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**IN AN UNUSUAL COURSE OF EVENTS, A GROUP OF SEVEN STAFF ENGINEERS WITHIN THE U.S. NUCLEAR REGULATORY COMMISSION (NRC) RAISED FEARS ABOUT A DESIGN FLAW IN ALMOST ALL U.S. NUCLEAR POWER PLANTS THAT COULD HARM IMPORTANT SAFETY SYSTEMS, GOING SO FAR AS TO ADVOCATE FOR IMMEDIATE SHUT DOWN OF THESE PLANTS.**

On February 19, the seven staff engineers petitioned the agency to take enforcement actions against power plant licensees around the country, suggesting a prevalent design flaw has to be fixed immediately or all operating nuclear power plants need to be shut down until the problem is solved.

Shutting down all nuclear plants would mean about 20 percent of America's power would go offline. That is zero carbon power, too. For general context—based on 2015 data from the U.S. EIA and U.S. EPA conversion factors—taking these plants offline for a year could be the equivalent of having to turn on 144 coal plants during that time.

Of course, the nuclear plants outages need only be temporary while design flaws are addressed. But even temporary outages could be disruptive if not administered in a coordinated manner. Reliability concerns, sky rocketing prices, and increased emissions from coal plants could result. Complete shut-down of all plants would have huge ramifications.

No doubt, the seven NRC engineers authoring the petition are well aware of the potential impacts of their recommended actions. Still, they issued the advice. This digest examines relevant details to better understand the issues and context of the petition.

## THE DESIGN FLAW

The design flaw in question is an inability to detect "open phase events" (for example, in threephase transformers) potentially causing voltage imbalances and electrical shorts that negatively impact plant safety systems.

Nuclear power plants are required to have redundant backup power systems to ensure that if the plant stops generating power, there is enough energy to power cooling systems that keep the hot nuclear core from melting down. Plants must have both on-site power systems (e.g. backup generators) and off-site power sources (e.g. from the electric grid) as a safety redundancy. The open phase design flaw was highlighted by the 2012 Byron Unit 2 reactor incident in Illinois (ML 13059A563) where an open phase condition resulted in the concurrent failure of both primary and secondary safety power system backups, resulting in the need for manual measures (e.g. physically opening the breakers) to address core cooling.[1]

The NRC engineer's February 2016 petition (ML16050A223) notes that to date, thirteen open phase events in the U.S. and abroad have been identified in the last fourteen years. The petition goes on to state:

"Operating experience indicates that open phase condition is a highly probable event with high consequences that results in common cause failures of multiple accident mitigation systems and barrier integrity systems. It is a significant safety concern…"

The petition provides a lengthy review of various legal, design, and safety requirements, making recommendations for immediate enforcement actions against licensees. Specifically, the petition asks the NRC to issue orders that require either:

1. Immediate corrective actions and compensatory measures to address electric power system operability and requirements, or
2. Immediate shutdown operating nuclear plants, because these plants are operating without addressing significant design deficiencies.

[1] To learn more about the technical aspects of the Byron Unit 2 incident and the underlying design flaw, refer to David Lochbaum's "Fission Stories #111: Lordy Byron! Another Wakeup Call for the NRC," September 25, 2012, *http://allthingsnuclear.org/dlochbaum/fission-stories-111-lordy-byron-another-wakeup-call-for-the-nrc*

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## THE REGULATORY RESPONSE TO DATE

The NRC is well aware of the widespread design flaw and has taken steps to address the situation. A detailed review of NRC's significant regulatory activities is included in Appendix A of this digest, and is briefly summarized below.

After the Byron Unit 2 incident in January 2012, the NRC embarked on an investigation of the incident and issued a summary report in 2013. In March 2012, NRC notified other nuclear power plant licensees about the Byron incident and open phase design flaw. In July 2012, the agency released a bulletin about the design flaw that requested certain information from all power plant licensees, in order to better understand how widespread the flaw was and if additional regulatory action was needed. In February 2013, the NRC issued a summary report analyzing the data requested from the July bulletin. Staff found that all nuclear plants were susceptible to the open phase condition, except for one plant (Seabrook Station), and recommended the agency take regulatory action to address the problem.

In October 2013, the Nuclear Energy Institute (NEI) submitted a strategy paper to NRC detailing an industry-supported initiative to address the open phase condition that included a compliance deadline of December 31, 2017. In December 2013, NRC issued a letter to licensees requesting more information about the status of corrective actions underway. In June 2014, NRC issued draft technical guidance (i.e. Branch Technical Position) for open phase conditions in electric power systems for public comment. The technical guidance would be used to establish criteria for NRC staff to use when reviewing licensing applications. The guidance described activities that licensees could take to meet compliance under existing regulatory authorities. In November 2014, NRC issued a letter responding to NEI's proposed industry solution, raising concerns that the corrective measures were insufficient.

In March 2015, NEI submitted a letter to NRC revising its proposed industry initiative and extending compliance by one year to December 31, 2018. In July 2015, NRC finalized the open phase branch technical position document and released responses to public comments received. Through the course of these actions, NRC held several public meetings to explore the open phase design flaw.

In short, the NRC has the authorizing regulatory authority to compel a solution and has developed technical guidance for staff and the industry to follow in meeting compliance. So far, the industry has begun implementing a voluntary solution that some NRC staff members believe is not consistent with regulatory requirements. What has not happened to date is NRC's issuance of implementation orders that will trigger mandatory industry compliance with the more stringent requirements of the branch technical position (or comparable alternatives).

## DIFFERENCES OF OPINIONS

It is clear that NRC staff and the industry have differing opinions on several aspects of the open phase condition issue. A complete discussion of the disagreements is beyond the scope of this digest. However, there are three main themes to highlight.

### WHAT REGULATIONS COVER THIS NEW PROBLEM?

Industry states (herein referenced by ML13333A147, ML14226A806) that before the 2012 Byron event, open phase condition was not considered as a credible vulnerability in the design of any operating nuclear power plant. Industry maintains approved plant design and licensing basis and design criteria for voltage protection systems do not include requirements for detection of OPCs. They state regulatory requirements or guidance documents for OPCs did not exist prior to the July 2015 draft BTP 8-9. However, industry does acknowledge that because OPCs are hard to detect and can result in loss of on and/or off site power, the OPC design vulnerability can impact compliance with GDC 17 (Electric Power Systems General Design Criteria 17 in Appendix A of 10 CFR Part 50) specifically,

*"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 on-site electric power supplies."*

[underline emphasis added]

NRC staff acknowledged (herein referenced by ML14120A203, ML13052A711) that the current regulations do not specifically address the OPC design flaw because it wasn't known until 2012. However, staff believes the broad regulatory requirements (for example in the GDC 17) to minimize the probability of losing power and maintain electric power systems for safety have been in place even though the specific design flaw wasn't identified. As a result, staff recommended NRC take additional regulatory actions and also require licensees to implement corrective actions per 10 CFR 50 Appendix B.

In their petition (ML16050A223) the NRC staff reiterate that to date, the NRC has not informed licensees that they are not in compliance with existing regulatory requirements and licensing and design basis for electric power systems.

### WHAT ARE APPROPRIATE ENFORCEMENT ACTIONS?

In 2014, NRC issued its draft Interim Enforcement Policy for the open phase condition (OPC) issue. Interim Enforcement Policies grant staff the ability to refrain from taking enforcement actions for issues not currently addresses in the broader enforcement policy. Among other things, NRC's broader enforcement policy (ML15029A148) outlines civil penalty amounts, criteria for assessing penalties, and considerations for using enforcement discretion to limit or waive penalties. For power plant reactor licensees, NRC has the authority to assess up to $140,000 per day for compliance violations. However, NRC's enforcement policy (p.15) clearly states the goal of civil penalties is not to create economic hardship that would put a licensee out of business, it would use Orders to terminate licensee activities.

Industry argues that the Interim Enforcement Policy for OPCs should not be applicable to currently plants because OPCs are beyond current plant design and licensing basis and as a result, they believe NRC should perform a backfit analysis before implementing any new requirements. In simple terms, the backfit rule (10 CFR 50.109) applies when NRC changes its position on an issue or puts new requirements on existing licensees. If a proposed NRC action qualifies as a backfit it may require development of a cost benefit analysis to ensure the public benefits outweigh the implementation costs. The cost benefit analysis requirement is waived if the action meets certain exemptions, such as if the action is required to bring the facility into compliance with an order of the NRC or if the action is necessary to ensure the facility provides adequate public health and safety protection.

It is unclear if a backfit analysis is being performed by the NRC. On the other hand, NRC staff petitioners might argue that their recommend actions are needed to ensure public safety, exempting the actions from backfit cost benefit analysis.

### WHAT SOLUTION IS ACCEPTABLE?

The licensee's argue that the NRC should accept their preferred voluntary solution, implementation of the Open Phase Isolation System (OPIS). The OPIS system would include installation of sensors in certain transmission equipment that connect the offsite power to the power plant. In the event of an open phase condition, the OPIS would sound an alarm in the main plant control room and isolate the problematic circuit.

According to the industry, in most cases, the OPIS system has to connect to "non-Class 1E" equipment at the power plant, rather than connecting to Class 1E systems. Class 1E standards, developed by the Institute of Electrical and Electronics Engineers (IEEE), pertains to equipment essential for the safe shut down of the nuclear reactor, and are generally referred to as safety-related equipment. Industry maintains that for OPIS "the Class 1E design may not be able to detect and provide an immediate alarm for all OPCs." However, they acknowledge it is possible for some plants to design an OPIS that is Class 1E connected, which would also result in preserving the independence of the onsite power system. By connecting to non-Class 1E systems, industry argues the OPIS should not be considered part of the plant's protection system, avoiding certain regulatory standards (e.g. 10 CFR 50.55a(h)(2), IEEE 603-1991 and 279-1971).

NRC staff believes that the industry's solution inadequately addresses the requirements of the GDC 17 and other criteria. They argue for a solution that provides greater redundancy, separation and independence in order to ensure vital emergency core cooling and public safety functions.

Nothing in the documentation indicates that solutions do not exist, it just seems there are disagreements about stringency and, as a natural corollary, costs.

## WHAT IS MOTIVATING NRC STAFF ACTIONS?

Without talking directly to the petitioners it is impossible to know their exact motives. However, there are important inferences that can be made.

The NRC engineers used a provision authorized in NRC regulations (10 C.F.R. Part 2.206) that allows members of the public to petition the commission to modify, suspend, or revoke a license or take any other enforcement-related action that might be necessary. NRC's Office of Public Affairs confirmed only one other NRC staff member has petitioned the agency under 2.206, filing five separate petitions between 2010-2012 seeking enforcement actions against one specific nuclear power plant.

Clearly, the act of seven staff engineers coordinating to jointly file this petition is without precedent.

It is also interesting that the seven staff engineers chose to exercise the external public petition program when there are at least two internal grievance processes.. For example, the NRC's Differing Professional Opinions Program (DPO) allows staff to express a position that differs from the established position of the agency. There is also a Non-Concurrence Process that allows employees to formally disagree with any part of a NRC document.

It is not clear if these engineers exhausted the internal processes first, before using the public petition. It is clear that the internal and external processes have very different impacts on public transparency. For example,

certain (e.g. excludes pre-decisional) documentation from the internal processes can be made public upon request, through a formal Freedom of Information Act request. The 2.206 petition process seems to be more readily transparent. According to the NRC's 2.206 handbook, the 2.206 petition and related correspondence (including transcripts from the internal petition review board) will be made public, for example, by being posted to the NRC's publicly accessible database (ADAMS).

Deadlines for decisions are also different for the internal and external processes. The internal dispute processes can be open ended, depending on the timeline for completion of the associated activity. The 2.206 process has suggested deadlines for responses and periodic reporting milestones to the petitioners. There is a petition review board that evaluates the petition and determines whether or not it meets consideration criteria. If accepted, the petition is assigned and the petitioner is sent an acknowledgement letter within 30 days of assignment. A proposed decision is issued 120 days from the acknowledgement letter with a comment period. A final decision is rendered 45 days after the close of the comment period.

On March 21, the staff petitioners received notice from NRC (ML16069A214) that their petition was accepted, though the request for immediate action was denied on the grounds that the petition only raised issues already subject to NRC review and did not present new information.

## WHAT IS GOING ON?

So, the NRC has comprehensively reviewed the issues, identified a widespread problem, and has determined solutions exist. So why do the seven NRC staff engineers have beef?

Perhaps they are trying to limit their professional liability from decisions of their superiors? By exhausting internal and external dispute processes, these staffers can insulate themselves from blame if another accident occurs. On the other hand, they are also taking a big professional risk by filing the petition. They may be protected from retaliation and termination without cause by certain federal protections (via the U.S. Office of Inspector General and U.S. Merit Systems Protection Board), but they are certainly still vulnerable to (at least) latent internal retribution. Maybe they acted against their own self-interest, because they perceive imminent danger and are frustrated with the agency's slow progress?

## ACTIONS?

Nuclear power plays an important role in keeping the lights on in America. It also happens to play a foundational role in America's current greenhouse gas reduction strategy and the nation's ambitions to finalize a global accord. Nuclear energy has to succeed if we are to achieve domestic and international climate change goals.

The nuclear industry is grappling with economic challenges facing many of its contemporaries in energy industries. Nuclear plants also face more unique issues related to long-term radioactive waste storage and extension of operating licenses. Comparatively, the design flaw concerns raised by the NRC engineers seem manageable. In light of the broader challenges facing the industry, country and nation, the NRC must take care to maintain public trust. The action of these seven engineers is not that of radical activists. They raise questions about the agency's ability to navigate solvable issues that are complicated and contentious. More importantly, they raise doubts about the agency's competency to handle issues where solutions are still unknown and the stakes are much higher.

Those interested in preserving this technology's role in addressing climate change should want the open phase issue addressed swiftly with sufficient stringency to maintain public trust. Solutions should be implemented in a methodical manner aimed at minimizing economic and energy system disruptions while avoiding incidents that could call into question the future of this important zero carbon energy source.

# APPENDIX A – NRC'S SIGNIFICANT REGULATORY ACTIVITIES ON OPEN PHASE CONDITIONS

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- NRC embarked on a special investigation of the January 2012 Byron incident and released a final report in 2013 (ML 12087A213).
- In March 2012, NRC issued an information notice to nuclear power plant licensees informing them of the Byron incident and design flaw (ML120480170);
- In July 2012, NRC released Bulletin 2012-01 (Design Vulnerability in Electric Power Systems, ML 12074A115) requesting information from licensees about detection and response to open phase conditions and to determine if further regulatory action is needed.
- In February 2013, NRC published a summary report (ML13052A711) Bulletin 2012-01 based on information collected from the licensees.
    - The summary report found that all operating nuclear plants were susceptible to the open phase condition, except for Seabrook Station. Staff found that existing protection schemes could not identify or mitigate open phase conditions and recommended NRC take regulatory actions to address the problem.
- In October 2013, the Nuclear Energy Institute (NEI) submitted to NRC a strategy paper (ML13333A147) on the industry's proposed initiative to address the open phase condition.
    - The initiative represented a formal commitment approved by chief nuclear officers of the licensee companies to follow a voluntary corrective action plan. The plan addressed detection of an open phase event, protective actions if an open phase event occurs, interim and follow up actions, and a deadline to complete corrective design updates by December 31, 2017.
- In December 2013, NRC issued a letter to licensees requesting more information (ML13351A314) about the status of interim and long-term corrective actions.
- In May 2014, the NRC issued a notice of public meeting (ML14134A162) to discuss the open phase condition and circulated a draft Interim Enforcement Policy on the open phase conditions.
    - The Interim Enforcement Policy outlines conditions under which NRC will exercise enforcement discretion (e.g. waiver of civil penalties) for certain noncompliances related to open phase conditions, such as immediate and long-term actions required by licensees.
- In June 2014, NRC issued draft Branch Technical Position (BTP) 8-9 (ML14058A093) to develop the NUREG-0800 Standard Review Plan (SRP) to establish criteria for NRC staff to review and evaluate applications to construct and operate nuclear power plants. NRC opened the draft to public comment.
    - According to the document, the SRP is not a substitute for NRC regulations and compliance with it is not required. The SRP relies on existing regulatory authorities (e.g. GDC 17) and serves as a technical guidance document to describe what activities licensees could engage in to meet compliance. Licensees can perform other actions, but the burden would be on the licensee to show that the action meets regulatory requirements.
- In November 2014, NRC staff issued a letter (ML14120A203) responding to NEI's proposed voluntary industry initiative, raising concerns about insufficiencies in their action plan.
- A January 2015 public meeting presentation (ML15013A054) by NRC staff indicated Q1 2015 as target date for NRC approval of the Interim Enforcement Policy.
- In March 2015, the NEI issued a letter (ML15075A455) to the NRC revising the December 2013 proposed industry initiative and extending the deadlines for compliance by one year (to Dec 31, 2018).
- In July 2015, NRC issued a public comment-response document (ML15056A521) and finalized the BTP 8-9 (ML15057A085).
- Throughout this process, NRC held a host of public meetings with the industry and advisory committees to discuss the problem and potential solutions (ML14262A378, for example).