Union of Concerned Scientists

ISSUE BRIEF

No More Fukushimas; No More Fort Calhouns

HIGHLIGHTS

On April 9, 2011, operators shut down the reactor at the Fort Calhoun nuclear plant in Nebraska for a routine refueling outage. But myriad safety problems discovered during the outage—many dating back to when the plant was constructed in the late 1960s and early 1970s—prevented the reactor from restarting for two and a half years. The U.S. Nuclear Regulatory Commission (NRC), which oversees the nation's nuclear power plants, needs to determine how its inspectors and the plant owner missed—or dismissed—numerous longstanding safety problems for years despite thousands of hours of inspections. It should appoint a task force to recommend changes to the NRC's inspection and oversight efforts, and then implement these changes as quickly as possible.

Two significant nuclear power safety events occurred in the spring of 2011. On March 11, an earthquake and the tsunami it spawned caused the meltdown of three reactors at the Fukushima Daiichi nuclear plant in Japan. Less than a month later, on April 9, operators shut down the reactor at the Fort Calhoun nuclear plant in Nebraska for a routine refueling outage. But myriad safety problems discovered during the outage—many dating back to when the plant was constructed in the late 1960s and early 1970s—prevented the reactor from restarting for two and a half years.

Following the first event, the U.S. Nuclear Regulatory Commission (NRC), which oversees the safety of the nation's nuclear power plants, formed a task force that examined the Fukushima accident and identified more than 30 lessons that could reduce vulnerabilities in the United States. The NRC ordered plant owners to implement specific safety upgrades and is pursuing additional measures to further reduce vulnerabilities.

Following the second event, the NRC made no such effort to examine the Fort Calhoun situation. It failed to identify lessons that would enable it to detect safety violations sooner and correct them before they could accumulate to epidemic proportions requiring years to fix—or worse, contribute to an American Fukushima.

Fort Calhoun received its first operating license in 1973, and the NRC relicensed the plant in 2003 to continue operating for as long as 20 more years. Neither of these licensing efforts, nor the tens of thousands of hours the NRC spent inspecting Fort Calhoun, led the agency to discover any of these many safety problems.

U.S. Army Corps of Engineers

For two weeks in June 2011, flooding on the Missouri River turned Nebraska's Fort Calhoun nuclear power plant into an island. The plant had already been shut down for myriad safety problems—many dating back to its construction in the late 1960s and early 1970s.

Fort Calhoun's shutdown was not an isolated incident: its two-and-a-half-year outage marked the fifty-second time a U.S. reactor remained shut down for longer than a year so the owner could correct accumulated safety problems (see the table). In each of those cases, the reactor had been operating with serious safety problems prior to the shutdown—problems that made an accident more likely. Moreover, these 52 outages have cost ratepayers and shareholders billions of dollars.

The NRC's goal of preventing a Fukushima-scale accident in this country must be accompanied by the goal of preventing another prolonged safety outage like that at Fort Calhoun. The fact that there have been 52 year-plus outages demonstrates that U.S. reactors often operate while violating numerous safety requirements. These safety violations not only make reactors more vulnerable to accidents, but also make them more likely to experience a Fukushima-scale disaster in the event of an accident.

By closing the gap between what its safety regulations require and what U.S. plant owners actually do, the NRC would not only prevent another Fort Calhoun, it would also strengthen its post-Fukushima reforms. And because year-plus outages for safety fixes are costly, preventing another

Year-Plus Nuclear Reactor Outages

Reactor	Date Outage Began	Date Outage Ended	Outage Length (years)
Fermi Unit 1	10/5/66	7/18/70	3.8
Palisades	8/11/73	10/1/74	1.1
Browns Ferry Unit 2	3/22/75	9/10/76	1.5
Browns Ferry Unit 1	3/22/75	9/24/76	1.5
Surry Unit 2	2/4/79	8/19/80	1.5
Three Mile Island Unit 1	2/17/79	10/9/85	6.6
Turkey Point Unit 3	2/11/81	4/11/82	1.2
San Onofre Unit 1	2/26/82	11/28/84	2.8
Nine Mile Point Unit 1	3/20/82	7/5/83	1.3
Indian Point Unit 3	3/25/82	6/8/83	1.2
Oyster Creek	2/12/83	11/1/84	1.7
St. Lucie Unit 1	2/26/83	5/16/84	1.2
Browns Ferry Unit 3	9/7/83	11/28/84	1.2
Pilgrim	12/10/83	12/30/84	1.1
Peach Bottom Unit 2	4/28/84	7/13/85	1.2
Fort St. Vrain	6/13/84	4/11/86	1.8
Browns Ferry Unit 2	9/15/84	5/24/91	6.7
Browns Ferry Unit 3	3/9/85	11/19/95	10.7
Browns Ferry Unit 1	3/19/85	6/12/07	22.2
Davis-Besse	6/9/85	12/24/86	1.5
Sequoyah Unit 2	8/22/85	5/13/88	2.7
Sequoyah Unit 1	8/22/85	11/10/88	3.2
Rancho Seco	12/26/85	4/11/88	2.3
Pilgrim	4/11/86	6/15/89	3.2
Peach Bottom Unit 2	3/31/87	5/22/89	2.1
Peach Bottom Unit 3	3/31/87	12/11/89	2.7
Nine Mile Point Unit 1	12/19/87	8/12/90	2.6
Surry Unit 2	9/10/88	9/19/89	1.0
Palo Verde Unit 1	3/5/89	7/5/90	1.3
Calvert Cliffs Unit 2	3/17/89	5/4/91	2.1
Calvert Cliffs Unit 1	5/5/89	10/4/90	1.4
FitzPatrick	11/27/91	1/23/93	1.2
Brunswick Unit 2	4/21/92	5/15/93	1.1
Brunswick Unit 1	4/21/92	2/11/94	1.8
South Texas Project Unit 2	2/3/93	5/22/94	1.3
South Texas Project Unit 1	2/4/93	2/25/94	1.1
Indian Point Unit 3	2/27/93	7/2/95	2.3
Sequoyah Unit 1	3/2/93	4/20/94	1.1
Fermi Unit 2	12/25/93	1/18/95	1.1
Maine Yankee	1/14/95	1/18/96	1.0
Salem Unit 1	5/16/95	4/20/98	2.9
Salem Unit 2	6/7/95	8/30/97	2.2
Millstone Unit 2	2/20/96	5/11/99	3.2
Millstone Unit 3	3/30/96	7/1/98	2.3
Crystal River Unit 3	9/2/96	2/6/98	1.4
Clinton	9/5/96	5/27/99	2.7
LaSalle County Unit 2	9/20/96	4/11/99	2.6
LaSalle County Unit 1	9/22/96	8/13/98	1.9
D.C. Cook Unit 2	9/9/97	6/25/00	2.8
D.C. Cook Unit 1	9/9/97	12/21/00	3.3
Davis-Besse	2/16/02	3/16/04	2.1
Fort Calhoun	4/9/11	12/21/13	2.7

SOURCE: UPDATED FROM LOCHBAUM 2006.

These year-plus outages demonstrate that U.S. reactors often operate while violating safety requirements.

Fort Calhoun would save ratepayers and shareholders money. Preventing financial meltdowns and avoiding reactor meltdowns is a goal too good to pass up.

Just as it did for Fukushima, the NRC must formally examine the Fort Calhoun case, identify the lessons that should be learned, and make appropriate changes to its oversight process to reduce the likelihood that safety problems remain undetected—and uncorrected—for months or years.

Safety Problems at Fort Calhoun

In a presentation to the NRC on March 27, 2013, Fort Calhoun's owner reported that 20,000 tasks had been completed between November 2012 and February 2013 and had approximately 5,000 other tasks to do before it could restart the reactor (OPPD 2013). While many of these tasks involved preventive maintenance and routine inspections, some entailed correcting serious safety problems.

When a safety problem's severity rises above a fairly high threshold, the plant owner must report it to the NRC. The safety problems reported by Fort Calhoun's owner during the prolonged outage included:

- **Inadequate flood protection.** NRC inspectors had already determined in 2010 that measures designed to protect safety equipment in the auxiliary building and at the intake structure from external flooding had not been adequately implemented as specified by the original safety studies. Workers identified additional deficiencies during the outage (Bannister 2011a). Furthermore, when the plant's owner replaced the original security system in 1985, it left portions of the old system in place. Although the owner sealed the intake structure's walls up to the calculated flooding level to protect vital cooling water pumps inside, it failed to seal areas where the old security system's cables penetrated the intake structure. As a result, the safety-related water pumps could have been damaged by flooding (Bannister 2011b).
- **Missing safety system parts.** Fort Calhoun's owner installed 32 seismically qualified General Electric electrical relays in safety systems at the plant. Workers tested seven of these relays and three failed the tests. Workers then discovered the cause was a missing part. Further inquiries concluded that the relays were most likely missing this part when they were installed during the plant's original construction (Cortopassi 2013a).
- **Inadequate earthquake protection.** Workers found that transmitters used to monitor reactor cooling water pressure had been installed on an instrument rack that was not designed to adequately protect them from

Nuclear Regulatory Commission/courtesy of Omaha Public Power District

In March 2013, Fort Calhoun's owner reported that it had completed 20,000 tasks required by the NRC before the reactor could be restarted—but still had approximately 5,000 more to do. Some of the tasks entailed correcting serious safety problems.

movement during an earthquake. The owner informed the NRC that, "During a seismic event, the excessive weight of these instrument racks could cause the racks to fail," resulting in a reactor cooling water leak that could not be isolated, increasing the risk of nuclear core damage (Bannister 2012a).

- **Vulnerability to high-speed debris.** In the event of a tornado, debris propelled by high winds can disable essential safety equipment. Workers identified numerous potential sources of such debris, including removable hatches on the intake structure, the exhaust stack for the steam-driven auxiliary feedwater pump, the vent stack and fill line for the emergency diesel generator's fuel oil tanks, the cable pull boxes for the raw water pumps, and the exhaust stacks for the emergency diesel generators (Cortopassi 2013b).
- **Overloaded backup power source.** Workers discovered that, in a situation where one of the two emergency diesel generators was unavailable, more equipment would be connected to the remaining emergency diesel generator than that generator could supply during certain types of accidents. The system designed to disconnect non-essential equipment from the emergency diesel generator during an accident would not perform properly during these types of accidents, and the overloaded generator could fail to function (Bannister 2012b).
- **Inadequately tested backup power source.** In 1990, workers revised a test procedure for the emergency diesel generators and no longer checked whether the plant's fuel oil transfer pumps would automatically start and send fuel from the onsite storage tank to the generators. This check, required by the reactor's operating license, had not been performed for nearly a quarter of a century (Bannister 2012c).
- **Overloaded support beam.** Workers discovered that some of the support beams for the containment structure were not properly designed to handle the weight they supported (Bannister 2012d).
- **Inadequate piping qualifications.** Workers discovered that chemical and volume control system (CVCS) piping had not been properly qualified for the stresses it could experience during its lifetime. Among other factors, the qualification was required to consider fatigue cycles—that is, the number of times the water carried by the piping goes from ambient temperature to reactor operating temperature and back again. These temperature changes cause the metal pipe walls to expand and shrink, which wears the piping out faster. Examination of two-inch-diameter socket-welded fittings in the CVCS found that this piping failed to comply with the piping code and therefore was not properly qualified (Cortopassi 2012).
- **Improperly grounded reactor protection system.** Workers discovered that the voltage in the reactor protection system—which detects unsafe conditions and initiates automatic safety system actions—was nearly 10 times higher than the design allowed. As a result, the system might not initiate the automatic responses the plant's safety studies assumed would happen. Even worse, this unacceptable condition had been previously identified and reported multiple times since 1993 but never corrected (Reinhart 2011).

[***Workers discovered that some of the support beams for the containment structure were not properly designed to handle the weight they supported.***]

- **Safety pumps operated outside vendor limits.** Workers determined that, since 1996, the motors for the component cooling water (CCW) pumps had been operating under conditions beyond those recommended by the manufacturer. The CCW system supplies cooling water to reactor components that could contain radioactive water (for example, reactor coolant pump lube oil and seal coolers, containment air cooling units, spent fuel pool heat exchanger). Motors operated outside the manufacturer's limits could fail during an accident (Bannister 2012e).

This list summarizes only a handful of the safety problems that eluded detection and correction at Fort Calhoun for years, subjecting the surrounding population to undue elevated risk. The plant's problems covered a range of engineering disciplines: electrical, mechanical, civil, and instrument and controls. They fell into several major safety areas, including fire protection, flood protection, and seismic design. In other words, the problems were programmatic and pervasive, not isolated to a single plant department.

The most recent of these problems dated to 1996, and many dated back to when the plant was originally built. Thus, there were dozens, and sometimes hundreds, of opportunities for workers and NRC inspectors to detect them before 2010.

Nuclear Regulatory Commission

Senior executives from the Fort Calhoun plant briefed NRC staff and commissioners several times (including here in June 2013) before they were allowed to restart the reactor.

The NRC's Reactor Oversight Process

In May 1997 the Government Accountability Office (GAO, then called the General Accounting Office) issued a report titled *Nuclear Regulation: Preventing Problem Plants Requires More Effective NRC Action* (GAO 1997). At the time, both reactors at New Jersey's Salem nuclear plant were mired in year-plus outages and the NRC had identified 43 problems the owner had to correct before it could safely restart either unit. The GAO report stated that the NRC knew about 38 of the 43 problems before the Salem reactors were shut down, and it knew about one of these problems for *more than six years* prior to the shutdown. The GAO also documented that the NRC was aware of unresolved safety problems at the Millstone plant in Connecticut and the Cooper plant in Nebraska.

These findings prompted the GAO to conclude:

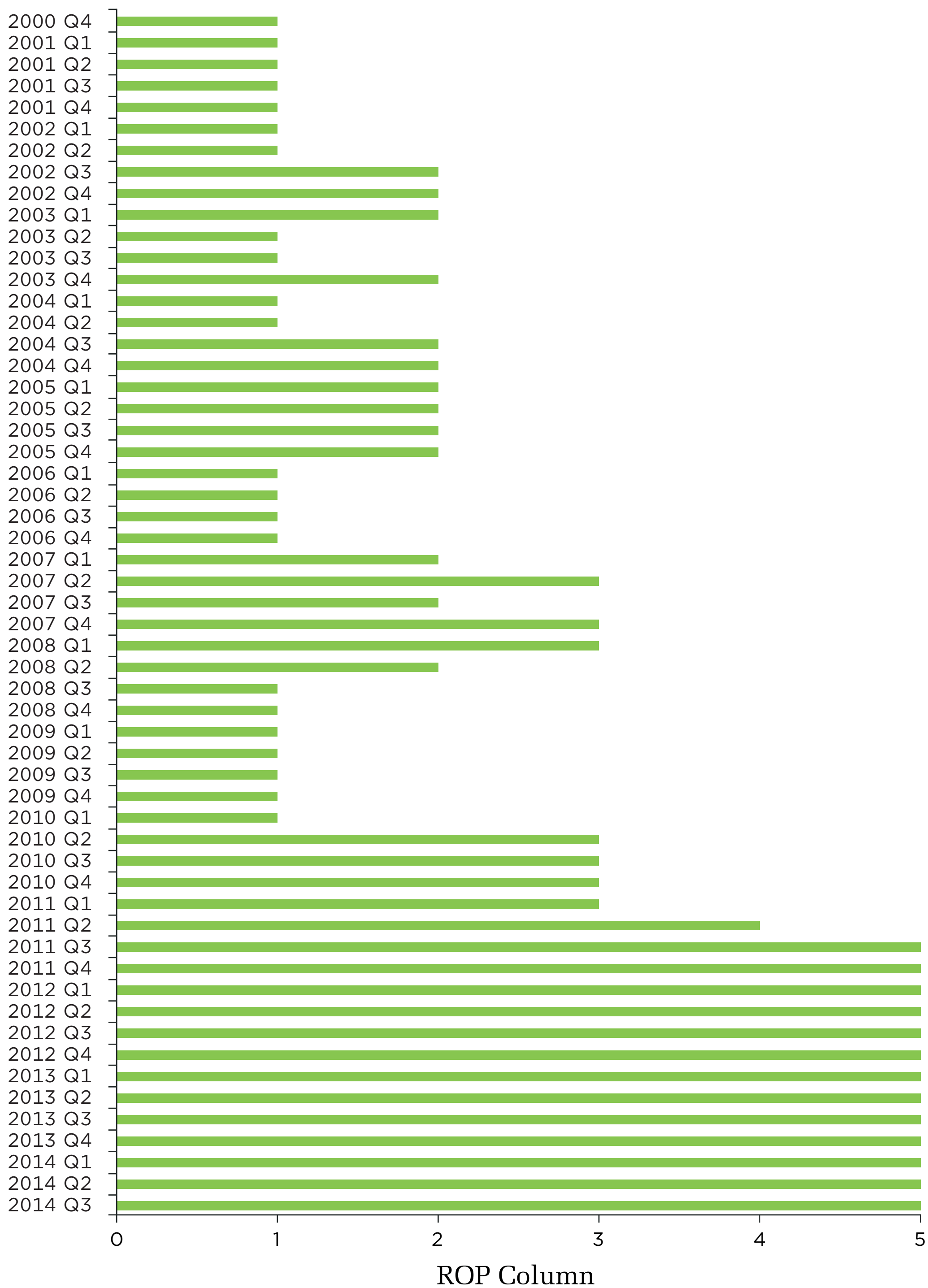
- "NRC has not taken aggressive enforcement action to force the licensees to fix their long-standing safety problems on a timely basis."
- "NRC allowed safety problems to persist because it was confident that redundant design features kept plants inherently safe."

In response to criticism from the GAO and others, the NRC replaced its safety monitoring programs in April 2000 with its Reactor Oversight Process (ROP). The ROP evaluates a reactor's safety performance by combining 17 performance indicators (submitted quarterly by plant owners) with NRC inspectors' findings, then places the reactor into one of five Action Matrix columns. When the safety performance of a reactor falls within the expected regime, the reactor is placed in Column 1 and the NRC conducts only a baseline number of inspections. As safety performance declines, the ROP mandates supplemental NRC inspections. If safety performance declines too much and a reactor falls into Column 5, the ROP will trigger a shutdown until the owner fixes the problems.

The ROP Action Matrix for Fort Calhoun from the fourth quarter of 2000 (when the ROP program began) to the third quarter of 2014 is shown in the figure on p. 6. The NRC moved Fort Calhoun from Column 1 into Column 2 in the third quarter of 2002, but later concluded that safety performance

[There were dozens, and sometimes hundreds, of opportunities for workers and NRC inspectors to detect safety problems at Fort Calhoun—opportunities that were missed.]

The NRC's ROP Action Matrix for Fort Calhoun, 2000–2014



As a nuclear power plant's safety performance declines, the NRC moves it from Column 1 to Column 5 in the Reactor Oversight Process Action Matrix. The NRC repeatedly moved Fort Calhoun back and forth in the matrix for over a decade until the agency decided the plant's problems were serious enough (Column 5) to warrant a shutdown.

SOURCE: NRC N.D.

Nuclear Regulatory Commission

NRC Commissioner William C. Ostendorff (left) speaks with NRC Senior Resident Inspector John Kirkland about repairs needed at Fort Calhoun while touring the plant during its 30-month outage.

had improved and returned the reactor to Column 1. This happened again in the fourth quarter of 2003 and the third quarter of 2004.

The NRC moved Fort Calhoun into Column 3 in the second quarter of 2007 and the fourth quarter of 2007, but each time returned the plant to Column 2. When the NRC again moved Fort Calhoun into Column 3 in the second quarter of 2010, however, the plant subsequently slipped into Column 4 and then into Column 5.

Thus, the ROP utterly failed to recognize the depth and breadth of the safety problems at Fort Calhoun until the third quarter of 2011. As noted above, all the safety problems summarized here existed at Fort Calhoun since at least 1996. They existed when the NRC returned Fort Calhoun from Column 2 to Column 1 on four occasions and when it returned Fort Calhoun from Column 3 to Column 2 on two occasions.

These problems were so serious that Fort Calhoun could not safely resume operation under NRC rules until each one was corrected, yet it had operated for over a decade with all of them. Quite simply, the people of Nebraska faced unduly high risk for over a decade because the NRC did not accurately evaluate safety levels at Fort Calhoun. The ROP has clearly not fixed the problems identified by the GAO in 1997.

Preventing Another Fort Calhoun—and an American Fukushima

A key nuclear safety principle is "defense in depth." Reactors are designed so that no single problem will lead to a meltdown or radiation release. At Fukushima, multiple problems caused three reactors to melt down: the reactors lost off-site power, the backup generators located in the basements were damaged when the basements flooded, floodwater disabled banks of batteries that backed up the backup generators, and workers could not deploy portable pumps and generators in time. The 1986 Chernobyl and 1979 Three Mile Island accidents also occurred when numerous things went wrong.

Quite simply, the people of Nebraska faced unduly high risk for over a decade because the NRC did not accurately evaluate safety levels at Fort Calhoun.

Conversely, there have been cases where many things went wrong and disaster was averted. For example, in 2002, workers at the Davis-Besse reactor in Ohio discovered that corrosion had caused a pineapple-sized hole in the reactor head, leaving only a thin steel cladding to contain the high-pressure coolant. Once the reactor was shut down, workers discovered additional serious safety problems. Despite operating with numerous safety problems, Davis-Besse avoided disaster because not all of its defense-in-depth barriers were compromised.

Nevertheless, a reactor operating with pre-existing safety problems is more vulnerable to disaster when another safety problem arises. Fort Calhoun, before its reactor was shut down, was more likely to experience a Fukushima-scale accident because it was already operating with multiple pre-existing safety problems. Pre-existing problems undermine defense in depth by reducing the number of things that must go wrong to transform a near-miss into a nightmare.

If the NRC's effort to prevent an American Fukushima is to be successful, it must augment that with an effort to prevent another Fort Calhoun. The NRC responded to Fukushima by forming a task force that examined the accident and made more than 30 recommendations to better manage nuclear power plant risks. It is now in the process of implementing those recommendations.

The NRC similarly needs to respond to Fort Calhoun by forming a task force to determine how the agency and the plant owner missed—or dismissed—numerous longstanding safety problems for years despite thousands of hours of inspections. The task force should recommend changes that will improve the effectiveness and reliability of the NRC's inspection and oversight efforts. The NRC then needs to implement these changes as quickly as possible.

REFERENCES

Bannister, D.J. 2012a. *Licensee event report 2012-010, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. August 3. Online at *http://pbadupws.nrc.gov/docs/ML1221/ML12219A010.pdf*.

Bannister, D.J. 2012b. *Licensee event report 2012-011, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. August 6. Online at *http://pbadupws.nrc.gov/docs/ML1222/ML12220A167.pdf*.

Bannister, D.J. 2012c. *Licensee event report 2012-005, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. April 23. Online at *http://pbadupws.nrc.gov/docs/ML1225/ML12250A189.pdf*.

Bannister, D.J. 2012d. *Licensee event report 2012-014, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. September 10. Online at *http://pbadupws.nrc.gov/docs/ML1225/ML12255A038.pdf*.

Bannister, D.J. 2012e. *Licensee event report 2012-006, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. June 25. Online at *http://pbadupws.nrc.gov/docs/ML1217/ML12178A293.pdf*.

Bannister, D.J. 2011a. *Licensee event report 2011-003, revision 2, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. March 1. Online at *http://pbadupws.nrc.gov/docs/ML1206/ML12061A224.pdf*.

Bannister, D.J. 2011b. *Licensee event report 2011-003, revision 3, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. December 17. Online at *http://pbadupws.nrc.gov/docs/ML1135/ML113530555.pdf*.

Cortopassi, L.P. 2013a. *Licensee event report 2013-008, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. June 7. Online at *http://pbadupws.nrc.gov/docs/ML1315/ML13158A138.pdf*.

Cortopassi, L.P. 2013b. *Licensee event report 2013-009, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. June 14. Online at *www.nrc.gov/site-help/search.cfm?q=ML13168A376*.

Cortopassi, L.P. 2012. *Licensee event report 2012-016, revision 0, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. September 17. Online at *http://pbadupws.nrc.gov/docs/ML1226/ML12262A317.pdf*.

Government Accounting Office (GAO). 1997. *Nuclear regulation: Preventing problem plants requires more effective NRC action.* Washington, DC. May. Online at *www.gao.gov/products/RCED-97-145*.

Lochbaum, D. 2006. *Walking a nuclear tightrope: Unlearned lessons of year-plus reactor outages.* Cambridge, MA: Union of Concerned Scientists. September. Online at *www.ucsusa.org/nuclear_power/making-nuclear-power-safer/who-is-responsible/walking-a-nuclear-tightrope.html#.VOYn5c8o670*.

Nuclear Regulatory Commission (NRC). No date. ROP historical performance from previous quarters. Rockville, MD. Online at *www.nrc.gov/NRR/OVERSIGHT/ASSESS/prevqtr.html*.

Omaha Public Power District (OPPD). 2013. *Fort Calhoun Station driving through restart*. Omaha, NE: Omaha Public Power District. March 27. Online at *https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML13093A473*.

Reinhart, J.A. 2011. *Licensee event report 2011-002, revision 1, for the Fort Calhoun Station.* Omaha, NE: Omaha Public Power District. July 27. Online at *http://pbadupws.nrc.gov/docs/ML1120/ML112081990.pdf*.

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