NEOP

Nuclear Energy Oversight Project

"Oversight of the U.S. Nuclear Regulatory Commission to protect public health and safety and the environment"

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Thomas Saporito
Executive Director

Date: November 4, 2023

Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
(Sent via Electronic Mail)
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RE: Amended 10 CFR 2.206 Petition

The Nuclear Energy Oversight Project (NEOP) - by and through its undersigned Executive Director (hereinafter "petitioners") - hereby submit an Amended 10 CFR 2.206 Petition requesting that the U.S. Nuclear Regulatory Commission (NRC) take enforcement action against the Florida Power & Light Company (FPL or licensee) and **all NRC licensees of pressurized nuclear reactors** that the NRC (1) has granted an extended operational license beyond the licensee's original 40-year operational license and/or (2) that the NRC is currently considering a licensee's request to extend their NRC operational licensee beyond its current expiration date as delineated below:

Background

On October 10, 2023, the NRC responded to petitioners' initial 2.206 petition (in relevant part) as follows:

- The Nuclear Regulatory Commission (NRC) received your 10 CFR 2.206 Petition dated September 17, 2023, and initiated the screening process immediately in accordance with Section II.A.2(d) of NRC Management Directive (MD) 8.11, "Review Process for 10 CFR [Code of Federal Regulations] 2.206 Petitions" (ADAMS Accession No. ML18296A043). In your petition, you requested that the NRC deny the subsequent renewal of the Turkey Point Unit 3 and Unit 4 (TPN) operating licenses (SLR). The basis for your request is that the integrity of the TPN reactor pressure vessels (RPVs) has not been accurately assessed, that rising sea levels in parts of Florida make TPN vulnerable to being swamped leading to a loss of coolant accident, and that solar power is a safe alternative to SLR based nuclear power.

- Regarding your concern with Charpy testing, this concern screens out of the 2.206 Petition Process consistent with MD 8.11 Section II.A.2(d)(ii), “General Assertions and Duplicative Requests for Action under 10 CFR 2.206,” as this concern was evaluated by a PRB in response to your October and November 2020 10 CFR 2.206 petitions. The March 11, 2021, PRB response is available in ADAMS (ML21040A376).

- Regarding rising sea levels, this concern screens out of the 2.206 Petition Process consistent with MD 8.11 Section II.A.2(d)(ii), “General Assertions and Duplicative Requests for Action under 10 CFR 2.206,” because your concern regarding sea level change is not accompanied by a specific vulnerability at TPN for the staff to consider.

- Regarding solar power being a safe alternative to SLR based nuclear power, this concern screens out of the 2.206 Petition Process consistent with MD 8.11 Section II.A.2(d)(v), “Requests That Would Not Reasonably Lead to an Enforcement Action,” because your position does not identify a safety issue or licensee non-compliance with NRC regulations that could justify the NRC staff pursuing enforcement action.

- No further action will be taken regarding your Charpy testing, sea level, and alternative power concerns but I would like to thank you for bringing these concerns to the attention of the NRC.

Requested Enforcement Action

First, petitioners request that the NRC require all licensees of pressurized water reactors who are currently operating their respective reactors beyond 40-years to immediately bring their reactors to a safe shut-down mode of operation until such time as the licensees can effectively test their reactor pressure vessels for neutron damage and embrittlement as delineated below.

Second, petitioners request that the NRC require all licensees of pressurized water reactors who were (1) granted an extended operational license by the NRC; or (2) who are currently seeking an extended operational license from the NRC beyond the licensee's current operational license expiration date – take the following actions (**to test their reactor pressure vessel's integrity)** prior to the NRC granting any request by any licensee to extend their operational license beyond its current expiration date:

- Conduct ultrasonic testing using high-frequency sound waves to detect and characterize internal flaws or changes in material properties. This non-destructive testing method can identify cracks, voids, or changes in the microstructure caused by neutron damage.

- Conduct radiographic testing which involves the use of X-rays or gamma rays to create images of the internal structure of the reactor vessel. Changes in density or the presence of defects, induced by neutron damage, can be identified through this method.

- Conduct neutron radiography which is specifically designed to visualize the distribution of neutron-absorbing materials within the reactor vessel. It can provide information about the distribution of neutron-induced changes in the material.

- Conduct metallographic examinations which involve the microscopic study of polished and etched samples of the reactor vessel material. This allows for the observation of changes in the microstructure, such as grain boundaries, voids, and precipitates, which may indicate neutron damage.

- Conduct ultrasonic velocity measurements which can detect changes in ultrasonic wave velocity through the material can be indicative of alterations in its mechanical properties. By measuring the velocity of ultrasonic waves, one can assess the effects of neutron damage.

- Conduct acoustic emission testing which involves monitoring the acoustic signals emitted by a material when subjected to stress. This method can detect the initiation and progression of cracks, providing insight into the material's condition.

- Conduct pulsed eddy current testing which uses electromagnetic induction to detect changes in the electrical conductivity of the material. Variations in conductivity may be associated with neutron-induced changes.

Basis and Justification

The embrittlement of pressurized nuclear reactor vessels over time is primarily attributed to neutron irradiation. Neutrons are high-energy particles released during the nuclear fission process in the reactor core. As these neutrons interact with the materials in the reactor vessel, they can induce changes that lead to embrittlement. The main reasons why pressurized nuclear reactor vessels cannot be safely operated beyond 40 years due to embrittlement include:

1. **Neutron Irradiation Effects:** Neutrons have the potential to displace atoms from their original positions in the crystalline structure of materials. Over time, this displacement leads to the degradation of the material's mechanical properties, such as toughness and ductility. This effect is more pronounced in the metal components of the reactor vessel, making them more susceptible to embrittlement. Neutrons, which are uncharged particles, can penetrate the reactor vessel's structural materials. As they collide with atoms in the material, they can displace these atoms from their original positions. This displacement leads to the creation of defects, such as vacancies and interstitials, in the crystalline structure.
2. **Formation of Embrittling Elements:** Neutron irradiation can also result in the formation of certain elements, such as helium and other transmutation products, within the material. These elements can accumulate in the metal matrix, creating microstructural changes that contribute to embrittlement. Neutron irradiation can also lead to the formation of helium and hydrogen within the material. Helium tends to

accumulate at grain boundaries, reducing the material's ductility. Hydrogen, on the other hand, can diffuse into the material, causing embrittlement by forming hydrides.

3. **Stress Corrosion Cracking (SCC):** Neutron irradiation can enhance the susceptibility of reactor vessel materials to stress corrosion cracking. This is a phenomenon where the combined effects of stress and a corrosive environment lead to the initiation and propagation of cracks in the material. The embrittled material becomes more prone to cracking under the influence of stress and corrosive conditions. Embrittled materials are more prone to stress corrosion cracking, especially in the presence of aggressive reactor coolant environments. This can further compromise the structural integrity of the reactor vessel.
4. **Loss of Toughness:** The combined effects of neutron irradiation, embrittling element formation, and stress corrosion cracking lead to a gradual loss of toughness in the reactor vessel material. As the material becomes more brittle, it is less able to withstand the dynamic and static loads to which it is subjected during normal and emergency operating conditions. The accumulation of defects, the presence of helium and hydrogen, and changes in the material's microstructure collectively contribute to a decrease in the material's toughness and ductility. This makes the reactor vessel more susceptible to cracking and brittle fracture.
5. **Regulatory Requirements:** As a reactor vessel approaches or surpasses the 40-year mark, the accumulated neutron damage may exceed regulatory limits, necessitating thorough assessment and potentially limiting the operational lifespan. Due to these factors, there is a limit to the safe operational life of pressurized nuclear reactor vessels. Beyond approximately 40 years, the risk of embrittlement becomes significant, and the potential for catastrophic failure due to vessel rupture or cracking and necessitates careful consideration and, in many cases, retirement or refurbishment of the reactor.

The licensees identified above, have relied on charpy impact testing which involves testing small samples taken from the reactor pressure vessel (RPV) material to measure their resistance to impact at various temperatures. The results provide information about the material's toughness and can indicate susceptibility to embrittlement due to neutron irradiation. However, this type of testing is simply not adequate to accurately assess the amount of neutron damage to the licensees' RPVs.

Moreover, to the extent that the licensees have delineated RPV integrity surveillance programs – these assessments are not adequate to accurately assess the amount of neutron damage to the licensees' RPVs. Therefore, the licensees cannot provide reasonable assurance to the NRC that the integrity of their respective RPVs will be maintained in full compliance with NRC rules and regulations for the period of any extended operations beyond the RPV's original 40-year safety design basis.

It's important to note that a combination of these methods is often used to obtain a comprehensive understanding of neutron damage in a reactor vessel. Regular and systematic inspections, as well as periodic surveillance programs, are essential for monitoring the condition of the reactor vessel over time and ensuring its safe and reliable operation. The choice of testing methods depends on factors such as the specific materials used, the reactor design, and regulatory requirements.

Petitioners cannot emphasize enough that - testing a nuclear reactor vessel for neutron damage is a critical aspect of ensuring its structural integrity and safety.

Conclusion

The embrittlement of pressurized nuclear reactor vessels beyond 40 years is a complex phenomenon driven by neutron irradiation effects, the formation of embrittling elements, stress corrosion cracking, and the gradual loss of material toughness. These factors collectively compromise the structural integrity of the reactor vessel, prompting safety concerns and regulatory limitations on extended operation.

For all the above stated reasons, the NRC should take the requested enforcement action against the licensees as described above to protect the health and safety of the public and to protect the environment.

For the Petitioners

Thomas Saporito
Executive Director

* A copy of this electronic communication is being provided to the NRC Office of the Inspector General to enable that agency to monitor the actions of the NRC in this important matter to protect the health and safety of the public and to protect the environment from the catastrophic effects of a serious nuclear accident originating from a licensed commercial nuclear power plant regulated by the NRC.