggressively engaging owners and workers over safety violations, whether small, medium, or large.

> ***NRC enforcement of safety regulations could be more timely and consistent.***

The Union of Concerned Scientists (UCS) has evaluated safety issues at nuclear power plants in the United States for over 40 years. We have found that NRC enforcement of safety regulations could be more timely and consistent. Our findings match those of the NRC's own internal assessments, as well as of independent agents such as the NRC's Office of the Inspector General (OIG) and the federal Government Accountability Office (GAO). Seldom does an internal or external evaluation conclude that a reactor incident or unsafe condition stemmed from a lack of regulations. Like UCS, these evaluators instead find that the NRC's untimely and/or inconsistent enforcement of existing regulations was a factor.

We have often found the NRC to be capable of enforcing its safety regulations. Because we believe the NRC's problem to be consistency rather than capability, we feel the appropriate remedy is to help the agency move towards more consistent and aggressive enforcement.

This report—like its predecessors—chronicles what the agency is doing right as well as what it is doing wrong. Our goal is to help the NRC achieve more of the former and avoid more of the latter.

The Reactor Oversight Process and Near Misses

The NRC monitors safety levels at nuclear plants using its Reactor Oversight Process (ROP). In this process, the NRC's full-time inspectors assess operations and procedures designed to detect problems before they become more serious. The ROP features seven cornerstones of reactor safety (Table 1, p. 5). Using this process, the NRC issued nearly 200 reports on its findings last year.[1]

When an event occurs at a reactor or a degraded condition is discovered, the NRC evaluates the chance of damage to the reactor core. A key nuclear safety principle called defense-in-depth means that many protective measures must fail for the reactor core to be damaged. The NRC estimates the degree to which the event or degraded condition has reduced the number of protective measures preventing core damage. Most incidents at nuclear power plants have a small effect on the risk of reactor core damage. If the event or

1 *See* http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/listofrpts_body.html *for the NRC's safety inspection reports.*

condition did not affect that risk—or if the risk was increased only by a very small amount—the NRC relies on routine measures in the ROP to respond.

When an event or condition increases the chance of reactor core damage by a factor of 10, however, the NRC is likely to send out a special inspection team (SIT). When the risk rises by a factor of 100, the agency dispatches an augmented inspection team (AIT). And when the risk increases by a factor of 1,000 or more, the NRC sends an incident inspection team (IIT). Because they are in response to an event or discovery at a site, the NRC considers its SIT, AIT, and IIT efforts to be reactive inspections (NRC 2010).

When an event or discovery at a reactor results in the NRC's sending out a team for a reactive inspection, UCS refers to it a "near miss." Over the years, using this label has proven to be more controversial than expected. UCS continues to use this term because it indicates a clear nexus to accidents involving core damage: the NRC inspection teams are dispatched only when something is believed to have increased the chances of such an accident by at least a factor of 10. In other words, the NRC dispatches inspection teams when it believes safety margins have been significantly reduced, placing the reactor closer to an accident. "Near miss" seems a more appropriate and more accurately illustrative label than the NRC's own term, "accident sequence precursor."

When NRC inspection teams are sent out, they go to a site to investigate what happened, why it happened, and whether the incident poses any safety implications for other nuclear plants. The teams take many weeks to conduct an investigation, evaluate the information they gather, and document their findings in a publicly available report.

Both routine ROP inspections and investigations by the special teams may identify violations of NRC regulations. The NRC classifies violations in five categories, with Red denoting the most serious, followed by Yellow, White, Green, and Non-Cited Violations.[2]

The color assigned by the NRC for a violation is sometimes related to how much it increased the risk of reactor core damage. But many violations do not lend themselves to such numerical analysis, such as ones associated with inadequate radiation protection of plant workers. In general, Red findings from the NRC reflect highest risk and lower performance while Green findings indicate lowest risk and higher performance. The NRC issues Non-Cited Violations not just as oxymorons. Instead, Non-Cited Violations flag situations that do not rise to even the Green threshold, but that reflect unacceptable behavior the NRC wants plant management to correct.

For certain violations that do not lend themselves to classification by their risk significance, the NRC uses four severity levels, with Level I being the most severe and Level IV the least serious. For example, the NRC's regulations prohibit the falsification of maintenance and test documents. The NRC's security regulations require protection against sabotage. It is difficult to assess how violations of either of these regulations might affect core damage risk, and thus how to assign the appropriate color. In such cases, the NRC assigns severity levels instead, considering such factors as whether senior managers were aware of or involved in the violations and whether the violations were caused by deliberate acts or sloppy practices.

[***When an event or discovery at a reactor results in the NRC's sending out a team for a reactive inspection, UCS refers to it a "near miss."***]

The classifications dictate the thoroughness of the responses the NRC expects from plant owners as well as the extent of the NRC's follow-up to the violations. For example, for a Green finding, a plant owner would be expected to fix the nonconforming condition and NRC inspectors might verify proper resolution during their next planned examination of that area, whether that opportunity was scheduled next month or next year. For a Yellow or Red finding, however, the plant owner would be expected to also take steps to determine whether the problem was an isolated case or reflective of a broader, programmatic breakdown. Moreover, the NRC's follow-up inspections are typically more extensive for Yellow and Red findings than for Green and White findings.

The Scope of This Report

Chapter 2 summarizes the "near misses" at nuclear reactors that the NRC reported in 2014, although one actually occurred in 2013. Near misses are events that prompted the agency to

2 *For security violations (as opposed to safety violations), the NRC uses a "Greater than Green" classification instead of White, Yellow, and Red labels to convey to the public some distinction about the seriousness of security problems without also pointing potential saboteurs to plants having especially serious security vulnerabilities.*

In these near miss events, a combination of broken or impaired safety equipment and poor worker training typically led owners of nuclear plants down a pathway toward potentially catastrophic outcomes.

dispatch an SIT, AIT or IIT. In these events, a combination of broken or impaired safety equipment and poor worker training typically led owners of nuclear plants down a pathway toward potentially catastrophic outcomes. After providing an overview of each event, this chapter shows in more detail how one problem led to another and notes any “tickets” the NRC wrote for safety violations that contributed to the near miss.

This detailed review of all the near misses reported in 2014 provides important insights into trends in nuclear safety, as well as into the effectiveness of the NRC’s oversight process. For example, if many near misses stemmed from failed equipment, such as emergency diesel generators, the NRC could focus its efforts in that arena until it arrests declining performance. Chapter 2 therefore uses the year’s safety-related events to suggest how the NRC can prevent plant owners from accumulating problems that may conspire to cause next year’s near misses—or worse.

With the near misses attesting to why day-to-day enforcement of regulations is vital to the safety of nuclear

NRC Resident Inspector conducts an inspection at the Fermi nuclear plant, which experienced a security problem in 2014.

TABLE 1. Seven Cornerstones of the Reactor Oversight Process

Initiating Events	Conditions that, if not properly controlled, require the plant's emergency equipment to maintain safety. Problems in this cornerstone include improper control over combustible materials or welding activities, causing an elevated risk of fire; degradation of piping, raising the risk that it will rupture; and improper sizing of fuses, raising the risk that the plant will lose electrical power.
Mitigating Systems	Emergency equipment designed to limit the impact of initiating events. Problems in this cornerstone include ineffective maintenance of an emergency diesel generator, degrading the ability to provide emergency power to respond to a loss of offsite power; inadequate repair of a problem with a pump in the emergency reactor-core cooling system, reducing the reliability of cooling during an accident; and non-conservative calibration of an automatic temperature set point for an emergency ventilation system, delaying its startup longer than safety studies assume.
Barrier Integrity	Multiple forms of containment preventing the release of radioactive material into the environment. Problems in this cornerstone include foreign material in the reactor vessel, which can damage fuel assemblies; corrosion of the reactor vessel head; and malfunction of valves in piping that passes through containment walls.
Emergency Preparedness	Measures intended to protect the public if a reactor releases significant amounts of radioactive material. Problems in this cornerstone include emergency sirens within 10 miles of the plant that fail to work; and underestimation of the severity of plant conditions during a simulated or actual accident, delaying protective measures.
Public Radiation Safety	Design features and administrative controls that limit public exposure to radiation. Problems in this cornerstone include improper calibration of a radiation detector that monitors a pathway for the release of potentially contaminated air or water to the environment.
Occupational Radiation Safety	Design features and administrative controls that limit the exposure of plant workers to radiation. Problems in this cornerstone include failure to survey an area properly for sources of radiation, causing workers to receive unplanned exposures; and incomplete accounting of individuals' radiation exposure.
Security	Protection against sabotage that aims to release radioactive material into the environment, which can include gates, guards, and guns. After 9/11, the NRC reduced the discussion of this cornerstone in the public arena.

The NRC's Reaction Oversight Process features seven cornerstones of reactor safety to help inspectors detect problems before they become more serious.

SOURCE: *WWW.NRC.GOV/REACTORS/OPERATING/OVERSIGHT/ROP-DESCRIPTION.HTML.*

power, the subsequent three chapters then highlight the NRC's own performance in monitoring safety through the reactor oversight process. Chapter 3 evaluates trends from the near misses since 2010 when UCS initiated this series of reports. (UCS issued many reports on nuclear safety issues prior to 2010. While those reports often identified recurring themes, different focuses and approaches made trending subjective. This series of reports applied a consistent methodology that enabled more objective, apple-to-apples trending analysis.) Chapter 4 describes occasions in which effective oversight by NRC inspectors led to actions to prevent safety problems from snowballing into near misses or even more dangerous situations. Chapter 5 then describes cases where ineffective NRC oversight failed to prevent dangerous situations—or actually set the stage for them.

Chapter 6 summarizes findings from the near misses in Chapter 2, the trend analysis of Chapter 3, the examples of positive outcomes from the reactor oversight process in Chapter 4, and the examples of negative outcomes from that process in Chapter 5. Chapter 6 recommends steps the NRC should take to reinforce behavior among plant owners leading to commendable outcomes, and steps the NRC should take to alter behavior that produces outcomes that pose risks to employees and the public.

Our primary aim in creating the annual reports on nuclear reactor safety is to spur the NRC to improve its own performance as well as that of reactor owners.

[CHAPTER 2]

Near Misses at Nuclear Power Plants in 2014

In 2014, the NRC reported on the nine events summarized in Table 2 (p. 7) that prompted the agency to send teams to analyze problems at those plants. All nine events triggered investi-gations by special inspection teams (SIT) in response to a 10-fold increase in risk of reactor core damage. Last year, no events triggered an augmented inspection team (AIT) inspection in response to a 100-fold increase in risk of core damage. And no events triggered an incident inspection team (IIT) inspection in response to a 1,000-fold or greater increase in risk of core damage.

UCS considers all nine events to constitute near misses because they increased the risk of damage to the reactor core—thus challenging the safety of workers and the public. As the end of this chapter will show, lessons from these near misses reveal how the NRC can apply its limited resources to reap the greatest returns for public safety.

Our "near miss" label for these events has been unexpectedly controversial. The NRC terms some of these events as "accident sequence precursors" (ASPs)—a term of art rather than plain-English communication. We stand by the "near miss" label and point to the online reporting system maintained by firefighters: "A near miss event is defined as an unintentional unsafe occurrence that could have resulted in an injury, fatality, or property damage if not for a fortunate break in the chain of events." The tagline for the firefighters' reporting system is "Lessons Learned Become Lessons Applied" (International Association of Fire Chiefs, 2015). UCS hopes the NRC and the nuclear industry will move past semantics to attain this safety spirit.

The NRC also sent a special inspection team to the nuclear fuel fabrication facility in Erwin, Tennessee following an event with potential implications for causing an uncontrolled nuclear chain reaction and worker exposure to hazardous chemicals (Gody 2014). Workers had to hold the control switches for two valves as a tank was filled. Over time, aging effects like degradation of gasket material partially blocked the supply pipe. Instead of holding the switches for 30 seconds, workers had to hold the switches open for up to 25 minutes before the tank could be filled via the partially blocked supply line. Workers dealt with this situation by essentially taping the switches in the open position and allowing the tank to fill while they performed other tasks—setting the stage for an inadvertent criticality or tank overflow that the switches had been installed to prevent. While the NRC's SIT identified lessons transferrable to nuclear power plants operating in the United States, UCS elected to summarize this near miss in commentary posted to our blog (*http://allthingsnuclear.org*) rather than in this report.

The special inspection reports issued by the NRC last year identified 11 violations of NRC safety regulations. Figure 1 (p. 8) classifies these violations by the seven cornerstones of the reactor oversight process (ROP).[3]

As described later in this chapter, not every NRC SIT resulted in one or more findings being issued. That an event or discovery prompted the NRC to dispatch a team to investigate does not automatically mean that violation(s) existed. UCS views the reactive inspections to be an extremely valuable component of the NRC's oversight toolkit. That value is not

3 *For more information on the cornerstones and related NRC inspections, see Table 1 and* http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/cornerstone.html.

TABLE 2: Near Misses at Nuclear Power Plants in 2014

Reactor and Location	Operator	Highlights
Calvert Cliffs Nuclear Power Plant Units 1 and 2 Lusby, MD	Exelon Generation Co., LLC	SIT: Moisture intrusion during a winter storm caused an electrical short that cascaded into the automatic shutdown of both reactors.
Catawba Nuclear Station Unit 1 York, SC	Duke Energy Carolinas, LLC	SIT: Problems with the emergency diesel generators were discovered to have been most likely caused by maintenance practices that conflicted with vendor recommendations.
Clinton Power Station Unit 1 Clinton, IL	Exelon Generation Co., LLC	SIT: An electrical transformer fault triggered the automatic shutdown of the reactor and eliminated the normal, preferred method of handling the reactor core's decay heat production.
Fermi, Unit 2 Newport, MI	DTE Electric Company	SIT: The NRC investigated a security problem at the plant.
Grand Gulf Nuclear Station Unit 1 Port Gibson, MS	Entergy Operations, Inc.	SIT: The NRC investigated a security problem at the plant.
Joseph M. Farley Nuclear Plant Unit 2 Columbia, AL	Southern Nuclear Operating Co., Inc.	SIT: The reactor had to be shut down after a periodic test of its protection system could not be successfully completed. Workers replaced a faulty circuit card and re-tested the system successfully.
Millstone Power Station Unit 3 Waterford, CT	Dominion Nuclear Connecticut, Inc.	SIT: Recurring problems with the turbine-driven auxiliary feedwater pump were found to have been caused by a wrong part and improper assembly during recent maintenance.
Millstone Power Station Units 2 and 3 Waterford, CT	Dominion Nuclear Connecticut, Inc.	SIT: A power fluctuation in the offsite electrical grid resulted in the plant disconnecting from the grid and the automatic shutdown of both reactors. Several problems were experienced on Unit 3 following its shutdown.
River Bend Station Unit 1 St. Francisville, LA	Entergy Operations, Inc.	SIT: The NRC investigated a security problem at the plant.

2014 saw nine near misses, all triggering investigations by the special inspection team. There were nine such near misses in 2013 as well, in addition to one event requiring an augmented inspection team.

diminished when a reactive inspection legitimately identifies no violations. The reactive inspections focus NRC team members and plant workers on the administrative controls (e.g., procedures, training, post-maintenance testing, etc.) that protect against unwanted outcomes. Verifying that these barriers are intact is as important as finding holes to patch—both results guard against tomorrow's problems.

Each near miss reported by the NRC in 2014 is described hereafter in alphabetical order by plant name (matching the order in Table 2).

Calvert Cliffs Nuclear Power Plant, Units 1 and 2, MD

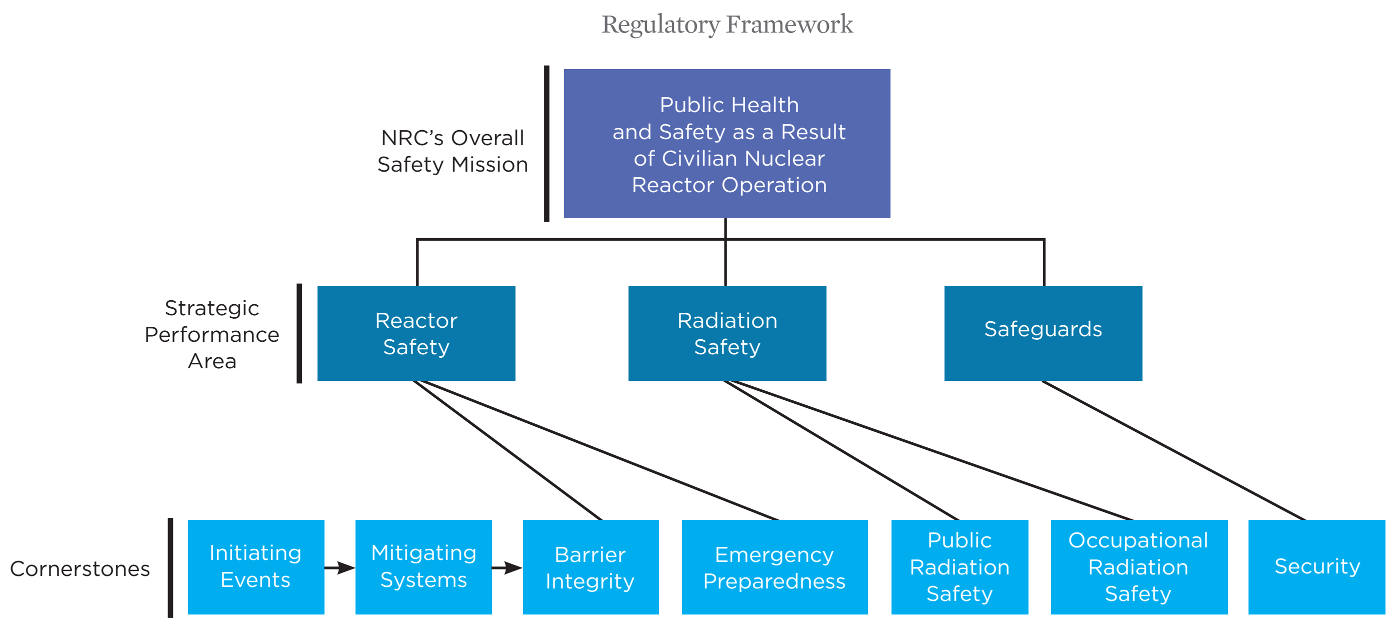
THE NEAR MISS

The NRC sent an SIT to the plant after intruding moisture during a winter storm on January 21, 2014, caused an electrical breaker to open. The opened breaker interrupted electricity flow to Unit 2 equipment. The de-energizing of that equipment forced the automatic shutdown of the Unit 2 reactor. The opened breaker also interrupted electricity flow to one circuit on Unit 1. An emergency diesel generator automatically started and re-powered this circuit within seconds. But the momentary power interruption caused a recently installed digital control system to unexpectedly close all the valves admitting steam to the turbine. The closure of the turbine valves caused pressure to rise, triggering the automatic shutdown of the Unit 1 reactor. The SIT identified no regulatory requirement violations (Krohn 2014).

HOW THE EVENT UNFOLDED

At approximately 9:25 p.m. on January 21, 2014, an electrical breaker shorted out due to water leaking in during a winter storm. The faulted breaker stopped the flow of electricity to the 13,800-volt (13.8 KV) electrical bus 21 on Unit 2. The de-energizing of bus 21 caused 4,000-volt (4KV) buses 14, 22, 23, 24, 25 and 26 to also de-energize (Figure 2, p. 10).

FIGURE 1. Near Misses in 2014 by Cornerstones of the Reactor Oversight Process



Near miss Category	Initating Events	Mitigating Systems	Barrier Integrity	Emergency Preparedness	Public Radiation Safety	Occupational Radiation Safety	Security
Red	0	0	0	0	0	0	0
Yellow	0	0	0	0	0	0	0
White	0	1	0	0	0	0	0
> Green*	n/a	n/a	n/a	n/a	n/a	n/a	2
Green	1	3	0	1	0	0	1
Level III	1	0	1	0	0	0	0
Total	2	4	1	1	0	0	3

Findings from near misses in 2014 fell into five of the Reactor Oversight Process' seven safety cornerstones and were assigned lower severity levels by the NRC.

* After 9/11, the NRC stopped publicly releasing the color assigned to security violations; instead it indicates that a violation is "Greater than Green."

SOURCE: U.S. NUCLEAR REGULATORY COMMISSION (TOP HALF OF FIGURE). UCS (BOTTOM HALF OF FIGURE).

© Jbs666/Creative Commons (Wikimedia)

The Calvert Cliffs Nuclear Power Plant, where water leaked in during a winter storm to short out electrical circuits and force both reactors to automatically shut down.

The electrical power losses stopped equipment like the main turbine and the pumps normally providing makeup water to the steam generators and triggered the automatic shutdown of the Unit 2 reactor. The plant's design needed much of the equipment to operate, so the reactor automatically shut down as a precautionary measure when the equipment became unavailable.

The 4,000-volt bus 14 supplies electricity to Unit 1 equipment while the remaining buses supply Unit 2 equipment. The de-energizing of bus 14 caused emergency diesel generator 12 to automatically start up just as the de-energizing of bus 24 caused diesel generator 21 to automatically start. The diesel generators (denoted DG in the figures) repowered these two buses within seconds (Figure 3, p. 11).

By design, the Unit 1 reactor should have endured the de-energizing of the Unit 2 buses and the momentarily de-energizing of bus 14. But the brief power interruption unexpectedly caused a recently installed digital control system to essentially reboot. During this process, the control system closed all the valves admitting steam to the main turbine. Stopping the flow of steam through the turbine upset the balance between the energy produced by the reactor core and the energy removed via the steam generators. The imbalance caused the pressure inside the reactor vessel to rise until it triggered the automatic shutdown of the Unit 1 reactor about 16 seconds after the initial breaker fault.

The in-plant power disruptions also disabled a security system. The security force personnel on shift at the time initiated recovery measures and implemented appropriate compensatory measures.

Bus 21 was repowered on January 25 after repairs to the electrical breaker.

NRC SANCTIONS

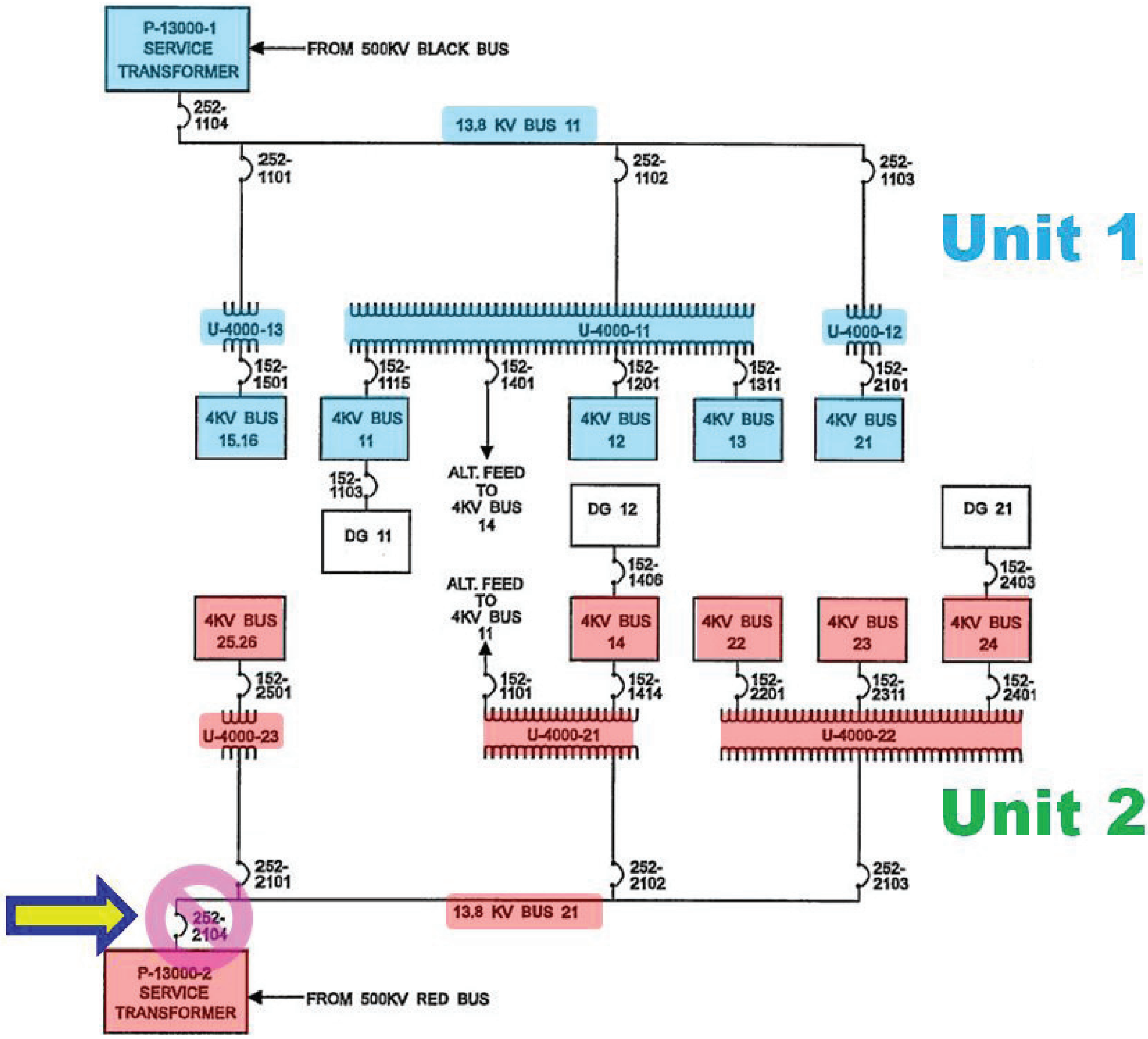
The NRC's SIT identified no violations (Krohn 2014).

UCS PERSPECTIVE

This NRC SIT concluded that actions taken by workers in response to previous water intrusion events at Calvert Cliffs could not have reasonably prevented this recurrence. Previous events like that had been documented by another NRC SIT visiting Calvert Cliffs just four years ago. On February 18, 2010, rainwater leaked in and dripped onto bus 14, shorting it out. Equipment that was installed to isolate the electrical disturbance failed to do so, resulting in bus 21 being de-energized. Both reactors automatically shut down as a result of the in-plant power disruptions (Lew 2010).

The UCS view differs. Twice within the past five years, precipitation leaked into the Calvert Cliffs nuclear plant and shorted out electrical power supplies, causing one reactor to automatically shut down and components to malfunction that should have protected the second reactor from automatically shutting down. Precipitation occurs all across the United States and its dozens of nuclear power plants, but none—except Calvert Cliffs—have experienced multiple reactor

FIGURE 2. Initial Fault on the Electrical Distribution System at Calvert Cliffs



Problems began at Calvert Cliffs when water leakage during a winter storm shorted an electrical breaker that interrupted the supply of electricity to plant equipment.

SOURCE: CONSTELLATION NUCLEAR ENERGY GROUP, ANNOTATED BY UCS.

shutdowns due to similar intrusions of moisture. In other words, other plant owners have successfully prevented even one intrusion event while Calvert Cliffs has been unable to prevent repeated events

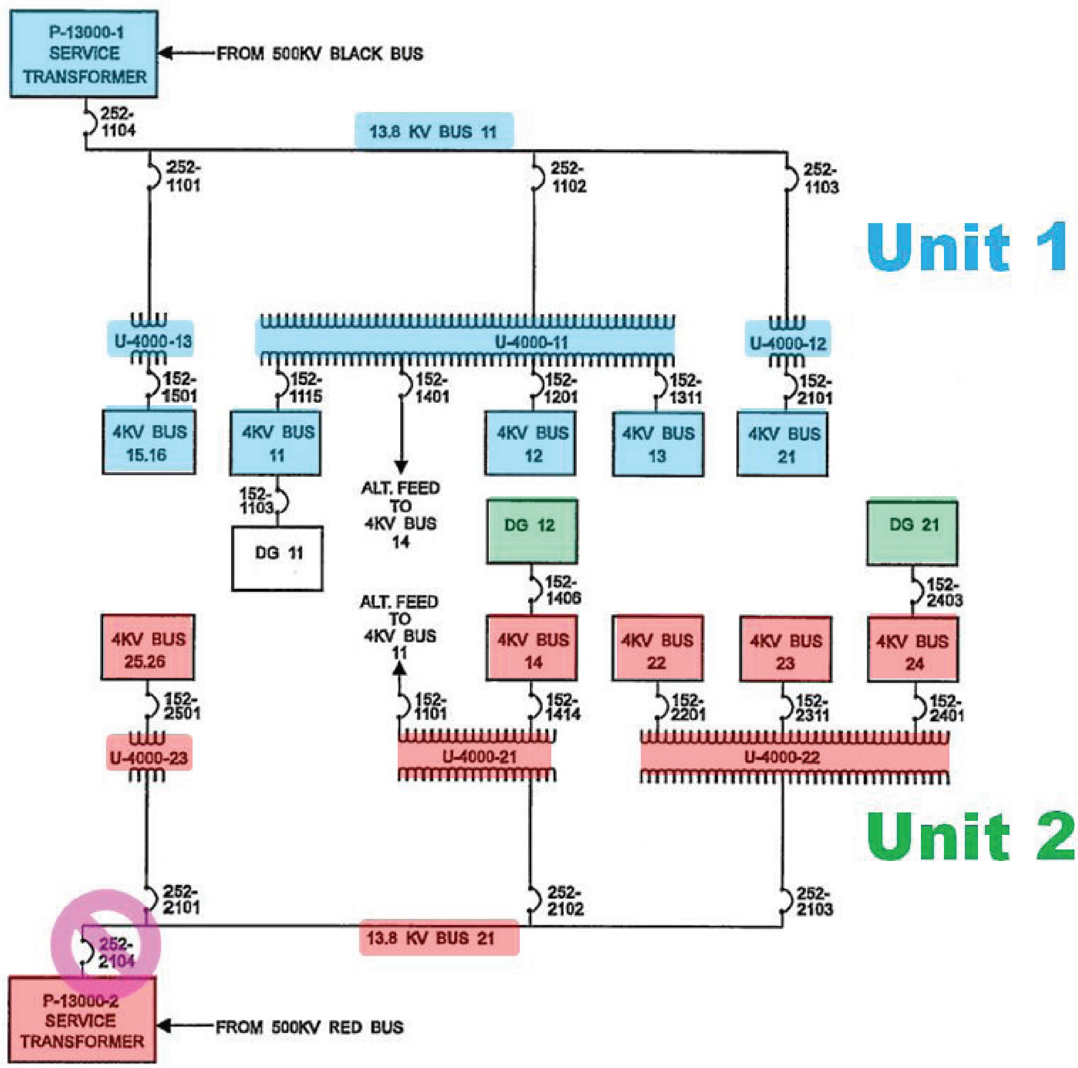
The NRC has a regulation on its books (Appendix B to 10 CFR Part 50) that requires plants owners to find and fix problems in a timely and effective manner. If the NRC enforced this regulation, it would not take several more rainfalls to find and fix all the holes in the roof and unsealed openings in the walls at Calvert Cliffs.

Catawba Nuclear Station Unit 1, SC

THE NEAR MISS

The NRC sent an SIT to the plant after workers identified problems with both of the emergency diesel generators for the Unit 1 reactor. Although workers were not able to definitively determine what damaged the emergency diesel generators, one of three likely causes involved the operators running the diesel with the lubricating oil below the minimum tem-

FIGURE 3. Response to Fault on the Electrical Distribution System at Calvert Cliffs



Emergency diesel generators automatically started and restored power to key electrical circuits, but the momentary power interruption caused Unit 2's problems to also cause problems on Unit 1.

SOURCE: CONSTELLATION NUCLEAR ENERGY GROUP ANNOTATED BY UCS

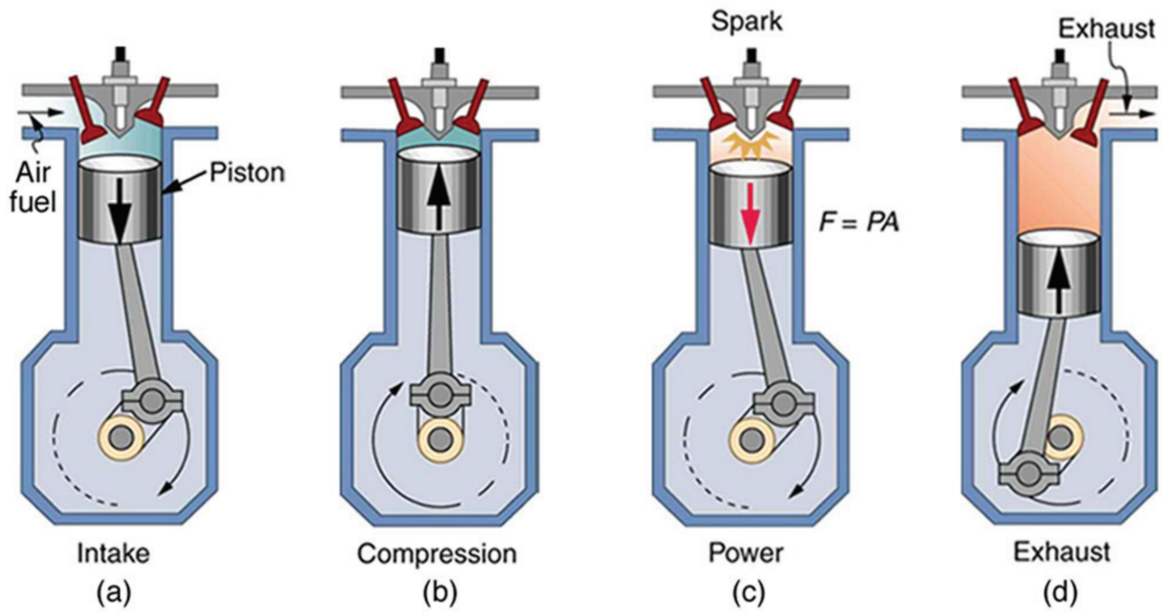
perature recommended by the vendor. The SIT identified no regulatory requirement violations (McCoy 2014).

HOW THE EVENT UNFOLDED

The Catawba Nuclear Station has two pressurized water reactors that began operating in the mid-1980s. Each reactor has two standby diesel generators intended to provide electrical power to essential equipment if the normal power supplies are unavailable. A standby diesel generator consists of a diesel engine that is connected to an electrical generator. Each standby diesel generator is rated for continuous service supplying seven megawatts of electricity at 4,160 volts.

Each four-stroke diesel engine has 16 cylinders. Each cylinder has a piston attached via a connecting rod to a crankshaft. (Note: Figure 4, p. 11, depicts a non-diesel internal combustion engine. The diesel engines at Catawba are similar, but lack the spark plug shown here.) The piston moves downward during the intake phase as fuel oil enters the cylinder. The piston moves upward during the compression phase. The fuel oil ignites to force the piston downward during

FIGURE 4. Internal Combustion Engine Four-Stroke Cycle



Connecting rods link the pistons of a diesel engine to its crankshaft. Half-shell bearings secure the lower end of the connecting rod to the crankshaft while still accommodating the crankshaft's rotations.

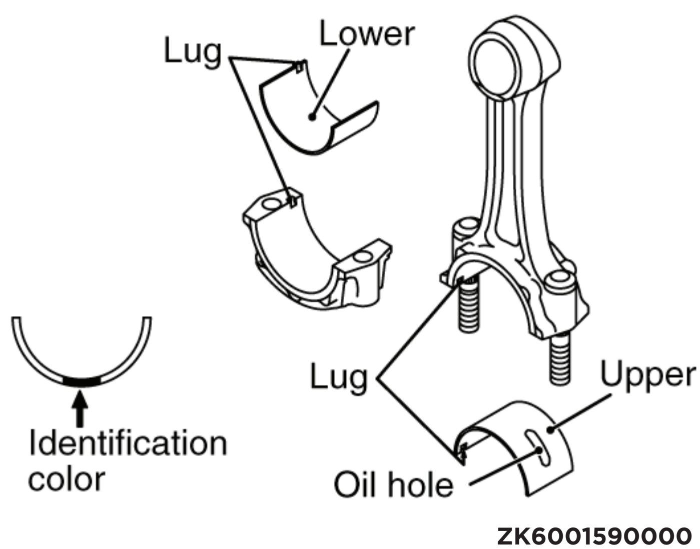
SOURCE: © OPENSTAX COLLEGE/CREATIVE COMMONS

the power phase. Finally, the rotating crankshaft pushes the piston upward while the exhaust valve opens to empty the cylinder for the next stroke. As the crankshaft rotates, the connecting rods move up and down within the pistons through the four strokes shown in the graphic.

A round hole near the bottom end of each connecting rod is used to attach it to the cylindrical crankshaft. Bearings made from cast aluminum and electroplated on the inside for a smooth, slippery surface fit between the connecting rod holes and the crankshaft. As shown in the Figure 5, the bearings are shaped as semicircular half-shells. When installed properly, the connecting rod bearing half-shell edges are aligned horizontally. In other words, if you looked at the bearing head-on superimposed over a clock's face, the half-shells would meet at 9 p.m. on the left and at 3 p.m. on the right.

Misalignment of the bearings could cause the emergency diesel generator to fail. The inner surfaces of the bearings have special coatings to allow them to better accommodate the rotating crankshaft. Lubricating oil also flows into the area for further protection against metal-to-metal rubbing. Misaligned bearings could block the inlet port for the lubricating oil, however, making it only a matter of time before the crankshaft and connecting rods lock together and damage the diesel engine.

FIGURE 5. Half-Shell Bearings



A hole in the lower half-shell bearing allows oil to enter and lubricate where the metal connecting rod contacts the metal bearings.

SOURCE: FAQ.OUT-CLUB.RU.

On March 4, 2014, during a routine inspection required every 18 months, workers at Catawba discovered the connecting rod bearings for the seventh cylinder on Unit 1's standby diesel generator A rotated about 26 degrees from the horizontal position. Operators declared the diesel generator inoperable and had 72 hours to fix it. If the diesel generator remained out of service after 72 hours, the reactor would have to be shut down for safety reasons.

> ***Operators declared the diesel generator inoperable and had 72 hours to fix it. If the diesel generator remained out of service after 72 hours, the reactor would have to be shut down for safety reasons.***

Catawba's operating license limits how long the reactor can operate with only one standby diesel generator available. Although each reactor unit is designed such that a single standby diesel generator can power enough equipment to adequately cool the reactor core during an accident, two diesel generators must be available for reliability of this vital function.

On March 6, the plant's owner asked the NRC for permission to ignore the operating license requirement and to operate the Unit 1 reactor for up to 60 hours beyond the normal 72-hour limit with a broken diesel generator (Henderson 2014b). The NRC granted this request (Croteau 2014b).

On March 9, workers completed the repairs to Unit 1 diesel generator A and the operators returned it to service following successful post-maintenance testing.

On March 10, workers examined Unit 1 standby diesel generator B and discovered that the connecting rod bearings for the first cylinder had rotated about 6 degrees from the horizontal position. Operators declared the diesel generator inoperable, entering another 72-hour period to either repair the broken diesel generator or shut down the Unit 1 reactor.

On March 12, workers completed the repairs to Unit 1 diesel generator B and the operators returned it to service following successful post-maintenance testing.

On March 13, workers examined Unit 2 standby diesel generators A and B and confirmed the connecting rod bearings to be properly oriented.

On March 24, the NRC announced it was dispatching an SIT to Catawba to look into these recent diesel generator problems (NRC News 2014).

The NRC's SIT reported that workers at Catawba were unable to determine the reason why the bearings had rotated from their properly installed positions on both backup diesel generators, but had developed three possible reasons:

- Workers improperly installed the bearings. In other words, the bearings did not rotate out of the proper orientation; they were not initially installed in the proper orientation. Improper installation had been blamed for several earlier connecting rod bearing misalignments:
    - On December 20, 2006, workers found the connecting rod bearing for the second cylinder on Unit 1's diesel generator B rotated about 2 degrees.
    - On January 16, 2007, workers found the connecting rod bearing for the third cylinder on Unit 1's diesel generator A rotated about 3 degrees.
    - On May 10, 2008, workers found the connecting rod bearing for the second cylinder on Unit 1's diesel generator B rotated about 2 degrees.
    - On May 26, 2008, workers found the connecting rod bearing for the third cylinder on Unit 1's diesel generator A rotated about 3 degrees.
- The vendor manufactured the bearings incorrectly. The bearings are supposed to be slightly larger than the holes in the connecting rods so the bearings can be wedged into place and stay in the proper orientation. This sizing situation is called "crush." When the misoriented bearings discovered in March 2014 were sent back to the vendor for evaluation, the vendor measured them for "crush" and found the bearings to be smaller than specified in the design.
- Workers improperly tested the standby diesel generators using cold lubricating oil. Because the diesel generators must be capable of starting up and supplying electricity to essential equipment within 11 seconds, a system continuously warms the lubricating oil to at least 140°F. Once the diesel generator starts, the running engine keeps the oil temperature around 170°F. But workers tested the diesel generators shortly after replacing the lubricating oil. The replacement oil was sometimes as cool as 40°F to 50°F. Under this theory, starting the diesel generator with cold lubricating oil caused the connecting rod and

> the bearings to shrink as the cool lubricating oil cooled the metals and then to expand as the warmed oil heated the metals. The connecting rods are made of steel while the bearings are made from aluminum—two metals that react to temperature changes at different rates. The contraction/expansion rate differential could have emulated bad "crush" and allowed the bearings to slip. (McCoy 2014)

During a meeting of the diesel generator owners group on January 8 and 9, 2007, the vendor reported on experience from non-nuclear users that connecting rod bearings rotated due to cold lubricating oil temperature. The vendor later issued a written recommendation to owners, including Catawba's, that the lubricating oil be warmed to at least 120°F.

Workers at Catawba received this recommendation in 2007, but had not revised their testing procedures for unknown reasons. In December 2012, workers tested Unit 1's diesel generator A after replacing its lubricating oil with 55°F oil.

The plant's owner informed the NRC that cold lubricating oil was the most probable cause for the rotated connecting rod bearings. The owner also informed the NRC, based on information it received from the vendor following an assessment of the connecting rod bearings, that "It was subsequently determined that that effected DG [diesel generator] 1A bearing would have been able to perform its specified safety function in the as-found condition." The vendor estimated that diesel generator's operation would not be impaired until the bearing rotated 45 degrees or more (Henderson 2014a).

NRC SANCTIONS

The NRC's SIT identified no violations (McCoy 2014).

UCS PERSPECTIVE

Catawba's owner played games to keep the Unit 1 reactor operating despite impaired standby diesel generators. Section 3.8.1 of the reactor's operating license requires both standby diesel generators to be in service when the reactor is operating. If one standby diesel generator is unavailable, the reactor may continue operating for up to 72 hours provided that that the other standby diesel generator is either started and demonstrated to be operable or determined not to be afflicted by the same impairment (NRC 2005).

The owner invoked the second option and asserted to the NRC that standby diesel generator (DG) 1B was not also impaired. The owner informed the NRC, in writing, that "During the period that DG 1A was inoperable while the affected bearing was being replaced, DG 1B was operable" (Henderson 2014b).

Shortly after repairing diesel generator 1A and returning it to service, workers looked at diesel generator 1B and found it suffered from the same problem. The operators then declared it inoperable and re-started the 72 hour clock to either fix it or shut down the reactor.

[Only after standby diesel generator 1A was repaired and returned to service did workers look at standby diesel generator 1B and find it too suffered from the very same problem.]

Had the operators declared both standby diesel generators inoperable at the same time, the operating license required at least one to be repaired within 2 hours or the reactor shut down. But the operators played games and declared the standby diesel generators inoperable in series. They "determined" that standby diesel generator 1B was not afflicted by the same impairment that caused standby diesel generator 1A to be declared inoperable and undergo extended repairs. Only after standby diesel generator 1A was repaired and returned to service did workers look at standby diesel generator 1B and find it too suffered from the very same problem.

Of course, the plant's owner could have declared both emergency diesel generators inoperable and asked the NRC's permission to ignore the two-hour limit on continued operation. After all, the NRC approved the owners' request to ignore the 72-hour limit.

In its letter approving the request, the NRC noted that the risk associated with the impaired emergency diesel generator exceeded the criterion in its enforcement discretion procedure (NRC 2013). When the UCS asked about approving this identified high-risk configuration, the NRC replied that it considered the procedure's steps to be guidance rather than requirements—in other words, sometimes it approves high-risk requests and sometimes it denies low-risk requests depending on how the agency is feeling at the moment (Croteau 2014a). The NRC quite properly does not tolerate plant owners who treat procedural commandments as mere suggestions, yet adheres to its own commandments only when convenient.

The SIT documented that the vendor of the diesel generators sent written warnings to owners, including Catawba's, about keeping the lubricating oil above a certain temperature to avoid damaging the equipment. Catawba's owner received the warning but took no action until after the equipment was damaged, quite likely by cold lubricating oil. The NRC has sanctioned other owners who failed to heed similar written warnings from vendors, but ignored the identical failure by this owner in this case.

The majority of plant owners do not play games with safety requirements. The NRC must stop punishing the many owners who do right by rewarding the few owners who do wrong.

Clinton Power Station Unit 1, IL

THE NEAR MISS

The NRC sent an SIT to the plant in response to the December 8, 2013, event in which complications from an electrical problem resulted in the operators manually scramming the reactor from full power and the normal method for removing the reactor core's decay heat becoming unavailable (Boland 2014).

HOW THE EVENT UNFOLDED

The Clinton Power Station has one boiling water reactor with a Mark III containment design that began operating in 1987. The plant operated at full power on December 8, 2013. Electricity produced by the main generator passed through the switchyard and out to the offsite power grid. Some of the electricity flowed through a transformer that reduced its voltage level to 4,160 volts. The electricity supplied in-plant equipment including Bus 1A1. Bus 1A1 in turn supplied electricity to two transformers that reduced its voltage level to 480 volts to power 480-volt Buses A and 1A. Individual electrical circuits from these buses provided power to equipment throughout the plant.

At 8:26 pm. on December 8, 480-volt Auxiliary Transformer 1A experienced an electrical fault. An electrical breaker between this transformer and 4,160 volt Bus 1A1 opened as designed to prevent the electrical disturbance from cascading throughout the plant. The breaker's opening stopped the flow of electricity to 480-volt Buses A and 1A, and to the equipment supplied by these buses.

The plant continued to operate at full power immediately following the electrical fault and automatic response. The 4,160-volt Bus 1A1 is one of three primary electrical circuits for in-plant equipment. Some equipment had lost power, but enough equipment was unaffected by the problem to allow the reactor to continue operating—at least for the moment.

About 10 minutes later, an alarm sounded in the control room notifying the operators about low air pressure to the control rod drive system. The control rod drive system is designed to be fail-safe. On loss of electrical power or loss of

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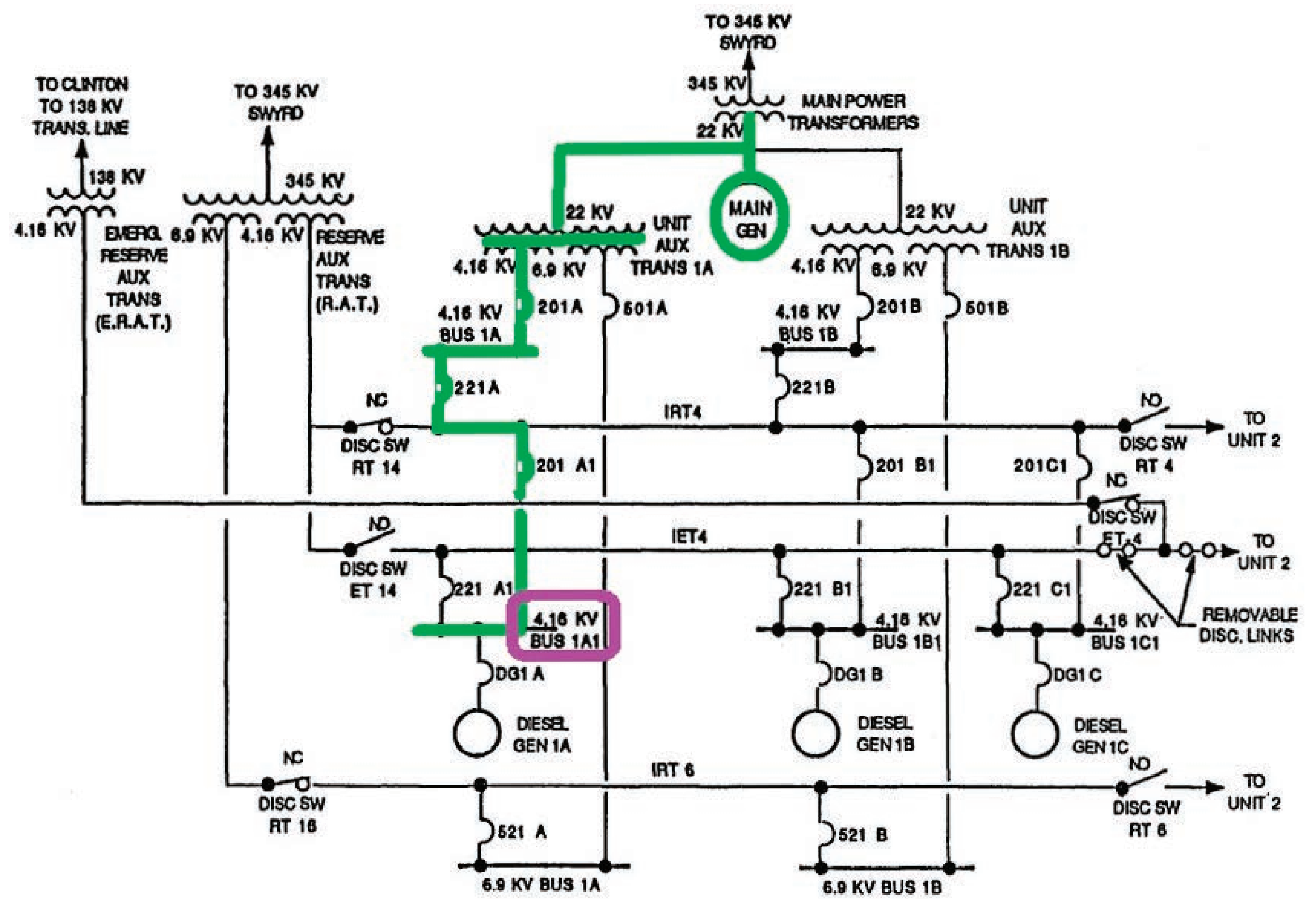
The Clinton Power Station in Illinois, where an unplanned shut down of the reactor was complicated by the loss of the normal method for cooling the reactor core.

FIGURE 6. Electrical Distribution System at Clinton



An electrical problem interrupted the normal supply of electricity to plant equipment at Clinton.

SOURCE: NUCLEAR REGULATORY COMMISSION, ANNOTATED BY UCS.

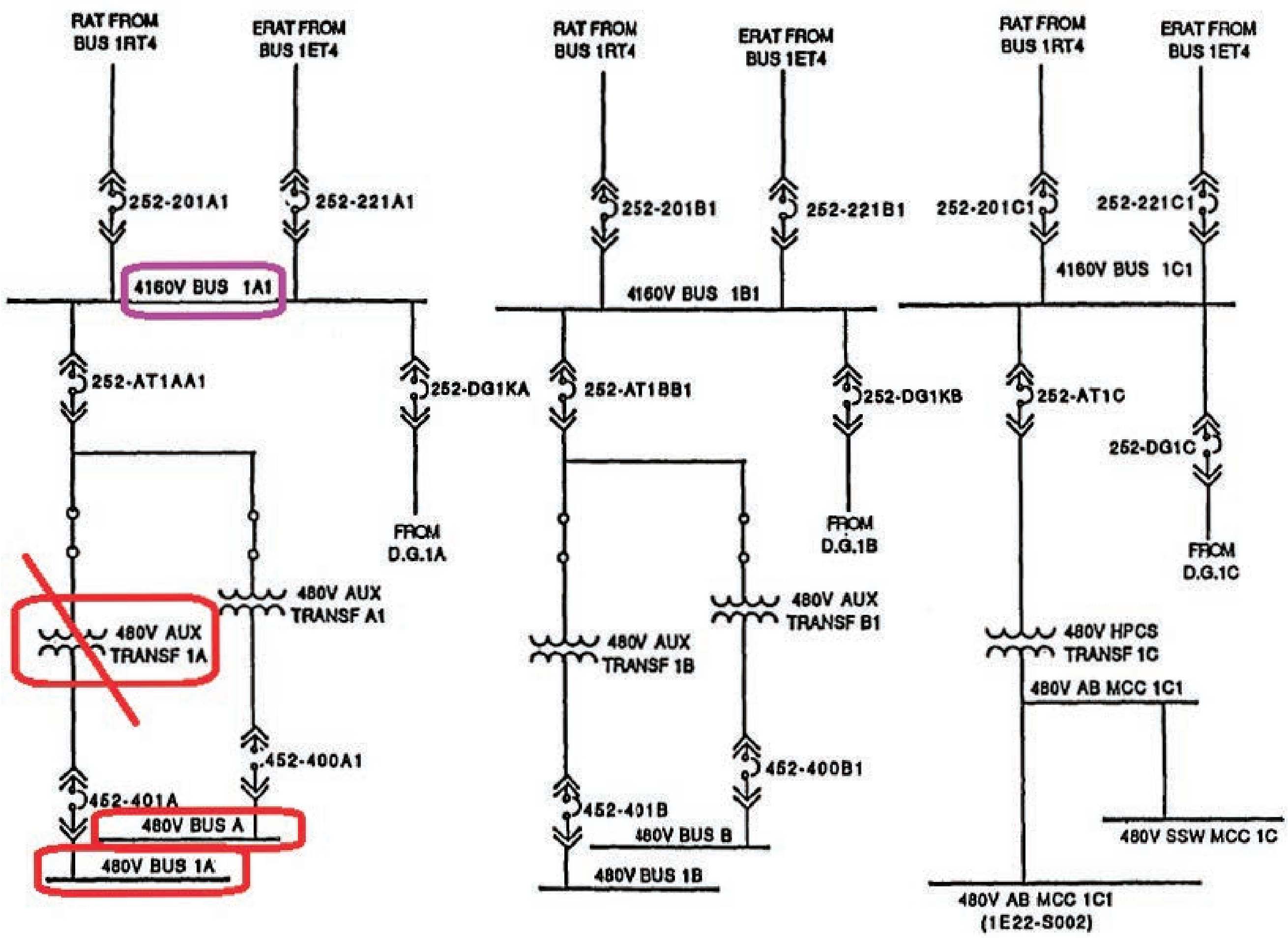
instrument air pressure, the control rods automatically insert to terminate the nuclear chain reaction and shut down the reactor. The electrical problem stopped the supply from air compressors to the control rod drive system. Normal leakage dropped the air pressure to the alarm setpoint. By procedure, the operators responded to the alarm by manually scramming the reactor.

The reactor was shut down, but the radioactive decay of unstable fission products in the nuclear fuel continued to produce about seven percent of the heat produced by the reactor at full power. Steam produced by the decay heat flowed through the main steam lines to the condenser where river water cooled it down and converted it back into water. The condensate and feedwater system pumped this water back into the reactor vessel to keep the reactor core safely covered with water.

The electrical problem also disabled the normal ventilation system for the Fuel Building. This system maintains the building's pressure slightly below ambient pressure outside the building. This design feature results in clean air leaking inward instead of potentially radioactively containment air leaking outward. At 8:43 p.m., the operators started the Standby Gas Treatment system to restore the negative pressure differential inside the Fuel Building.

The electrical problem that stopped the supply of compressed air to the control rod drive system also stopped the air flow to the main steam isolation valves. Normal leakage would eventually lead to the fail-safe main steam isolation valves automatically closing. Closure of the main steam isolation valves would eliminate the normal method—the main condenser—of cooling steam produced in the reactor vessel, and could thus result in one or more of the safety/

FIGURE 7. 4,160- and 480-Volt Electrical Distribution System at Clinton



Another electrical problem at Clinton caused more equipment at Clinton to lose power.

SOURCE: NUCLEAR REGULATORY COMMISSION, ANNOTATED BY UCS.

relief valves opening to discharge the steam into the water in the suppression chamber. Closure of the main steam isolation valves would also eliminate the normal method—the feedwater system—for providing makeup water to the reactor vessel. In that case, the reactor core isolation cooling (RCIC) system would take some of the reactor steam to spin its turbine to pump makeup water from the condensate storage tank into the reactor vessel.

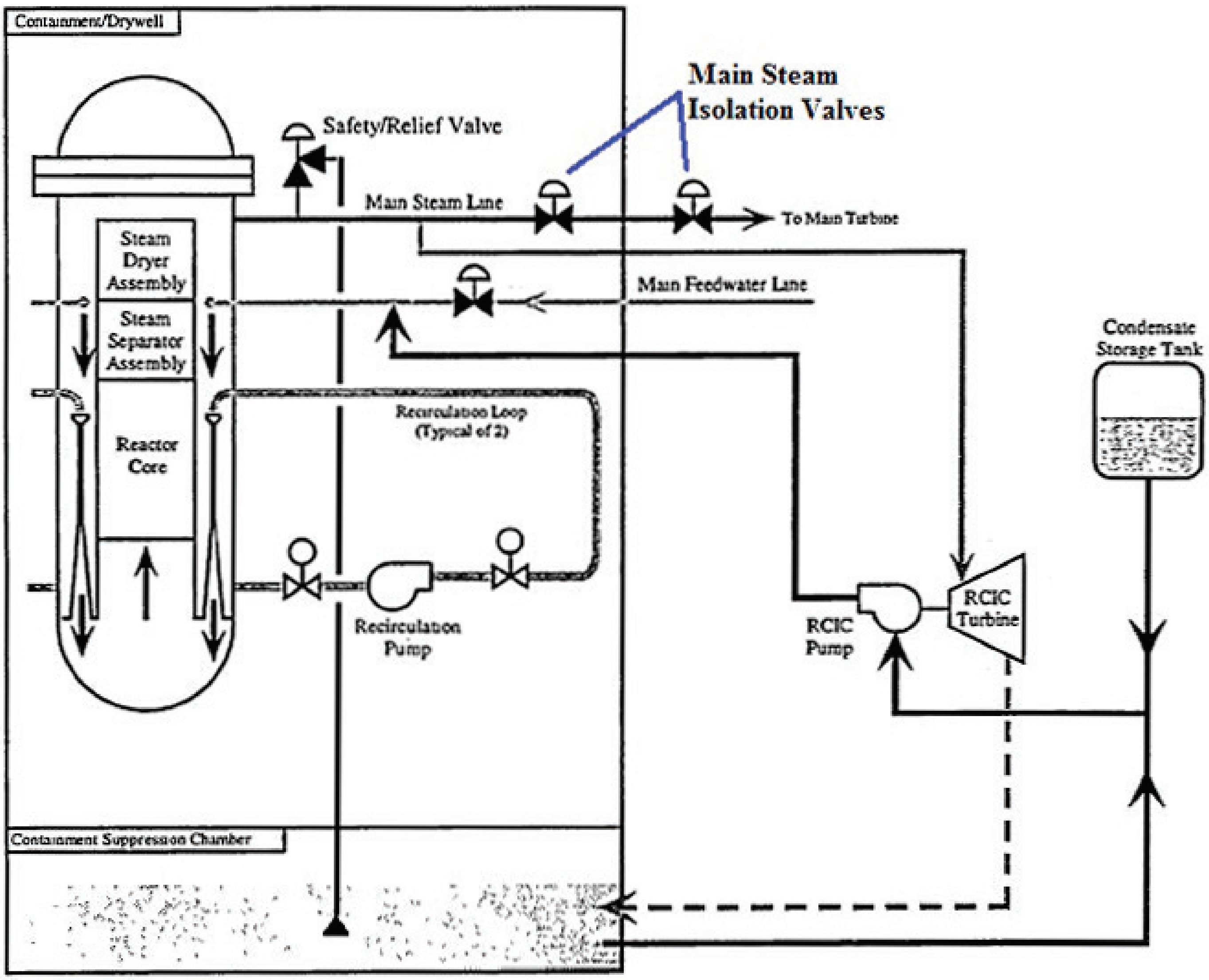
Anticipating closure of the main steam isolation valves, the operators started the residual heat removal system at 9:12 p.m. to cool the water in the suppression chamber. If safety/relief valves opened or the RCIC system operated, steam would enter the suppression chamber and warm up its water.

Represented by a single line in Figure 8 (p. 18), there are actually four main steam pipes between the reactor vessel and the main turbine and its condenser. Air pressure dropped low enough to close the first main steam isolation valve at 9:30 p.m. The second valve closed a minute later, the third 21 minutes later, and the fourth and final valve closed at 10:12 p.m.

Because the reactor had been operated for only a few weeks since refueling in October 2013 and because it had been shut down nearly an hour before the main steam isolation valves closed, the closure of the valves did not cause pressure to rise to the point where the safety/relief valves automatically opened.

The operators did not need to start the RCIC system to provide makeup water to the reactor vessel. Instead, they utilized non–safety-related systems to supply makeup water. The operators maintained a gradual cooldown of the reactor and placed it in cold shutdown—reactor water temperature below 212°F—at 5:38 a.m. on December 10 (Boland 2014).

FIGURE 8. Reactor Core Isolation Cooling (RCIC) System



The de-energized equipment at Clinton might cause the main steam isolation valves to close, forcing the pressure inside the reactor vessel to increase. Workers started the Reactor Core Isolation Cooling system that used steam from the reactor vessel. This step offset the closure of the main steam isolation valves and controlled pressure inside the reactor vessel.

SOURCE: NUCLEAR REGULATORY COMMISSION, ANNOTATED BY UCS.

NRC SANCTIONS

The NRC's SIT identified two Green findings in the mitigating systems cornerstone related to testing procedures for alternating current circuits. Workers troubleshooting the original problem in Auxiliary Transformer 1A incorrectly measured the electrical resistance between the three phases of the alternating current power supply instead of measuring the resistance between each phase and the ground. The second problem was related in that the procedure used by workers to test the electrical resistance had acceptance criteria that conflicted with the values recommended by the vendor (Boland 2014).

UCS PERSPECTIVE

Workers at the plant—with the exception of the minor electrical testing miscues—responded as expected during this event. They took proper and timely measures that lessened the severity of the event.

The NRC also responded commendably to this event. While hindsight might suggest that a special team inspection was not necessary, the initial event was complicated by loss of some emergency systems, brief loss of secondary containment integrity, and loss of the reactor's normal heat sink. Dispatching an SIT to the site to verify that equipment and worker responses were as expected is better than assuming or hoping that's the case.

Fermi, Unit 2, MI (First Incident)

THE NEAR MISS

The NRC sent an SIT to the plant on December 16, 2013, in response to the discovery of a vulnerability that could have allowed unauthorized and undetected entry into the protected area around the plant. Reflecting the NRC's post–9/11 procedures, the SIT report on the problems and their remedies is not publicly available. However, the cover letter sent to the plant owner with the SIT report is publicly available, and indicated that the agency identified a finding with Greater-than-Green significance (Shear 2014).

UCS PERSPECTIVE

The scant information publicly available about this security near miss prevents any meaningful commentary.

Grand Gulf Nuclear Station Unit 1, MS

THE NEAR MISS

The NRC sent an SIT to the plant on February 3, 2014, in response to a security event that occurred on January 15, 2014. Reflecting the NRC's post–9/11 procedures, the SIT report on the problems and their remedies is not publicly available. However, the cover letter sent to the plant owner with the SIT report is publicly available, and indicated that the agency identified one Green finding (Haire 2014).

UCS PERSPECTIVE

The scant information publicly available about this security near miss prevents any meaningful commentary.

Joseph M. Farley Nuclear Plant Unit 2, AL

THE NEAR MISS

The NRC sent an SIT to the plant after workers were unable to successfully test the solid state protection system—the system that monitors key parameters and automatically actuates safety equipment when undesired conditions are detected—and shut down the reactor. Workers determined the problem to be an electrical short on a printed circuit card. The SIT identified no regulatory requirement violations (Ehrhardt 2014).

The Grand Gulf Nuclear Station near Port Gibson, Mississippi—one of three nuclear plants in the U.S. to experience a security-related near miss in 2014.

© NRC

The Joseph M. Farley Nuclear Plant in Columbia, AL where plant workers and the NRC responded very well to reactor control problems.

HOW THE EVENT UNFOLDED

Sensors for key plant parameters send signals to the solid state protection system. When parameter values exceed specified limits, the solid state protection system automatically initiates safety responses such as shutting down the reactor within seconds or starting emergency pumps that provide makeup cooling water to the reactor vessel. The solid state protection system features two logic trains with multiple sensor inputs. This design protects against a single failed sensor from shutting down the reactor unnecessarily and allows workers to periodically test the system while the reactor continues to operate.

Workers began testing a portion of the solid state protection system on January 10, 2014. The operating license required this test be performed at least once every 84 days. About an hour into the test, workers encountered problems when test results did not match expected outcomes. Workers performed troubleshooting of the problems using an approved diagnostic procedure. During troubleshooting, the circuit breakers tripped on the 15-volt power supply to the solid state protection system. Workers contacted the solid state protection system's vendor, staff in the company's headquarters, and system engineers at other nuclear plants for assistance in identifying the problems.

When the 48-hour limit in the operating license for operating the reactor with an impaired solid state protection system ran out, the operators shut down the reactor on January 12.

As workers replaced potentially defective circuit cards within the solid state protection system, a metal clip was found that caused an electrical short across two pins on one card. Another card was also found with an electrical short caused by a stray metal clip. After replacing the cards, workers successfully completed the test and declared the solid state protection system operable on January 13.

The operators restarted the reactor on January 14 and achieved full power the following day.

The SIT reviewed past maintenance records and identified 10 circuit card failures in the past 20 years. The SIT also identified some routine maintenance procedures, such as periodically removing dust and debris from the solid state protection system cabinets using a vacuum cleaner or compressed air, that could have removed the metal clips before this event. Although the SIT found that additional preventative maintenance activities could have avoided this event, it did not find the maintenance activities to be inadequate or substandard (Ehrhardt 2014).

NRC SANCTIONS

The NRC's SIT identified no violations (Ehrhardt 2014).

UCS PERSPECTIVE

The plant's owner and the NRC responded well to this event. When problems with the solid state protection system were encountered during routine testing, workers implemented a mix of pre-planned and event-specific troubleshooting procedures. The event-specific procedures were approved after consultation with appropriate onsite, offsite, and vendor personnel.

When the troubleshooting efforts failed to find and fix the cause of the problem in the allotted time, the operators complied with regulatory requirements in the license and manually shut down the reactor.

Following a successful test of the solid state protection system to demonstrate that its problems had been adequately corrected, the operators restarted the reactor.

The NRC's SIT verified that appropriate administrative controls had governed the troubleshooting efforts and that operation with the impaired solid state protection system complied with regulatory requirements.

Millstone Power Station Unit 3, CT

THE NEAR MISS

The NRC sent an SIT in February 2014 in response to recurring problems with the turbine-driven auxiliary feedwater pump (Nieh 2014a).

HOW THE EVENT UNFOLDED

Millstone Unit 3 has a pressurized water reactor that began operating in 1986.

During normal operation, pumps within the condensate and feedwater systems transfer water from the condenser to the steam generators. Heat from the reactor coolant water flowing through tubes within the steam generator is conducted through the tube walls to boil water. Steam flows through the turbine which spins a generator to make electricity. Steam leaving the turbine gets cooled within the condenser and turned back into water for reuse.

The condensate and feedwater system are not safety-related. They cannot function without offsite power and are not assumed to function in the plant's safety studies in preventing reactor core overheating.

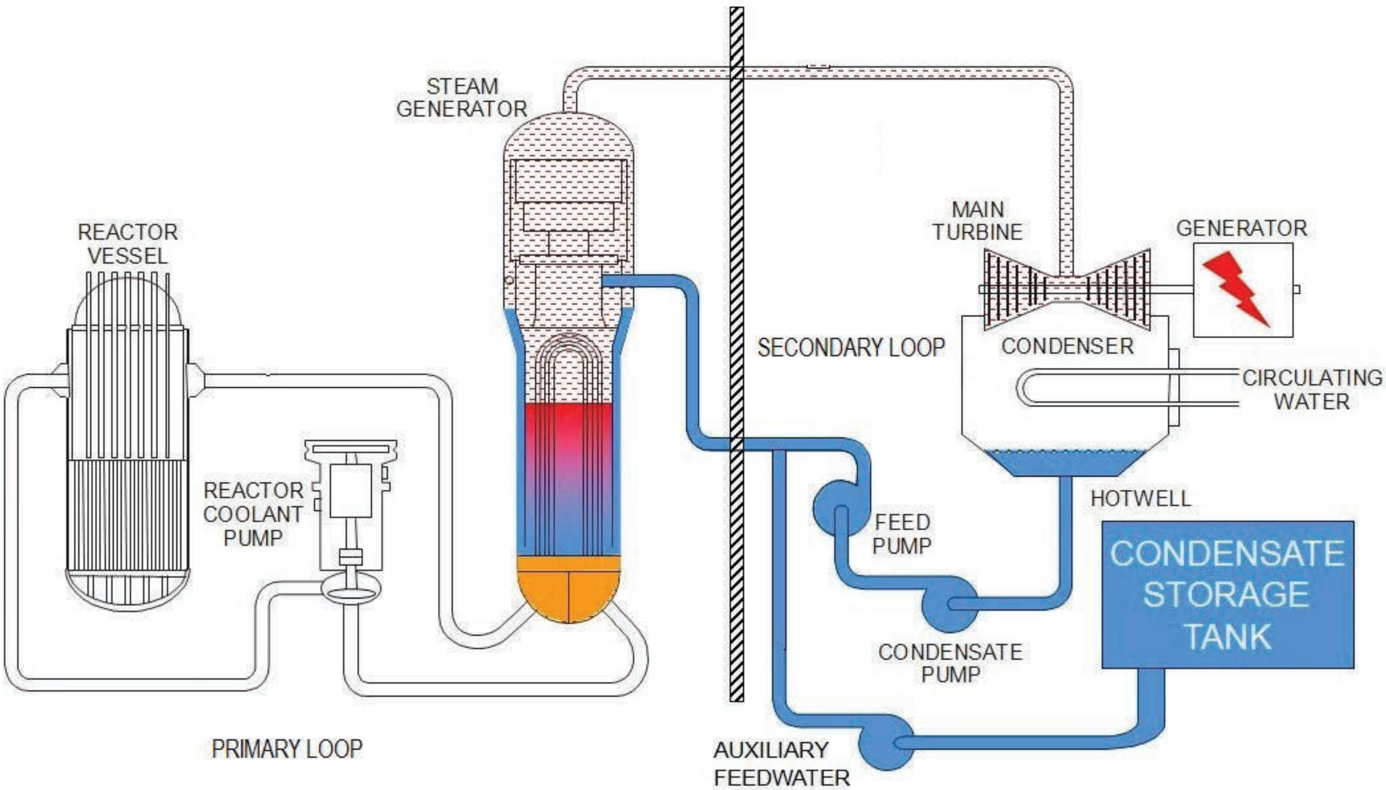
The auxiliary feedwater (AFW) is the safety-related backup to the normal condensate and feedwater systems (Figure 9, p. 22). Normally in standby mode during normal operation, the AFW pumps can transfer water from the condensate storage tank to the steam generators to remove heat from the reactor coolant. The AFW system is designed to mitigate the consequences of several design basis accidents and transients including a broken feedwater pipe, loss of normal feedwater flow, rupture of a steam generator tube, broken main steam pipe, small-break loss of coolant accident, and loss of offsite power.

The Unit 3 AFW system features two motor-driven pumps and one turbine-driven pump. Each of the motor-driven pumps has 50 percent capacity, meaning both must operate to provide the necessary makeup flow to the steam generators. The turbine-driven auxiliary feedwater (TDAFW) pump has 100 percent capacity (Figure 10, p. 23).

© NRC

The Millstone Power Station in Waterford, CT, which experienced two self-inflicted near misses in 2014 when recent maintenance and modifications introduced problems that reduced safety margins.

FIGURE 9. Normal and Auxiliary Feedwater Systems



During normal operation, the condensate and feedwater pumps supply water to the steam generators. The auxiliary feedwater pumps are in standby, ready to take over this task during accidents and when the normal makeup systems are unavailable.

SOURCE: NUCLEAR REGULATORY COMMISSION.

On February 3, 2014, the NRC announced it was sending an SIT to Millstone to investigate recurring problems with the TDAFW pump. The problems included unexpected oscillations in the speed of the turbine as well as unplanned shutdowns of the TDAFW pump.

The SIT traced the problems back to May 15, 2013. The Unit 3 reactor was nearing the end of its fifteenth refueling outage. Workers had replaced parts of the TDAFW pump on May 12 during routine maintenance. Operators started the TDAFW pump on May 15 for a required post-maintenance test. They observed that the turbine speed was fluctuating about 100 revolutions per minute (rpm) above and below steady state speed of about 4,500 rpm, with the peaks coming close to the point where the AFW pump would automatically shut down.

Workers adjusted the turbine speed control governor in an effort to dampen the oscillations. When operators retested the TDAFW pump on May 17, it failed to satisfy the acceptance criteria specified in the procedure. Management decided, however, that while the pump had not performed as well as desired by the test procedure, it had performed well enough to satisfy the role assumed in the safety studies. Based on that determination, the Unit 3 reactor was restarted from its refueling outage.

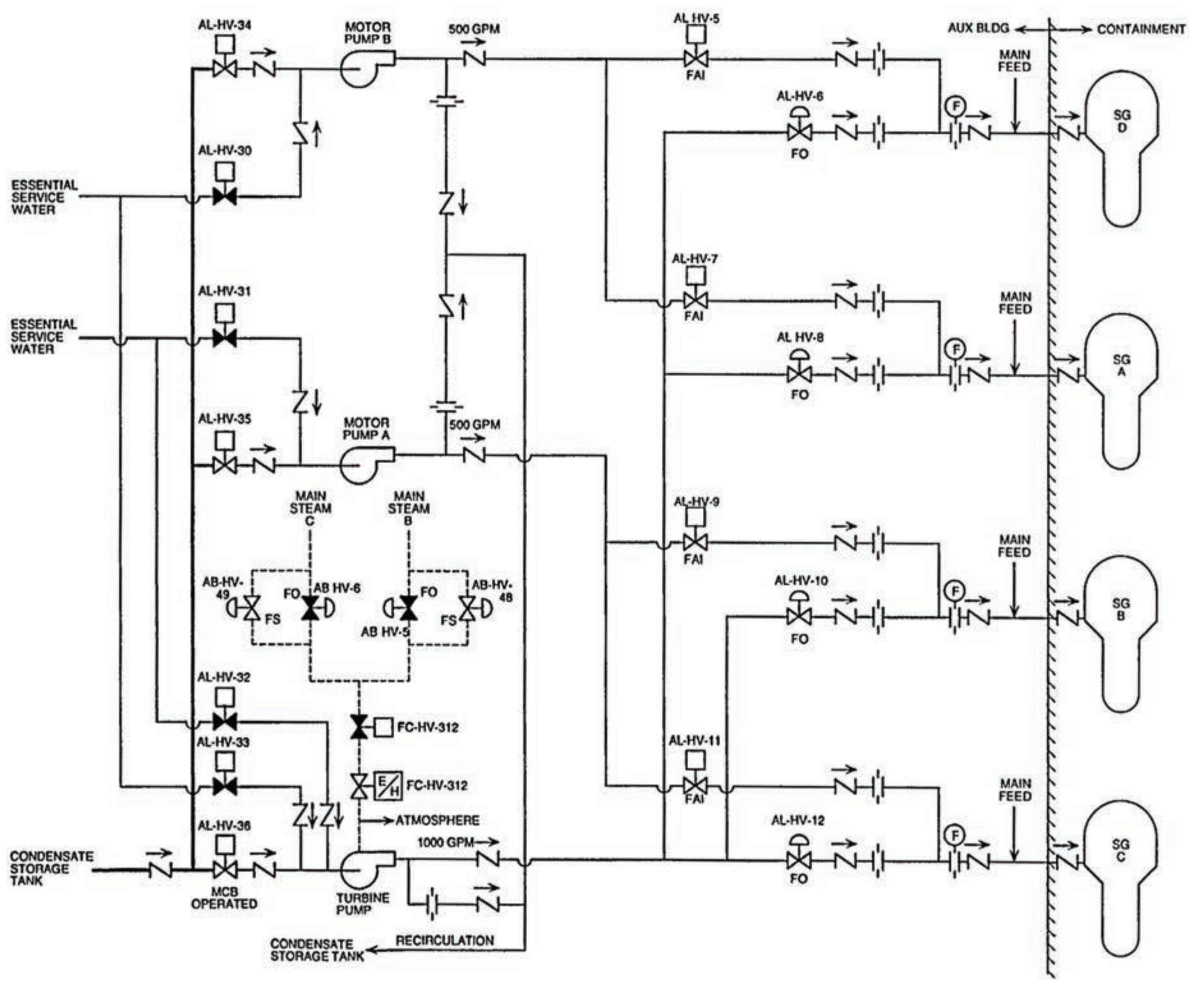
The reactor automatically shut down on August 9, 2013, and the TDAFW pump automatically started and provided makeup water to the steam generators. As the reactor core decay heat generation rate decreased following the shutdown, the operators reduced the amount of makeup flow provided by the TDAFW pump. They again observed that the turbine speed was fluctuating from as low as 4,350 rpm to as high as 4,656 rpm. The TDAFW was designed to automatically shut down when turbine speed increased to between 4,612 and 4,888 rpm, but it had not done so. The operators stopped the pump and called for maintenance help. Workers found the control linkage for the turbine's governor valve out of adjustment. They fixed this problem and Unit 3 was restarted.

During a quarterly test run on November 4, 2013, the TDAFW pump automatically shut down due to excessive turbine speed as it was starting. Workers attributed the cause to water condensing in the steam supply pipes and flashing to steam when the TDAFW pump started. Due to the recurring TDAFW pump problems, the testing frequency was increased to weekly.

During a test run on December 18, 2013, the TDAFW pump again automatically shut down due to excessive turbine speed as it was starting. Workers again attributed the cause to water condensing in the steam supply pipes and flashing to steam when the TDAFW pump started. Several steps were taken to preclude water accumulating in the idle steam lines when the TDAFW pump was in standby mode.

During a test run on January 23, 2014, the TDAFW pump again automatically shut down due to excessive turbine speed as it was starting. This time, workers did not blame water condensing in the steam supply lines. Conducting a fuller investigation, workers found that part of the control linkage between the turbine speed governor and the control valve had been installed backwards. They also found that a wrong part had been installed in the control linkage. The wrong part lacked an aluminum bronze insert that allowed the metal parts to move freely. These parts had been improperly installed during the original maintenance in May

FIGURE 10. Auxiliary Feedwater System on Millstone Unit 3



The auxiliary feedwater system on Millstone Unit 3 uses two motor-driven and one steam-driven pump to transfer water to the four steam generators. The steam generators are the fulcrum in the balance between the energy produced by the reactor core and the energy dissipated to the environment during an accident.

SOURCE: NUCLEAR REGULATORY COMMISSION.

2013 and contributed to the recurring TDAFW pump trips since then.

NRC SANCTIONS

The NRC's SIT identified a White finding (in the Green, White, Yellow, Red hierarchy from least to most serious) in the mitigating systems cornerstone for the owner's failure to promptly identify and correct a safety problem. The problem reduced the reliability of the TDAFW pump, which in turn increased the risk of reactor core damage. The risk increase resulted in a White rather than a Yellow or Red finding due to several factors. The problem did not impair the motor-driven AFW pumps. The problem impaired rather than disabled the TDAFW pump, as evidenced by the fact that the pump started and ran successfully more times than it failed between May 2013 and January 2014. The wrong parts were eventually identified and replaced in less than a year, limiting the window of opportunity for the vulnerability to have been exploited.

> ***Workers found that part of the control linkage between the turbine speed governor and the control valve had been installed backwards. They also found that a wrong part had been installed in the control linkage.***

UCS PERSPECTIVE

The TDAFW pump saga at Millstone remains open. On September 15, 2014, the NRC announced it was sending another special inspection team to Millstone to investigate more unexpected shutdowns of the TDAFW pump on Unit 3. The pumps shut down during quarterly test runs on July 15 and September 10.

The NRC's regulations require highly reliable safety systems. The TDAFW pump on Unit 3 clearly violates this regulation. The NRC's regulations also require that owners find and fix safety problems in an effective and timely manner. The recurring TDAFW pump problems clearly violate this regulation. At some point, the NRC needs to stop visiting Millstone to write chronicles about the latest TDAFW malfunctions and start regulating Millstone by writing tickets for violating federal regulations.

Millstone Power Station Units 2 and 3, CT

THE NEAR MISS

The NRC sent an SIT in response to a May 25, 2014, event in which the plant was disconnected from its offsite electrical power grid, causing the automatic shutdown of both operating reactors. The Unit 2 shutdown was as expected, with one minor exception. The Unit 3 shutdown was complicated by the loss of the normal means of controlling pressure and water inventory in the reactor vessel (Trapp 2014).

HOW THE EVENT UNFOLDED

The Unit 2 and 3 pressurized water reactors at the Millstone Power Station were operating at full power on the morning of May 25, 2014. (The Unit 1 reactor had been permanently shut down nearly two decades earlier.) Electricity produced by the Unit 2 and 3 generators flowed through the 345,000-volt switchyard and out to the offsite power grid via four transmission lines. Electricity also flowed through reserve station service transformers (RSSTs) to power in-plant equipment. One of the offsite transmission lines, the Haddam Neck 371 line, had been removed from service for planned maintenance (Figure 11, p. 25).

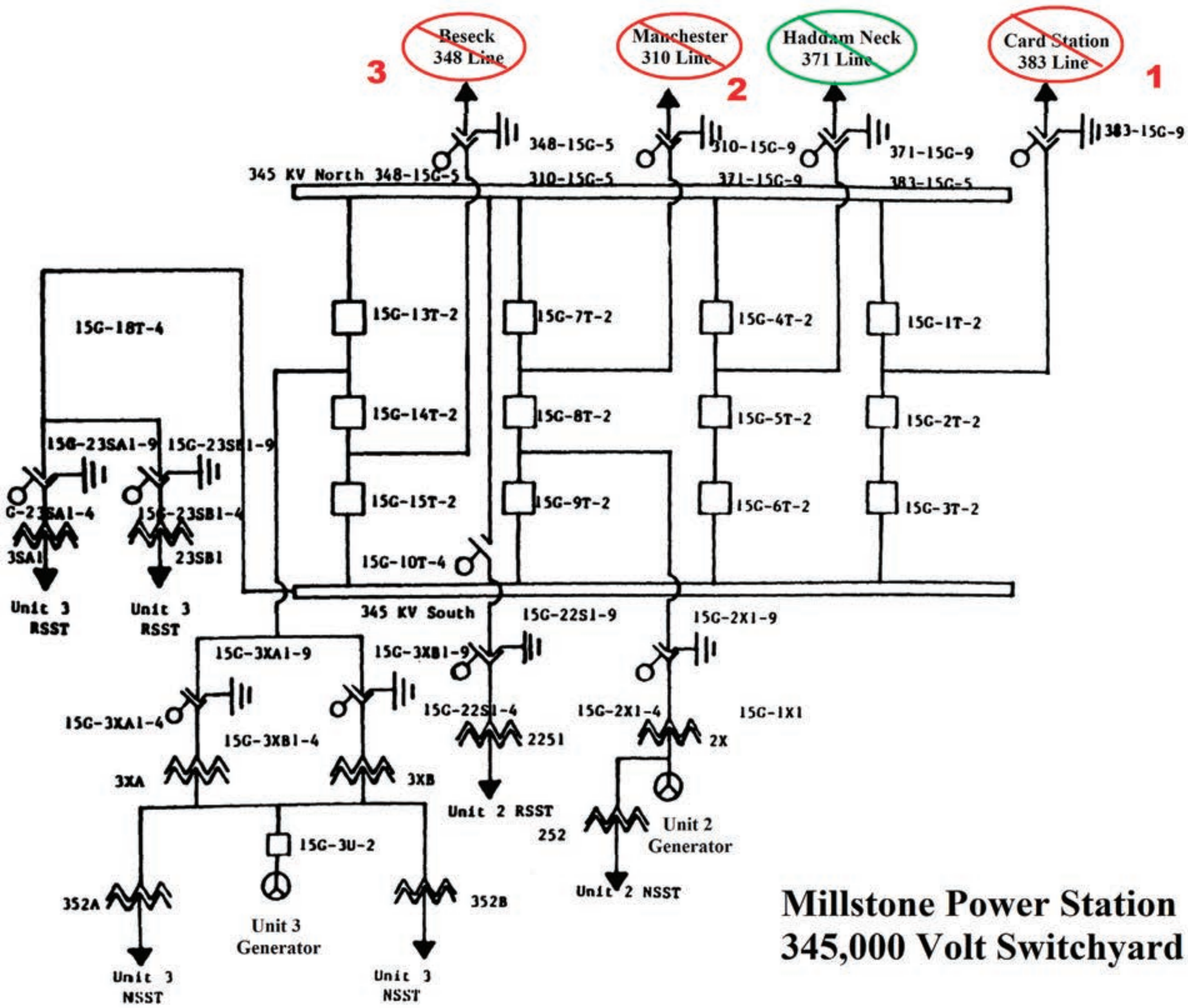
At 7:01 a.m., an electrical fault near the electrical substation near the town of Card caused the Card Station 383 line to trip.

The two remaining transmission lines should have been able to transmit the electricity from both Millstone reactors (a combined total of 2,166 megawatts) to the offsite grid. But the Manchester 310 line unexpectedly tripped on overcurrent. The remaining Beseck 348 line then also tripped on overcurrent as it was neither designed for nor capable of transmitting the electricity produced by both reactors at full power.

By design, the loss of the connections to the offsite power grid triggered the automatic shutdown of both reactors. The control rods inserted into the reactor cores within seconds to terminate the nuclear chain reactions. All the standby emergency diesel generators automatically started and soon supplied electricity to essential plant equipment.

The shutdown of the Unit 2 reactor transpired as expected with one minor exception. The initial power outage caused the pumps that take water from the condenser and send it through filters and demineralizers on its way to the steam generators to stop running. When power was restored, the

FIGURE 11. Electrical Distribution System at Millstone



The electricity generated by the two reactors at Millstone is carried to residential and commercial customers via four transmission lines. Prior to this event, one transmission line had been removed from service for maintenance. An electrical problem at an offsite substation tripped another line and started a domino effect that caused all four lines to be lost.

SOURCE: NUCLEAR REGULATORY COMMISSION, ANNOTATED BY UCS.

pumps resumed operating. In the meantime, some water had drained from the system's piping, perhaps back into the condenser. When the pumps restarted, refilling the piping caused water hammer-vibrations not unlike the movement of a rubber hose at home when its spigot is opened.

The shutdown of the Unit 3 reactor was significantly more complicated by the loss of the normal means for controlling pressure and water inventory in the reactor vessel. The initial loss of power turned off the air compressors. When power was restored, one of the air compressors was supposed to automatically restart but it failed to do so. The pneumatically-positioned valves in the letdown system closed on low air pressure. The letdown system normally allows some of the reactor cooling water to be drained to treatment systems. The operators adjust the letdown flow rate to match the rate that other systems are adding makeup water to the reactor coolant system. With the loss of the letdown system, the operators minimized the makeup flow rate but could not, for safety reasons, totally stop it.

Per procedure, the operators established an alternate letdown flow path that discharged water from the reactor head vents to the pressurizer relief tank.

The letdown system problem steadily increased the inventory of water in the reactor coolant system. Another power-related problem also caused pressure to rise. The normal means of controlling pressure of the reactor coolant system is to spray cool water into the pressurizer or turn on electric heaters in the pressurizer. The pressurizer is a large metal tank partially filled with water and connected to the reactor coolant system piping. It accommodates expansion and contraction of the reactor coolant system's water as it heats up and cools down and minor imbalances between letdown and makeup flow rates in addition to providing operators the ability to control pressure.

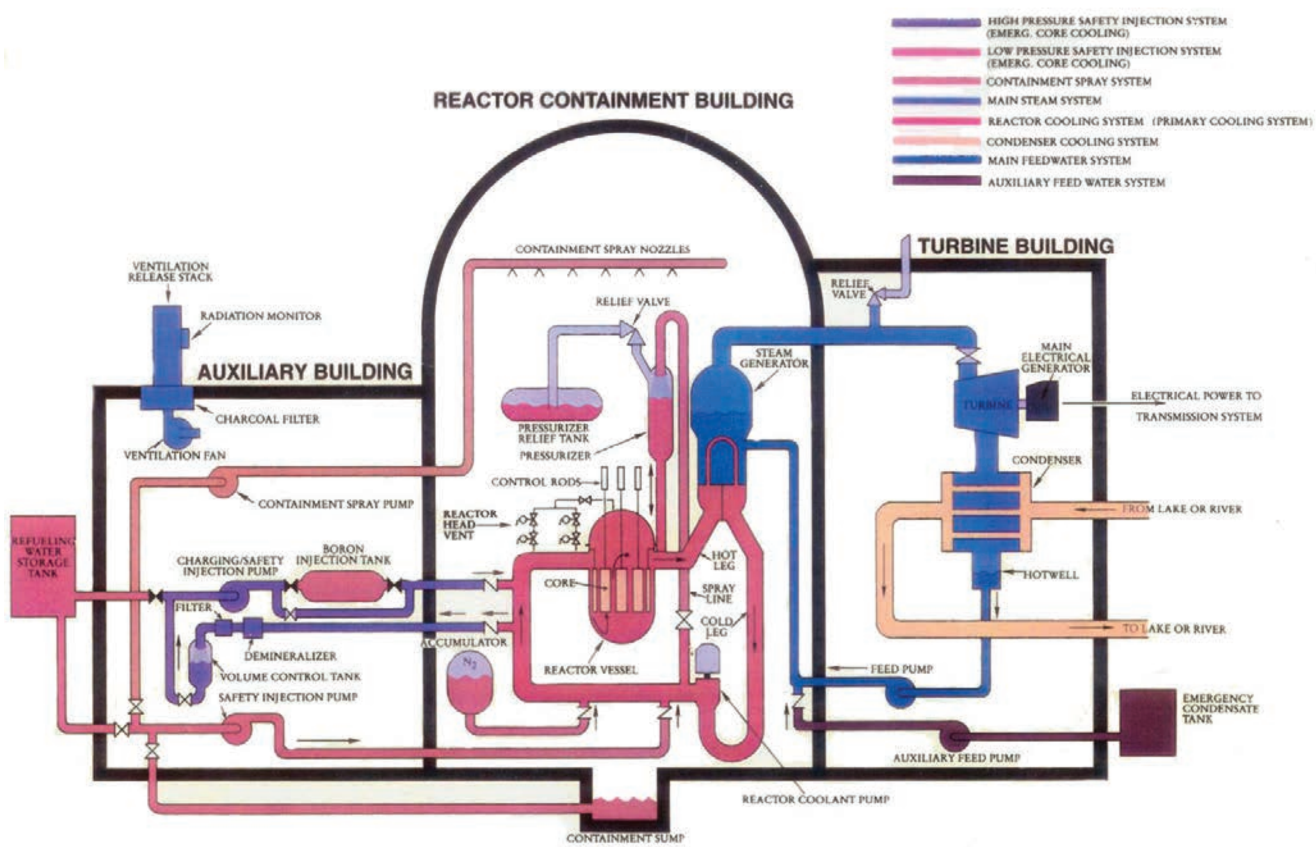
The reactor coolant pumps stopped running after the initial power loss. The reactor coolant pumps provide the cool water that is sprayed into the pressurizer to reduce reactor coolant system pressure. The emergency diesel generators supply electricity only to essential equipment—so the reactor coolant pumps remained off due to loss of power.

Per procedure, the operators handled the increasing pressure in the pressurizer by periodically opening and reclosing its relief valve. When open, the relief valve allowed water to flow from the pressurizer to the pressurizer relief tank.

The alternate letdown flow path and the cycled relief valves overfilled the pressurizer relief tank causing its rupture disc to open automatically about 2 hours and 20 minutes after the initial loss of power. Reactor cooling water now flowed onto the containment floor.

The circulating water pumps also stopped running after the initial power loss. The circulating water pumps draw water from the Long Island Sound and route it through thousands of tubes in the main condensers to cool steam exhausted from the main turbines. The loss of circulating water flow caused the condenser pressures to rise until rupture discs on the low pressure turbines automatically opened about 27 minutes after the initial loss of power. The operators responded by closing the main steam isolation valves a minute later. The valves' closure isolated the reactor core from its normal heat sink, the main condenser.

FIGURE 12. Pressurized Water Reactor Like Millstone Unit 3



A pressurized water reactor like Millstone Unit 3 showing the safety systems in the auxiliary building on the left and the systems used to generate electricity within the turbine building on the right.

SOURCE: NUCLEAR REGULATORY COMMISSION.

Workers re-connected the plant to the offsite power grid at 10:02 a.m. Within minutes, the operators were able to re-establish the normal systems for letdown and pressure control.

NRC SANCTIONS

The NRC's SIT identified one Severity Level III violation, one Green finding in the initiating events cornerstone and another Green finding in the mitigating systems cornerstone (Trapp 2014).

The violation stemmed from the December 20, 2012, disabling of an electrical protection device for the 345,000-volt switchyard without prior NRC review and approval. This device protected one transmission line when the other three transmission lines were unavailable. A single transmission line cannot handle more than 1,750 megawatts of electrical power without becoming unstable (both reactors were generating 2,166 megawatts of power at the time of this event). Had this device been in service on May 25, it would have responded to the loss of the third transmission line by automatically opening an electrical breaker in the switchyard. The breaker's opening would have caused Unit 3 to automatically shut down, but it would have enabled Unit 2 to continue operating and, more importantly, would have kept the plant connected to the offsite power grid.

The Green finding in the initiating events cornerstone was for the associated failure to implement effective design change control over the revision to the switchyard's electrical protection scheme.

The Green finding in the mitigating systems cornerstone was for the operators using the wrong procedure in responding to the Unit 3 shutdown. The operators entered procedure ES-0-1, "Reactor Trip Response," immediately following the automatic reactor shutdown and followed it until Step 14, which required the verification that offsite power was available. Since offsite power was not available, they stopped and did not proceed further in this procedure. But the NRC's SIT determined the operators should have, per procedures and training, transitioned from that procedure into procedure ES-0.2, "Natural Circulation Cooldown," that would have directed them in handling the actual conditions they faced.

UCS PERSPECTIVE

Federal regulations, specifically General Design Criterion 17 within Appendix A to 10 CFR Part 50, specify in the final two paragraphs:

> *Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. A switchyard common to both circuits is acceptable. . . .*
>
> *Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.*

[*The violation stemmed from the disabling of an electrical protection device for the 345,000-volt switchyard without prior NRC review and approval.*]

The Millstone Power Station has four transmission lines, exceeding the minimum of two physically independent circuits. But with one line out of service, a failure on one transmission line triggered the loss of the two remaining lines, plunging the entire plant into a loss of offsite power. This configuration seems, at best, to satisfy the letter of the law but clearly not its spirit. Defense-in-depth safety is not well served when a single failure results in all redundant offsite power supplies being lost.

River Bend Station Unit 1, LA

THE NEAR MISS

The NRC sent an SIT to the plant on March 21, 2012, in response to a security event that occurred on March 18. Reflecting the NRC's post–9/11 procedures, the SIT report on the problems and their remedies is not publicly available. However, the cover letter sent to the plant owner with the SIT report is publicly available, and indicated that the agency identified one finding with Greater than Green significance (Vegel 2014).

The plant's owner contested the NRC's proposed sanction and elected to resolve the matter via the agency's Alternate Dispute Resolution (ADR) process. During the ADR mediation session, the NRC and the owner agreed on the basic facts in the case—that a security officer's actions at River Bend willfully violated federal security regulations. The owner and the NRC agreed to a number of steps to upgrade the security program at River Bend. In addition, the owner agreed to pay a $70,000 civil penalty (Dapas 2014).

UCS PERSPECTIVE

The scant information publicly available about this security near miss prevents any meaningful commentary. However, it is disturbing that the NRC's process took over 2.7 years (from March 18, 2012, to December 3, 2014) to require fixes to known security shortcomings. Whatever the non-disclosed upgrades are, they would have been immensely more effective had they been implemented in 2012 instead of in 2015.

> ***The near misses from last year and prior years strongly suggest that the NRC and the nuclear industry need to put more attention on electrical systems to prevent recurrence of old problems and the introduction of new problems.***

Observations on the Near Misses in 2014

The majority of the near misses last year involved electrical problems, sustaining a trend from prior years. Given that nuclear power plants' primary purpose is to generate electricity and utilize a considerable array of electrical equipment to do so, it's not surprising for electrical problems to occur.

But these near misses did not involve garden variety electrical problems. Instead, these near misses involved failure of the devices specifically installed to prevent garden variety electrical problems from becoming overgrown. At both Calvert Cliffs and Millstone, garden variety electrical problems that should have, at most, caused one reactor to automatically shut down, cascaded to take out both reactors.

At least two of the electrical problems (e.g., Catawba and Millstone) did not exist at the plants until they were recently introduced by modifications and maintenance.

The near misses from last year and prior years strongly suggest that the NRC and the nuclear industry need to put more attention on electrical systems to prevent recurrence of old problems and the introduction of new problems.

The NRC's SITs at Calvert Cliffs, Catawba, and Joseph M. Farley did not identify any findings. The NRC's report on Farley's event explained why no findings were warranted. But the NRC's reports on Calvert Cliffs and Catawba described opportunities in the past that, had workers taken measures mandated by federal regulations, would have avoided the near misses. In other words, the NRC's reports described violations of federal regulations but did not explain why those findings were dismissed.

The NRC's SITs at Clinton, Millstone Unit 3, and Millstone Units 2 and 3 made findings based on violations of federal regulations. The NRC's reports described the violations that justified the associated findings. The violations described in the NRC's reports for Calvert Cliffs and Catawba were at least as serious as the violations flagged by the NRC at Clinton and Millstone Units 2 and 3. The "Inconsistently Applying Standardized Oversight" section in Chapter 5 discusses further the broader theme of inconsistent NRC treatment of similar infractions.

Last year, as in previous years, a small number of the near misses involved security problems. Quite properly, the NRC does not explicitly describe the security systems and associated vulnerabilities in the public reports on the near misses. But the NRC needs to find ways to better communicate to the public about these events. For example, the NRC publicly reported that the near miss at River Bend involved a security officer's willful actions that caused federal security regulations to be violated but did not characterize the nature of the offending actions.

The NRC needs to find a better balance between the public's right to know and the agency's need to withhold sensitive information.

Trends from Near Misses 2010–2014

This chapter describes our analysis of the data from the nuclear reactor near misses reported in our five annual reports covering the years 2010 through 2014.

As presented in Table 3 (p. 31), 81 near misses were reported at 53 different reactors over these five years. The number of reactors experiencing near misses decreased from 19 in both 2010 and 2011, 18 in 2012, and 14 in 2013 to 11 in 2014. As noted above in the "Observations of Near Misses" section of Chapter 2, there was also a reduction in the significance of near misses in 2014 compared with the prior four years. The decrease in number of reactors experiencing near misses coupled with lessening of the severity of such events is encouraging. The longer this trend continues, the more likely that it reflects true performance gains rather than luck.

Five reactors, including the three shaded in Table 3 (p. 30), have permanently shut down during this period while no new reactors have joined the U.S. fleet. Because 99 reactors continue operating, the retirement of five reactors is an insignificant factor in the decline in near misses, so the improvement appears to be real.

More than half of the nation's reactors experienced at least one near miss between 2010 and 2014. The 81 near misses in five years means there's been an average of one nuclear reactor near miss every 22.5 days. Although the number of near misses declined, still averaging more than one near miss per month is not grounds for rejoicing.

While none of the 81 near misses over the past five years harmed the general public (as opposed to workers), the "safety pyramid" provides ample reason to reduce their occurrence. Introduced by H. W. Heinrich in his 1931 book *Industrial Accident Prevention,* the safety pyramid explains the relationship between the numbers of accidents and their severity levels.[3] As suggested by its name, the larger the base of minor accidents, the more often major accidents will occur. By reducing the situations and behaviors that lead to near misses, one reduces the number of serious accidents, too.

[***Although the number of near misses declined, still averaging more than one near miss per month is not grounds for rejoicing.***]

While both the number and severity of near misses dropped in 2014 compared to events from 2010 to 2013, it is far from time to declare victory and reallocate resources and attention elsewhere. Positive outcomes reinforce the need for the efforts that achieved them rather than suggest the efforts have served their purpose and can be trimmed or eliminated. If anything, once movement in the right direction is verified, it's time to step on the accelerator instead of letting up or applying the brakes.

4 *See* http://www.skybrary.aero/index.php/Heinrich_Pyramid.

TABLE 3. Near Misses 2010 to 2014

	Reactor	Total Number of Near Misses	Near Misses in 2010	Near Misses in 2011	Near Misses in 2012	Near Misses in 2013	Near Misses in 2014
1	Arkansas Nuclear One Unit 1	2	1			1	
2	Arkansas Nuclear One Unit 2	2	1			1	
3	Braidwood Unit 1	2	1	1			
4	Braidwood Unit 2	2	1	1			
5	Browns Ferry Unit 1	1				1	
6	Browns Ferry Unit 2	1				1	
7	Browns Ferry Unit 3	1				1	
8	Brunswick Unit 1	1	1				
9	Brunswick Unit 2	2	1		1		
10	Byron Unit 1	1		1			
11	Byron Unit 2	2		1	1		
12	Callaway	1		1			
13	Calvert Cliffs Unit 1	2	1				1
14	Calvert Cliffs Unit 2	2	1				1
15	Catawba Unit 1	3	1		1		1
16	Catawba Unit 2	1	1				
17	Clinton	1					1
18	Columbia	3				3	
19	Cooper	1		1			
20	Crystal River Unit 3	1	1				
21	Davis-Besse	1	1				
22	Diablo Canyon Unit 2	1	1				
23	Farley Unit 1	1			1		
24	Farley Unit 2	2	1		1		
25	Fermi Unit 2	1					1
26	Fort Calhoun	4	1		2	1	
27	Grand Gulf	1					1
28	H.B. Robinson	2	2				
29	Joseph M. Farley Unit 2	1					1
30	LaSalle Unit 1	1				1	
31	LaSalle Unit 2	1				1	
32	Millstone Unit 2	2		1			1
33	Millstone Unit 3	2					2

CONTINUED

TABLE 3. Near Misses 2010 to 2014 (continued)

	Reactor	Total Number of Near Misses	Near Misses in 2010	Near Misses in 2011	Near Misses in 2012	Near Misses in 2013	Near Misses in 2014
34	North Anna Unit 1	1		1			
35	North Anna Unit 2	1		1			
36	Oconee Unit 1	1		1			
37	Oconee Unit 2	1		1			
38	Oconee Unit 3	1		1			
39	Oyster Creek	1				1	
40	Palisades	3		2	1		
41	Palo Verde Unit 1	1			1		
42	Palo Verde Unit 2	1			1		
43	Palo Verde Unit 3	1			1		
44	Perry	2		1	1		
45	Pilgrim	2		2			
46	River Bend	2			1		1
47	San Onofre Unit 2	1			1		
48	San Onofre Unit 3	1			1		
49	Shearon Harris	2			1	1	
50	Surry Unit 1	1	1				
51	Susquehanna Unit 2	1				1	
52	Turkey Point Unit 3	1		1			
53	Wolf Creek	4	1	1	2		
	Total	81	19	19	18	14	11

The overall number of near misses continues to decline each year, as does the number of affected sites and the severity of events.

SOURCE: UCS.

Positive Outcomes from NRC Oversight

This chapter describes situations in 2014 where the NRC acted to bolster nuclear safety. These positive outcomes are not necessarily the best the NRC achieved last year—to make that claim, we would have had to review and rate all NRC efforts. Nor are these outcomes the only positive ones the NRC achieved last year—far from it. Instead, we chose situations with good outcomes that show that the NRC can be an effective regulator and provide insights into how the agency can emulate these commendable outcomes more consistently.

[NRC undertook two separate extensive projects in 2013 to evaluate the program and recommend enhancements.]

Fixing It Before It Breaks

The NRC adopted its Reactor Oversight Process (ROP) in April 2000 to monitor safety levels at the nation's operating nuclear power reactors and to intervene when declining safety was identified. Through devices such as annual assessments solicited from internal and external stakeholders, the NRC has revised the ROP many times over the years to improve its effectiveness and efficiency. Despite no evident signs that the ROP was broken, the NRC undertook two separate, extensive projects in 2013 to evaluate the program and recommend enhancements. Both projects concluded in 2014 and chronicled their efforts and results in publicly released reports.

The Reactor Oversight Process Independent Assessment was conducted by six NRC staffers led by Brian McDermott. The team made eight recommendations and ten suggestions for improvements to the ROP (McDermott 2014).

The Reactor Oversight Process Enhancement Project focused on the baseline inspection program. The baseline inspection program consists of the inspections conducted by the NRC at each operating nuclear power reactor. When declining safety levels are identified, supplemental inspections are invoked. The ROP Enhancement Project was conducted by nearly three dozen staffers from the NRC's headquarters offices as well as from all four regional offices. The project team conducted public meetings to solicit input from external stakeholders (e.g., industry representatives and UCS). The project team made numerous recommendations for improvements to the ROP (Nieh 2014b).

Two aspects of the ROP Enhancement Project were particularly admirable. First, it was a very inclusive effort involving NRC resident inspectors at nuclear plants, NRC specialty inspectors from regional and headquarters offices, NRC mid-level and senior managers, industry representatives, and public interest groups (see box, p. 33). These participants have different needs and priorities. By soliciting many perspectives, the project team lessened the chances that good intentions here might have unintended consequences there.

And second, the project team sought zero-sum outcomes. It is tempting to overlay new efforts on top of existing efforts, thus diluting focus on key issues. The ROP Enhancement Project aimed to either make existing efforts more effective or replace existing efforts with ones designed to yield better safety outcomes. Such discipline is important because even the best jugglers in the world can get too many balls up in the air.

UCS views the ROP as the best protection the public has against safety problems at nearby nuclear power plants caused by aging equipment, cost-cutting measures, and other causes. That the NRC proactively undertook two separate efforts to strengthen and improve this important safety net is very commendable.

Plugging the Brain Drain

A decade ago, the NRC realized it faced a challenge—its work force was aging and many experienced individuals would be retiring. The agency could, and did, hire capable replacements with comparable skills and qualifications. But retirees would take considerable tribal knowledge with them into their golden years. The NRC initiated a formal knowledge management effort in 2006 intended to capture as much of this invaluable experience as possible and facilitate its acquisition by newly hired staff (Reyes 2006).[5] In other words, the NRC sought to plug the "brain drain" as experienced workers left the agency.

Three facets of the NRC's multi-faceted knowledge management program are its knowledge management publications, its Communities of Practice, and its Ask the SME series (Hudson et al. 2014).

To date, the NRC has published eight knowledge management reports about events (for example, on the Three Mile Island and Fukushima accidents, the Browns Ferry fire,

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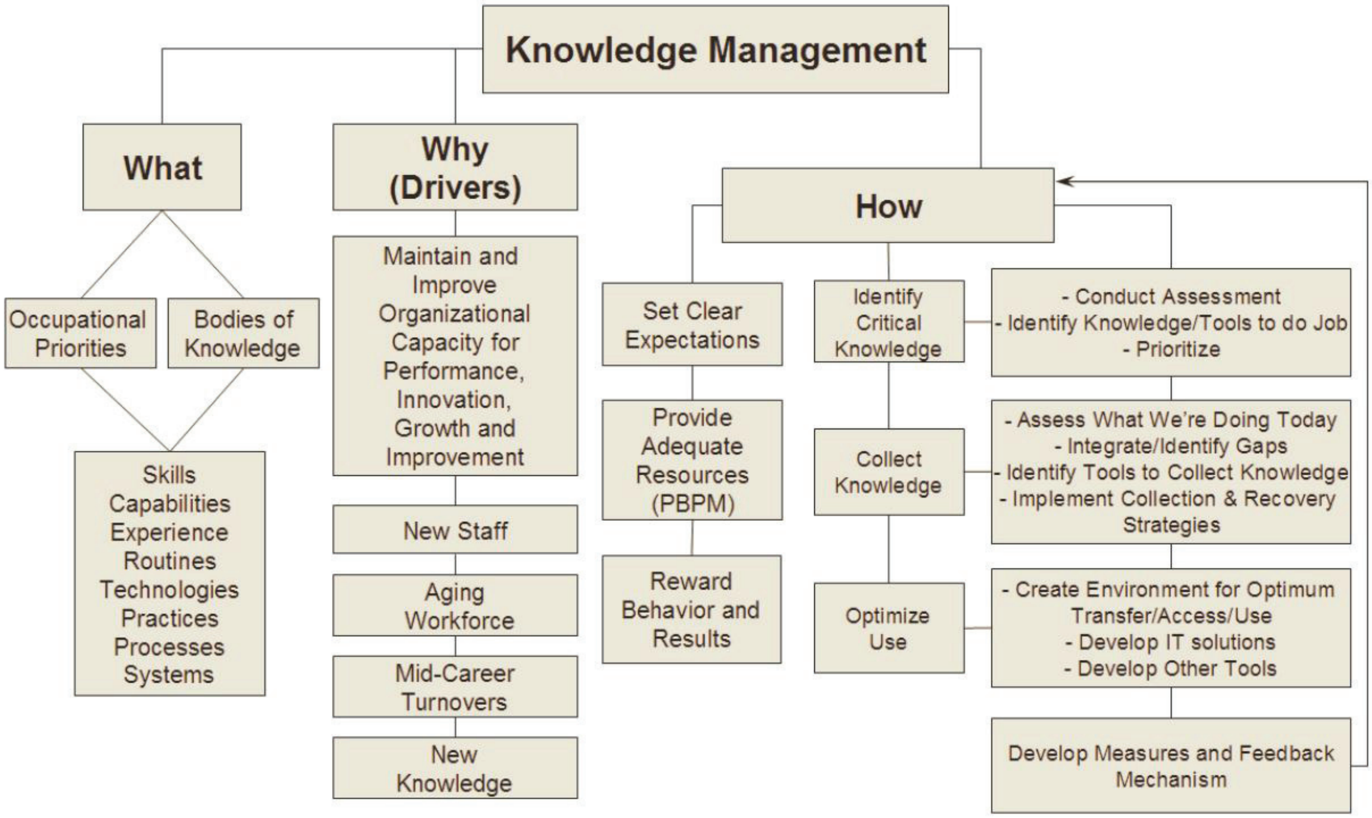
The NRC's ROP enhancement project involved staff from all four regional offices and virtually all departments within its headquarters office.

SOURCE: NUCLEAR REGULATORY COMMISSION.

FIGURE 13. NRC Knowledge Management Program



A decade ago, the NRC initiated a knowledge management program to capture the experience of aging workers soon to retire.

SOURCE: NUCLEAR REGULATORY COMMISSION

and the Davis-Besse reactor vessel head degradation) and safety research (for example, fuel behavior under abnormal conditions and fire safety) that have been posted to its website at *http://www.nrc.gov/reading-rm/doc-collections/nuregs/knowledge*. The Browns Ferry report includes a DVD containing the reflections of the late Jack Lewis about the fire. Lewis worked at Browns Ferry at the time of the March 1975 fire and commented about coping with the fire as well as the changes made to the plant and its procedures in response to it. The Three Mile Island report also includes a DVD containing the reflections of Ed Frederick, who was an operator inside the control room at the time of the accident; Harold Denton, who was the NRC's Director of the Office of Nuclear Regulation at the time and was dispatched by President Jimmy Carter to the site as the federal government's representative; and Richard Thornburgh, governor of Pennsylvania at the time who made the tough decisions about public health measures.

The Communities of Practice are sections of the agency's intranet that allow staff to share information. For example, staff can post discoveries made during recent inspections or reviews. In addition, staff seeking answers to nuclear safety questions (or assurance that their answers are correct) can post those questions and solicit answers from their peers.

The NRC initiated its Ask the Subject Matter Expert (Ask the SME) series in 2013. NRC experts field questions from staff both in the room and participating by videoconference. The sessions are videotaped and the videos uploaded on the NRC's intranet to make this information available to new staff.

If information is power, the NRC's knowledge management program boosts the agency's horsepower.

5 This is not to imply that the NRC failed to manage knowledge prior to 2006. The program initiated by the NRC in 2006 built upon and expanded efforts up to that time.

© NRC

The Three Mile Island knowledge management report includes a DVD that contains historical documents and archival photographs like this one, of NRC staff meeting to discuss the event.

Observations on Effective NRC Oversight

The positive outcomes summarized in this section share the admirable traits of being proactive and encompassing. It is easy to keep fighting yesterday's battles. It is harder to take steps to avoid tomorrow's battles.

The NRC undertook the ROP Independent Assessment and the ROP Enhancement Project not in response to clear-cut signs of deficiencies but to make an effective tool even better. The NRC involved a large number of individuals in the efforts seeking the greatest good for the greatest number.

A decade ago, the NRC initiated its knowledge management program. No accident or near miss had been linked to awareness lost when NRC veterans retired months and years before. Yet the NRC de-briefed veterans to capture their experiences before retirements. And the NRC captured those experiences in ways that make them accessible to workers of tomorrow and not just those workers fortunate enough to hear the de-briefings in person.

If a stitch in time truly saves nine, the NRC's efforts came out dozens of stitches ahead.

Negative Outcomes from NRC Oversight

This chapter describes situations that arose or were revealed in 2014 where lack of effective oversight by the NRC led to negative outcomes. These outcomes are not necessarily the worst the NRC achieved last year. Rather, they shed light on practices and patterns that prevent the NRC from achieving the return it should from its oversight investment.

Chapter 4 above provided positive outcomes achieved by the NRC last year—an abridged listing demonstrating that the NRC is a capable regulator. The abridged listing in this chapter demonstrates, however, that the NRC has some consistency issues to work through.

[***The NRC has systematically withheld virtually all documents it received from nuclear plant owners about fire protection and emergency planning since October 2004.***]

Improperly Hiding Information (Revisited)

Last year's report in this annual; series, *The NRC and Nuclear Power Plant Safety in 2013: More Jekyll, Less Hyde*, described how the NRC mandated that steps be taken to address a flooding hazard at the Oconee Nuclear Station in Seneca, South Carolina in 2010 nine months before Fukushima, but withheld information about that problem and its solution from the public until a reporter obtained the records through the Freedom of Information Act in 2013. The NRC could have, and should have, openly communicated about the situation at Oconee the same way the agency publicly communicated about similar flooding problems that same year at the Fort Calhoun Station in Nebraska (Collins 2010); the Browns Ferry Nuclear Plant in Athens, AL the Sequoyah Nuclear Plant in Soddy-Daisy, TN; and the Watts Bar Nuclear Plant in Spring City, TN (Lingam 2010).

The NRC has been improperly withholding even more information from the public for a longer period. As detailed in "Senseless Deprivation: The NRC Hiding Documents from the Public" (post to the blog *All Things Nuclear* available at *http://allthingsnuclear.org/senseless-deprivation-the-nrc-hiding-documents-from-the-public)*, the NRC has systematically withheld virtually all documents it received from nuclear plant owners about fire protection and emergency planning since October 2004 (Figure 14, p. 37). The NRC knew these documents were unlikely to contain information that "will need to be designated as sensitive," yet they withheld the records from the public with no explanation. Most onerous about this ill-conceived practice was that the NRC withheld documents involving requests by plant owners for revisions to reactor operating licenses and exemptions from federal safety regulations. The NRC approved the license changes and granted the exemptions, depriving the public of its legal rights under federal regulations to contest the licensing requests.

For example, the owners of Crystal River 3 in Florida and Kewaunee in Carlton, WI, asked the NRC for permission

FIGURE 14. Portion of Table from NRC Paper SECY-04-0191

Fire Protection	"Incoming documents are initially profiled as nonpublic—staff will review for release upon request. Most information related to fire protection will not need to bedesignated as sensitive. Drawings showing details such as the specific location of equipment, doorways, stairways, etc. are to be withheld under 10 CFR 2.390."
Emergency Planning	"Incoming documents are initially profiled as nonpublic—staff will review for release upon request. Most information related to emergency planning will not need to be designated as sensitive. Special attention is needed to determine if information relates to the response by a licensee or government agency to a terrorist attack. Note that some State and local governments consider parts of their emergency plans to be sensitive."

In October 2004, the NRC decided to withhold all documents it received from plant owners about fire protection and emergency planning even though the agency realized these documents were not likely to contain information that could be used to sabotage nuclear plants.

SOURCE: NUCLEAR REGULATORY COMMISSION, WITH HIGHLIGHTS BY UCS.

The NRC transformed what it touts as an open and transparent licensing process into secret negotiations between it and plant owners.

to significantly reduce the scope of emergency planning measures. The NRC withheld from the public these requests and all updates to the emergency plans submitted by the owners since October 2004. The public had no chance to see the requested reductions in measures developed to protect them in event of a nuclear accident and legally intervene if they felt the proposed changes would lessen protection levels.

Likewise, the NRC withheld from the public requests by several owners over the past decade to revise procedures and equipment intended to protect against fires at nuclear plants. The NRC also withheld numerous reports by plant owners about deficient procedures and malfunctioning equipment that resulted in elevated risk from the fire hazard. In doing so, the NRC transformed what it touts as an open and transparent licensing process into secret negotiations between it and plant owners.

That the NRC could have, and should have, made these documents publicly available was demonstrated by the public process the agency used to revise its security regulations following the 9/11 tragedy (Borchardt 2008).

In response to 9/11, the NRC revised regulation 10 CFR 2.390, "public inspections, exemptions, requests for withholding," to provide the means for plant owners to withhold from public disclosure sensitive information. Thus, if a document being submitted to the NRC contains sensitive information that might aid saboteurs, this revised regulation describes how the document should be properly handled.

UCS neither expects nor seeks that all information about nuclear power plants be made publicly available. Nuclear plants are vulnerable to sabotage and certain information could be used maliciously in planning and executing sabotage attacks. UCS wholeheartedly supports the need to keep such information out of the public domain.

None of the hundreds of fire protection and emergency planning documents withheld by UCS, however, was requested by the plant owners submitting them to be withheld in whole or in part. Yet the NRC hid them from the public anyway with no explanation. Moreover, when the NRC finally released the documents to the public in response to a Freedom of Information Act request submitted by UCS, no text was redacted from the fire protection records and only personal information (i.e., home and cell phone numbers) was redacted from the emergency planning records (Figure 13, p. 38).

UCS and a coalition of non-governmental organizations have formally asked the NRC's Chairman to terminate the unsavory practice of blanket withholding incoming documents about fire protection and emergency planning (Lochbaum 2014b).

UCS has also formally asked the NRC's Inspector General to investigate the agency's information blackout practices to ascertain how many federal statutes and regulations have been violated (Lochbaum 2014a).

Chilling the Workers

Lawrence S. Criscione and Dr. Michael Peck have much in common:

- Both work for the NRC.
- Both have decades of experience in the U.S. civilian nuclear power industry and the NRC.

- Both have been the subject of multiple investigations by the NRC's Office of the Inspector General (OIG).
- Both still work for the NRC.
- Both have had promising NRC careers detoured into cul-de-sacs, unlikely to ever receive another promotion.

What crimes did these two long-time nuclear veterans commit to warrant each being the target of repeated investigations of wrongdoing? None, literally and figuratively.

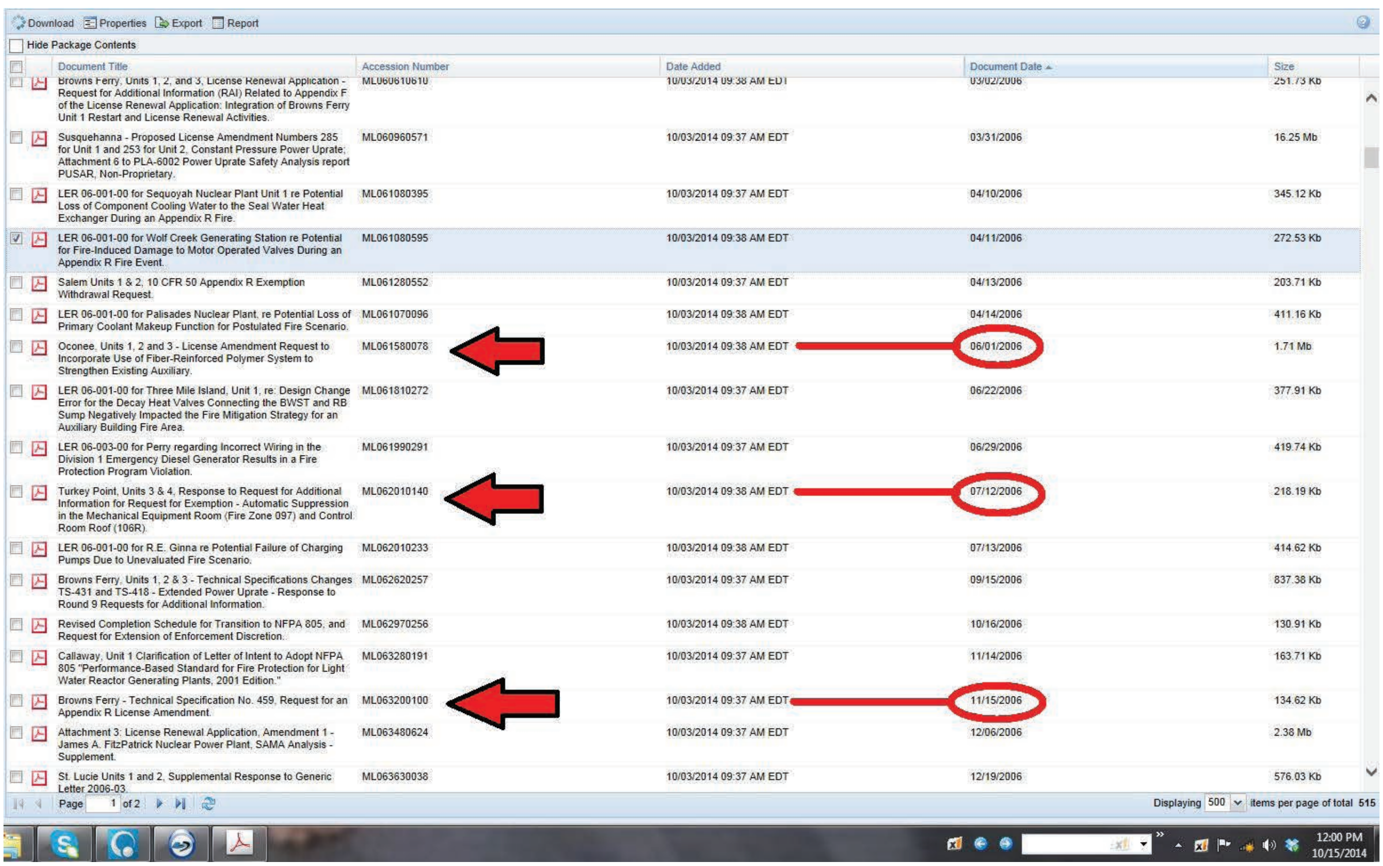
Criscione and Peck are guilty of having raised safety concerns. On September 18, 2012, Criscione emailed an 19-page letter to then NRC Chairman Allison M. Macfarlane describing his concerns about inadequate flooding protection at the Oconee nuclear plant in South Carolina (Criscione 2012). Criscione copied several members of the U.S. Congress and their staffs on the email he used to transmit the letter to the Chairman. Under the Lloyd–La Follette Act of 1912, federal workers have every right to raise concerns to the U.S. Congress without the fear of reprisals. At least, that's the theory.

> ***Criscione and Peck are guilty of having raised safety concerns.***

Tom Zeller Jr., writer for the Huffington Post, acquired a copy of Criscione's letter and authored an article published October 19, 2012, about it, as well as a longer article titled "Dam Lies." The articles exposed deceit by the NRC, irking and embarrassing the agency.

The NRC's OIG investigated Criscione for allegedly distributing sensitive information outside the NRC (i.e., to Mr. Zeller). The OIG completed its investigation and referred the case to the U.S. Department of Justice for criminal

FIGURE 15. Abridged Listing of Fire Protection Documents in NRC's Online Library (ADAMS)



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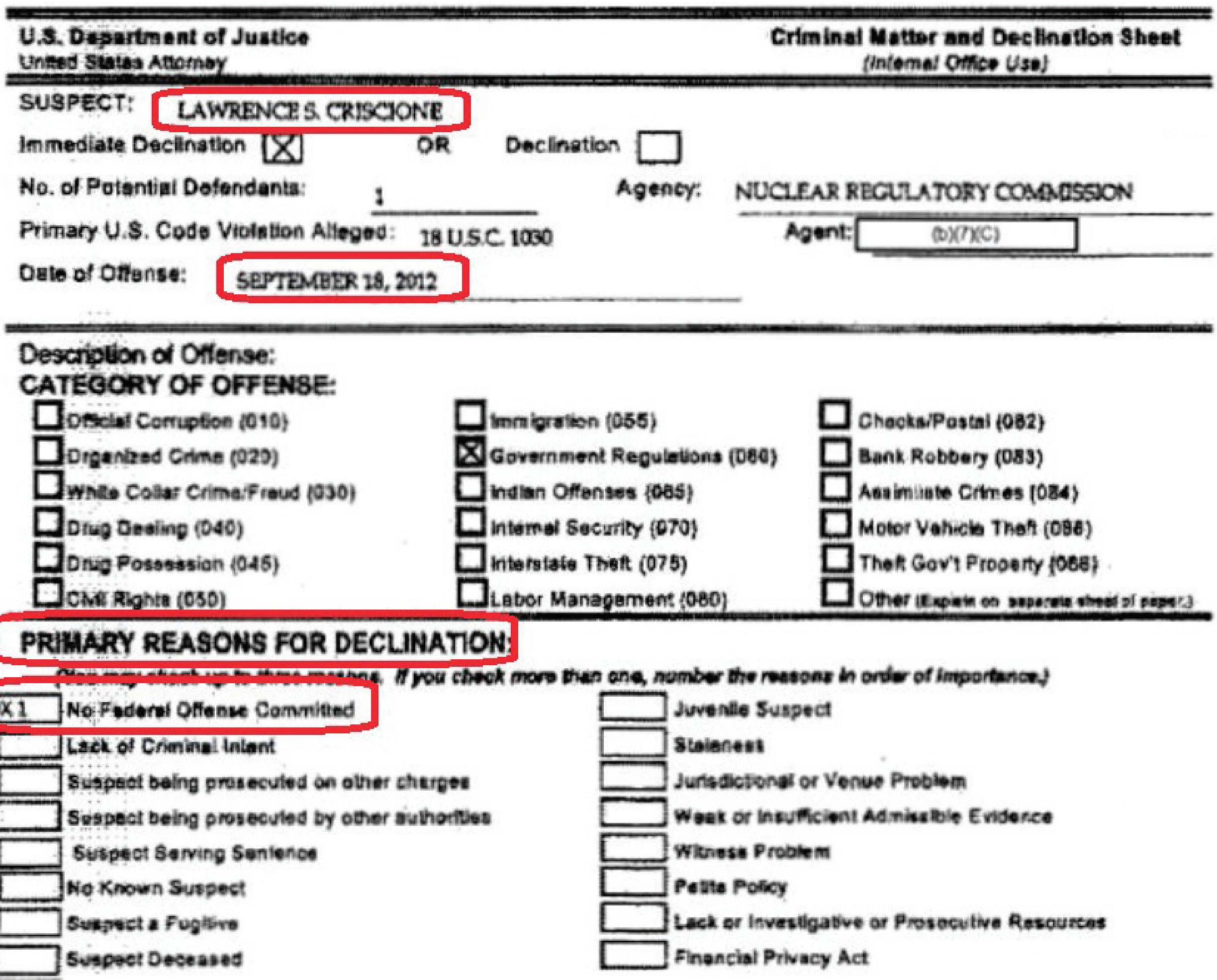
Bibliographic listing of some of the dozens of fire protection documents released by the NRC in response to UCS's request under the Freedom of Information Act.

SOURCE: NUCLEAR REGULATORY COMMISSION FOIA RESPONSE

FIGURE 16. Department of Justice Declination Form



U.S. Department of Justice
United States Attorney

Criminal Matter and Declination Sheet
(Internal Office Use)

SUSPECT: LAWRENCE S. CRISCIONE

Immediate Declination [X] OR Declination [ ]

No. of Potential Defendants: 1

Agency: NUCLEAR REGULATORY COMMISSION

Primary U.S. Code Violation Alleged: 18 U.S.C. 1030

Agent: (b)(7)(C)

Date of Offense: SEPTEMBER 18, 2012

Description of Offense:

CATEGORY OF OFFENSE:

- [ ] Official Corruption (010)
- [ ] Organized Crime (020)
- [ ] White Collar Crime/Fraud (030)
- [ ] Drug Dealing (040)
- [ ] Drug Possession (045)
- [ ] Civil Rights (050)
- [ ] Immigration (055)
- [X] Government Regulations (060)
- [ ] Indian Offenses (065)
- [ ] Internal Security (070)
- [ ] Interstate Theft (075)
- [ ] Labor Management (080)
- [ ] Checks/Postal (082)
- [ ] Bank Robbery (083)
- [ ] Assimilate Crimes (084)
- [ ] Motor Vehicle Theft (086)
- [ ] Theft Gov't Property (088)
- [ ] Other (Explain on separate sheet of paper.)

PRIMARY REASONS FOR DECLINATION:

(You may check up to three reasons. If you check more than one, number the reasons in order of importance.)

- [X 1] No Federal Offense Committed
- [ ] Lack of Criminal Intent
- [ ] Suspect being prosecuted on other charges
- [ ] Suspect being prosecuted by other authorities
- [ ] Suspect Serving Sentence
- [ ] No Known Suspect
- [ ] Suspect a Fugitive
- [ ] Suspect Deceased
- [ ] Juvenile Suspect
- [ ] Staleness
- [ ] Jurisdictional or Venue Problem
- [ ] Weak or Insufficient Admissible Evidence
- [ ] Witness Problem
- [ ] Petite Policy
- [ ] Lack or Investigative or Prosecutive Resources
- [ ] Financial Privacy Act

The NRC referred its investigation of Larry Criscione to the U.S. Department of Justice for prosecution, but DOJ declined to pursue the matter after determining he had committed no offenses.

SOURCE: NUCLEAR REGULATORY COMMISSION FOIA RESPONSE.

prosecution. Criscione passed up an offer from OIG—that if he'd voluntarily resign from the NRC, OIG wouldn't refer the case to DOJ and try to send him to federal prison.

The U.S. DOJ declined to prosecute Criscione. As the form obtained from OIG through the Freedom of Information Act reveals, the DOJ declined to prosecute Criscione because he had committed no federal offenses (Figure 16). Irking and embarrassing the NRC is not a federal offense—at least not yet.

Zeller received Criscione's 19-page letter from Jim Riccio, Nuclear Policy Analyst at Greenpeace. Riccio obtained the letter from a Congressional staffer, not from Criscione. But OIG never bothered to interview Riccio about how he came by the letter en route to seeking to prosecute Criscione for committing no federal offenses.

FierceGovernment, an internationally recognized e-newsletter (*http://www.fiercegovernment.com*), announced on November 13, 2014, that it recognized Criscione among 15 creative and innovative federal employees for his unflagging efforts on nuclear safety.

As in the situation with Criscione, OIG's repeated investigations have yet to find Michael Peck guilty of anything other than raising safety concerns. Peck was the NRC's senior resident inspector at the Diablo Canyon Power Plant near San Luis Obispo, CA, when its owner informed the NRC about the Shoreline Fault in late 2008. The discovery of an earthquake fault so close to the plant raised doubts whether existing earthquake protection was adequate. Dutifully performing his job, Peck reviewed the plant's design and licensing bases

© NRC

Dr. Michael Peck (right) conducting an inspection at Diablo Canyon.

against the newly found seismic hazard. He attended public meetings where representatives of the NRC, the plant's owner, the state government of California, and the United States Geological Survey discussed the fault and its implications for Diablo Canyon. Peck respectfully asked questions that his research was unable to answer.

Later, Peck was asked to sign an NRC report on its inspection of the seismic hazard at Diablo Canyon in which he had participated. Peck disagreed with the report because he believed that the owner's evaluation of the hazard neither conformed to its approved procedures nor complied with the NRC's safety regulations. Peck refused to sign the report that stated the hazard had been adequately evaluated and initiated a non-concurrence report via a formal NRC process for resolving disagreements.

After the NRC responded to his non-concurrence report without fully addressing the points he raised, Peck initiated a Differing Professional Opinion (DPO) via another formal NRC process for resolving disagreements.

Mistreating Criscione and Peck is wrong because many other workers are aware of the abuse these two nuclear safety stalwarts experienced simply for their vigilance.

Using formal NRC processes to resolve disagreements was tantamount to inviting OIG investigations. Peck experienced back-to-back OIG investigations that failed to find any evidence of wrongdoing on his part. But Peck saw the handwriting on the wall and transferred to an instructor position at the NRC's Technical Training Center.

Harassing and intimidating Criscione and Peck for doing their duty and raising safety issues is simply unacceptable. The NRC does not tolerate plant owners harassing and intimidating workers for having raised safety issues. When the NRC finds that an owner's treatment of a worker who raised a safety concern has left even the perception among the workforce that management is not receptive, it will send a "chilling effects" letter requiring that owner to take measures to redress the perception (or reality). The NRC is concerned about "chilling effects" but seems to have the largest freezer in the nation. Surveys of the NRC's workforce about their unwillingness to raise safety issues internally was described in Section 5 of our March 2013 report, *The NRC and Nuclear Power Plant Safety in 2012: Tolerating the Intolerable* (Lochbaum 2013).

Mistreating Criscione and Peck is wrong because it is unjustified. But it is also wrong because many other workers within the NRC are aware of the unwarranted abuse that these two nuclear safety stalwarts experienced simply for their vigilance about safety. The "chilling effect" on the NRC workforce must be rectified. The NRC would require a plant owner with a similar situation to take steps to correct it—the agency must take comparable measures to thaw out its work force.

Inconsistently Applying Standardized Oversight

Students take the American College Testing (ACT) and/or Scholastic Aptitude Test (SAT) examinations when applying for admission to colleges. College admissions offices rely on the results from such standardized tests for a more apples-to-apples measure of students' capabilities than can be gained solely from high school transcripts.

The NRC's Reactor Oversight Process (ROP) is the nuclear equivalent to an ACT or SAT. Rather than counting the number of workers at plants or auditing budget amounts, the ROP uses baseline inspections and common performance indicators to assess safety levels in an apples-to-apples way.

At least that's the theory behind the ROP. In practice, the NRC's ROP is being implemented differently by its four regional offices. The U.S. Government Accountability Office (GAO) documented significant differences between regions when examining results from the ROP's first 13 years (GAO 2013).

TABLE 4: Nonescalated Findings and Inspection Hours per NRC Region, Calendar Years 2000–2012

	Region I (Northeast)	Region II (Southeast)	Region III (Midwest)	Region IV (West)
Number of Plants	17	18	16	14
Number of Reactors	26	33	24	21
Number of Nonescalated Findings	2,518	1,885	3,148	3,225
Number of Inspection Hours (Thousands)	562.8	532.2	505.3	396.1
Average Number of Nonescalated Findings per Reactor	96.8	57.1	131.2	153.6
Number of Inspection Hours (Thousands) per Reactor	21.6	16.1	21.1	18.9
Number of Nonescalated Findings per 1,000 Inspection Hours	4.5	3.5	6.2	8.1
Average Number of Nonescalated Findings per 1,000 Inspection Hours per Reactor	0.17	0.11	0.26	0.39

The GAO examined results from the NRC's Reactor Oversight Process from 2000 to 2012 and found significant differences between the agency's four regions.

SOURCE: GOVERNMENT ACCOUNTABILITY OFFICE

The GAO found that while Region II (the southeast) oversees the most reactors, it identified the fewest number of non-escalated findings (GAO's term for the lowest severity level finding—Green in the color-coded enforcement system or Level IV under the traditional enforcement system). Conversely, the GAO found that Region IV (the west) oversees the fewest reactors yet identified the most non-escalated findings.

The GAO analyzed the data further to see if the difference could be explained by level of oversight—perhaps more inspections are being conducted in Region IV thus yielding more findings. But when the GAO calculated the number of non-escalated findings per inspection hour, the disparities remained intact, just on a different scale.

The GAO's analysis was impaired by the fact that the NRC's regions track both inspection hours and findings differently. Some regions consider an inspection hour to be only the time spent examining a widget or reviewing test reports. Other regions also include the time spent preparing for an inspection and writing the inspection report. Consequently, inspections of exactly the same level of effort might be reported by one region was taking 10 inspection hours and another region as taking 20 inspection hours.

The regions also tally up findings differently. One region reports a regulatory violation and lists each example its inspectors identified of that infraction. Another region reports each example as individual violations. Consequently, inspections each identifying eight non-escalated findings can be reported as a single violation by one region and eight violations by another.

Going from bad to worse in inconsistency, the NRC's regions do not consistently characterize findings. Last year, the NRC's headquarters staff gave the four regional offices the exact same stack of inspection findings to assess. Regions I and II characterized the findings as being less severe than did Regions III and IV, replicating the theme identified by

> ***Inspections of exactly the same level of effort might be reported by one region was taking 10 inspection hours and another region as taking 20 inspection hours.***

the GAO. In other words, a finding characterized by Green by Regions I and II might be deemed as White or Yellow by Regions III and IV.

Colleges rely on ACT and SAT results because students are tested and graded consistently whether they take the tests in Florida, Texas, Minnesota, Arizona or California. It makes little sense to administer standardized tests that are then graded non-uniformly. Colleges would be ill-served if a student scoring 1150 on an SAT taken in Florida would have scored 810 had the test been taken and graded, in Idaho.

Likewise, the value of the standardized ROP is diminished when its numbers have varying contexts. The ROP's output is undermined when regions characterize severity levels of findings differently, tally the number of findings differently, and track inspection hours differently. Differences in ROP numbers should reflect varying reactor safety performances rather than disparate regional accounting systems. The ROP uses a common language across all four regions—it must adopt and apply a common math as well.

Observations on Ineffective NRC Oversight

The NRC does much more right than wrong. But just as sports referees tend to be known more for the occasional bad calls than for the more routine correct calls, the NRC's negative outcomes likely receive disproportionate attention.

That the NRC usually achieves positive outcomes is great, but that accomplishment does not excuse its negative outcomes.

That the NRC usually achieves positive outcomes suggests the proper path forward. If the NRC seldom achieved positive outcomes, the path would be to seek a different regulator; replacing the gold standard with a "platinum standard." Because the gold standard often works well, the shorter path is to remove the tarnish and restore the luster to the "gold standard."

[**CHAPTER 6**]

Summary and Recommendations

Chapter 2 summarizes near misses that the NRC reported at U.S. nuclear plants last year. The lessons learned from the near misses described in Chapter 2 are:

- A majority of non-security near misses last year and in recent years involved in-plant electrical distribution systems that failed to confine electrical problems. The NRC should consider additional enforcement and inspection efforts to curb this adverse trend. The near misses have been caused by non-compliance with longstanding regulatory requirements, not failures to meet recently mandated measures. Electrical-related near misses in recent years have reminded plant owners about the importance of electrical protection devices and removed all valid excuses owners could proffer for experiencing similar problems in the future.

- A growing number of non-security near misses last year (Millstone and Catawba) and in earlier years involved problems introduced by recent modifications and maintenance. The NRC should consider additional enforcement and inspection efforts aimed at re-calibrating plant owners on the important need to retain safety margins, not compromise them.

Chapter 3 shows that the number of near misses has declined over the past five years. But the 81 near misses during these 60 months yield a rate of one near miss every 22.5 days. Given enough chances, it seems only a matter of time before near misses become an actual hit. Effort should be taken to sustain and accelerate the declining near miss rate. The NRC should take two steps to better protect the public:

- Each SIT, AIT, and IIT should include a formal evaluation of the NRC's baseline inspection effort: the array of routine inspections conducted by the NRC at every nuclear plant. When an SIT, AIT, or IIT identifies safety violations that contributed to the near miss, the NRC's evaluation should determine whether the baseline inspection effort could have, and should have, found the safety issues sooner before they became violations. Such insights from the near misses may enable the NRC to make adjustments in what its inspectors examine, how they examine it, and how often they examine it, to increase the chances of finding potential violations.
- Plant owners must be required to formally evaluate why their routine testing and inspection regimes failed to find problems before they became self-revealing. The owners' testing and inspection regimes mandated by federal regulations are intended to find and fix problems preventively, but clearly failed to do so. Programmatic weaknesses in the testing and inspection must be remedied to offer better protection against future near misses.

The NRC's generally effective performance suggests that it can undertake the necessary reforms. More importantly, the positive outcomes from Chapter 4 strongly suggest that if the NRC attempts the needed reforms, their efforts will likely be successful. Any regulator truly deserving a gold standard label will not balk at securing such readily attainable success.

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The NRC and Nuclear Power Plant Safety in 2014

Tarnished Gold Standard

[*The NRC deprived the public of legal rights for regulatory decision-making and painted a misleading picture of nuclear safety.*]

The Nuclear Regulatory Commission (NRC) often claims to be the gold standard for nuclear power plant safety regulation and oversight. Ample evidence suggests much validity to these claims. One cannot count the number of nuclear disasters averted by the NRC's effective regulatory performance, but one can generally count on the NRC to be an effective regulator. The NRC has done much to earn the gold standard label.

For example, the NRC pro-actively conducted two reassessments of its reactor oversight process to enhance its effectiveness and efficiency. And a decade ago the NRC recognized it had an aging work force and took steps to retain as much tribal knowledge as possible before retirees left. Actual performance complements the process improvements. The number and severity of near misses at nuclear power plants have been steadily declining.

But the NRC's gold standard is tarnished. For the past decade, the NRC has been improperly withholding documents about safety problems. By doing so, the NRC deprived the public of legal rights for regulatory decision-making and painted a misleading picture of nuclear safety. The NRC subjected engineers who voiced safety concerns to repeated investigations of alleged but unsubstantiated wrongdoing, sending a very clear message throughout the agency that "silence is golden." And the NRC has been using nonuniform answer keys to grade standardized tests administered via its reactor oversight process, yielding numerical outcomes less predictable than fluctuating gold prices.

If the NRC truly is the gold standard, it must restore the luster and prevent the tarnish from recurring.

Union of Concerned Scientists

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