From: Perry Buckberg
Sent: Friday, July 21, 2023 8:13 AM
To: Mark Leyse
Subject: 2.206 Petition Initial Assessment - Transfer Spent Fuel to Dry Storage

Good morning Mr. Leyse,

The Petition Review Board (PRB) has completed its initial assessment of the petition you submitted on February 28, 2023, as supplemented on March 26, 2023, and April 18, 2023. Your petition requested that the U.S. Nuclear Regulatory Commission (NRC) take action under Title 10 of the Code of Federal Regulations (10 CFR), Section 2.206 by issuing an order to licensees to promptly transfer all sufficiently-cooled spent fuel assemblies that are presently stored in each of the spent fuel pools (SFPs) at U.S. Nuclear Power Plants (NPPs) to dry cask storage. Your justification for the requested action is that a solar storm, electromagnetic pulse (EMP), cyber-attack and/or a physical attack could cause widespread, long-term power grid failure which could lead to SFP coolant loss. You state that reducing the density of spent fuel assemblies in SFPs may help ensure that the properly configured remaining assemblies would not ignite and lead to a zirconium fire once a SFP loses a significant portion of its coolant. Specific concerns listed in your petition include:

1. An extreme solar storm might occur as frequently as once in 153 years to once in 500 years and initiate a widespread and long-term loss of the AC power grid and lead to widespread SFP coolant level challenges due to multiple loss-of-offsite power (LOOP) events.
2. An EMP with a magnitude that could cause widespread, long-term power outages and lead to widespread SFP coolant level challenges due to multiple LOOP events.
3. Diverse and Flexible Mitigation Capability (FLEX) equipment will work only 6 out of 10 times in arresting an accident involving an extended loss of AC power.
4. Without a timely restoration of AC power, a station blackout (SBO) will lead to a reactor core meltdown at each affected nuclear power plant unit, as occurred at Fukushima Daiichi.
5. The NRC's MELCOR Computer Code is incapable of simulating some spent fuel pool fire phenomena.
6. Power Grids are Vulnerable to Physical Attacks and Cyberattacks.
7. Many high-density SFP physical environment and chemical reaction scenarios, which were described in the petition, may result from a loss of SFP coolant and could lead to spent fuel zirconium fires, which may be severe.

The PRB performed its initial assessment to determine whether the petition meets the applicable acceptance criteria in NRC's Management Directive (MD) 8.11, "Review Process for 10 CFR 2.206 Petitions," and its associated Directive Handbook (DH) 8.11, Section III.C.1 (Agencywide Documents Access and Management System (ADAMS) Accession number ML18296A043).

The PRB's initial assessment is that the concerns represented in your petition which are within the NRC's regulatory authority (concerns 3, 4, 5 and 7) do not meet the DH 8.11 acceptance criteria in Section III.C.1(b)(ii). Specifically "The issues raised have previously been the subject of a facility-specific or generic NRC staff review…" and the petition does not provide significant new information that the staff did not consider in the prior review. Our initial assessment is to not accept your petition for review.

The PRB is providing the following responses to address your concerns:

1. An extreme solar storm might occur as frequently as once in 153 years to once in 500 years and initiate a widespread and long-term loss of the AC power grid and lead to widespread SFP coolant level challenges due to multiple LOOP events.

   PRB Response
   Grid resilience (including under extreme solar storm conditions) is outside the NRC's authority and is regulated by the Federal Energy Regulatory Commission (FERC) with participation from the North American Electric Reliability Corporation (NERC). Therefore, in accordance with MD 8.11 Section II.A.2(d)(vi), this issue is not appropriate for a petition under 10 CFR 2.206.

   All U.S. NPPs are equipped to respond to an extended loss of AC power (ELAP), in accordance with 10 CFR 50.155 (b)(1) and (c). Further, it is the NRC's position that U.S. NPPs can safely shut down following an extreme solar storm event and maintain spent fuel pool cooling. In the Federal Register for the Mitigation of Beyond-Design-Basis Events (MBDBE) rule (84 FR 39684; August 9, 2019), the commission stated that the requirements in § 50.155(b)(1) and (c) and the associated regulatory guidance, address the issues raised by the (PRM–50–96) petitioner because these regulations require licensees to establish offsite assistance to support maintenance of the key functions (including both reactor and SFP cooling) following an extended loss of AC power, which has been postulated as a consequence of geomagnetic disturbances. These requirements include diesel fuel resupply during and following beyond design basis events. This does not include any diesel fuel resupply efforts that may come as part of the federal government's response efforts.

   The NRC participated with other government agencies to develop the National Space Weather Strategy (NSWS) and the National Space Weather Action Plan (NSWAP). On October 13, 2016, President Obama issued Executive Order 13744, "Coordinating Efforts to Prepare the Nation for Space Weather Events" (81 FR 71573; October 18, 2016), requiring agencies to begin to implement the NSWAP. As a result, the NRC emergency response center now receives space weather forecasts, which it relays directly to U.S. NPPs, providing as much as 3 days early warning.

   While the NRC has focused largely on impacts to licensee locations, other agencies continue to research and improve overall space weather readiness. FERC and NERC have worked to produce improved reliability standards for grid operators. The new requirements established by FERC to address geomagnetic disturbances (81 FR 67120; September 30, 2016) add requirements that will improve overall grid resilience. Further, the Electric Power Research Institute (EPRI) has documented research to better understand the impacts of space weather on the current infrastructure. In a 2017 report on that research (Magnetohydrodynamic Electromagnetic Pulse Assessment of the Continental U.S. Electric Grid: Voltage Stability Analysis. EPRI, Palo Alto, CA: 2017. 3002011969), EPRI concluded, in part, that grid failures from extreme space weather

would likely result in transformer saturation that would cause overcurrent tripping before most transformers would be damaged. It also concluded that the largest shutdowns would be in the most densely populated areas in the northern latitudes. The EPRI report evaluation did not show any scenarios where a national grid collapse would occur. Based on this information and existing NRC requirements, staff asserts that recovery from this type of shutdown would happen within the timeframe encompassed by existing mitigating procedures

2. An EMP with a magnitude that could cause widespread, long-term power outages and lead to widespread SFP coolant level challenges due to multiple LOOP events.

   PRB Response:
   As described above, grid resilience is outside NRC's regulatory authority. However, all U.S. NPPs are equipped to respond to an ELAP, in accordance with 10 CFR 50.155(b)(1) and (c). Further, it is the NRC's position that U.S. NPPs can safely shut down following an EMP or extreme solar storm event.

   The NRC has been examining impacts of EMPs for more than 40 years, starting in the late 1970s when the agency studied how EMPs could affect nuclear power plant safe-shutdown systems. In February 1983 the NRC issued the study's conclusion: nuclear power plants' safety systems can fulfill their intended safety functions after an EMP event (NUREG/CR-3069, SAND82-2738/1 Vol. 2, "Interaction of Electromagnetic Pulse with Commercial Nuclear Power Plant Systems"). The agency revisited the issue in 2007 to account for the increasing use of digital computer systems in nuclear plants, which potentially could be more susceptible to an EMP ("Assessing Vulnerabilities for Present Day Digital Systems to Electromagnetic (EM) Threats at Nuclear Power Plants", F. Wyant, M. Walker, L. Bacon, M. Dinallo December 2009 (non-public - Security-Related content)). Most recently, the agency worked closely again with Sandia National Laboratories on further EMP related testing and the Sandia report concluded that the test results supported previous determinations that US NPPs will safely shutdown following an EMP event (SAND2022-10244, "Ensuring a Nuclear Power Plant Safe State Following an EMP Event", December 2022 (non-public - Official Use Only)).

3. Diverse and Flexible Mitigation Capability (FLEX) equipment will work only 6 out of 10 times in arresting an accident involving an extended loss of AC power.

   PRB Response:
   The petitioner's claim that FLEX will work 6 of 10 times is taken from the 2015 document, "Draft Regulatory Basis for Containment Protection and Release Reduction for Mark I and Mark II Boiling Water Reactors" (ML15022A214). This was a conservative estimate developed before FLEX had been fully implemented at any plant and the estimate included seismic contributors to core damage frequency for an ELAP. In the context that the comment is being applied by the petitioner, one would have to assume an ELAP caused by space weather concurrent with a seismic event. The NRC does not assume concurrent beyond design basis events. Further, FLEX response for SFP cooling typically only involves a single diesel pump with hand laid fire hose. This removes risk for other internal equipment and has much lower human factor contributors.

4. Without a timely restoration of AC power, a SBO will lead to a reactor core meltdown at each affected nuclear power plant unit, as occurred at Fukushima Daiichi.

PRB Response:
The NRC position is that space weather is not a credible initiating event that results in a SBO. A SBO differs from a LOOP in that AC power is provided through inverters and/or a dedicated SBO diesel and it has very specific dedicated procedures to provide a prescribed coping time. In contrast, the MBDBE rule provides a broader set of equipment with a broader set of guidelines to address a wider array of scenarios, with the minimum capability of mitigating the loss of all AC power in conjunction with a loss of ultimate heat sink. Under the MBDBE rule, licensees may use FLEX equipment at any time and as needed to protect public health and safety. The rule requires that the strategies and guidelines be capable of site-wide implementation and include enabling the use and receipt of offsite assistance and resources to support the continued maintenance of the functional capabilities for core cooling, containment, and SFP cooling indefinitely, or until sufficient site functional capabilities can be maintained without the need for the mitigation strategies.

5. The NRC's MELCOR Computer Code is incapable of simulating some spent fuel pool fire phenomena.

PRB Response:
The petitioner lists many concerns about MELCOR modeling. Among the arguments being made are that MELCOR cannot not capture the ignition timing, total chemical reaction energy, and the consequences of spent fuel pool accidents because it does not explicitly model the nitriding of zirconium fuel-cladding, that it does not explicitly model the effects of an oxide layer, and that MELCOR does not model criticality.

The NRC has addressed these specific concerns regarding MELCOR in Appendix D to NUREG–2157, Volume 2, ''Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel'' (ML14196A107). To briefly summarize the NUREG–2157, Volume 2 response to related comments D.2.39.18 and D.2.39.24, the NRC considers that the physical models in MELCOR capture the most important phenomena necessary to realistically evaluate the initiation and progression of SFP fires. Although zirconium nitriding was not explicitly modeled in the NRC's spent fuel pool fire analyses, the NRC believes such a model is not necessary since initiation and progression has been validated against air-oxidation experiments which do involve the effects of nitriding, that oxygen-starved scenarios where the inclusion of a nitriding model would change results compared to current modeling necessarily involve less energy release and also necessarily involve less release of radioactive material to the environment than scenarios involving a failed reactor building which readily allow both air (oxygen) ingress to the fuel and radioactive materials release to environment, and for which limiting cases or sensitivity analyses can be used to bound results. The NRC concluded that it is reasonable to rely on the quantitative results from NUREG–1738, "Technical Study of Spent Nuclear Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants" (ML010430066) for NUREG–2157, Volume 1 because NUREG–1738 makes appropriate, bounding conservative assumptions regarding SFP fire progression.

Additional information about the capabilities of the MELCOR code to model SFP accidents can be found in the NRC response to stakeholder comments in Appendix E to NUREG–2161 "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor," (ML14255A365).

The NRC also addressed MELCOR modeling concerns in the August 24, 2016 SECY-16-0100 (ML16188A300), "Staff Review and Response to National Academy of

Sciences Study of the Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Power Plants." In this report, the staff concluded that spent fuel continues to be stored safely and securely at nuclear power plants in both spent fuel pools and dry casks. The petitioner referenced the National Academy of Sciences report but did not reference SECY-16-0100 responding to this report.

The PRB is aligned with previous NRC responses regarding MELCOR which convey the following: The NRC disagrees with the petitioner's statements that MELCOR is flawed. MELCOR is the NRC's best estimate tool for severe accident analysis and has been validated against experimental data. The findings from the experimental programs and the MELCOR assessments have been documented in NUREG/CR-7143 for BWR assemblies and NUREG/CR-7215 & NUREG/CR-7216 for PWR assemblies. Sensitivity analyses are used to account for uncertainties inherent to the progression of severe accidents. Alternative conservative assumptions are used in modeling when needed.

6. Power Grids Are Vulnerable to Physical Attacks and Cyberattacks.

PRB Response:

Power grid security beyond NRC licensee-controlled areas is outside of the NRC's authority and is regulated by FERC. Therefore, in accordance with MD 8.11 Section II.A.2.(d)(vi), this issue is not appropriate for a petition under 10 CFR 2.206.

FERC has responsibility for regulating interstate transmission lines and substations. FERC issued, "Reliability Standards for Physical Security Measures," 146 FER 61,166 (2014), Docket Number RD14-6-00, which directed the NERC Commission-certified Electric Reliability Organization (ERO), to submit for approval one or more Reliability Standards that will require certain registered entities (owners of portions of the power transmission system/subsystems) to take steps (or demonstrate that they have taken steps) to address physical security risks and vulnerabilities related to the reliable operation of the Bulk-Power System. According to FERC Order 146 FER 61,166, the proposed Reliability Standards "should" require owners or operators of the Bulk-Power System, as appropriate, to identify facilities on the Bulk-Power System that are critical to the reliable operation of the Bulk-Power System. Then, owners or operators of those identified critical facilities "should" develop, validate, and implement plans to protect against physical attacks that may compromise the operability or recovery of such facilities.

Subsequently, NERC implemented CIP-014-2, Physical Security, dated January 27, 2015, which directs certain registered entities, "to identify and protect transmission stations and transmission substations, and their associated primary control center, that if rendered inoperable or damaged as a result of a physical attack could result in instability uncontrolled operation, or cascading within an inter connection."

The Federal Aviation Administration (FAA) has responsibility regarding threats to the power grid from a drone (unmanned aircraft system). Title 49 of the United States Code (49 U.S.C.), "Transportation," § 44801 requires the FAA to regulate aircraft operations, including those of unmanned aircraft systems (UASs) such as drones, conducted in the national airspace that need to remain a safe distance from and to avoid collisions with other airborne aircraft, structures on the ground, and other objects.

The FAA Reauthorization Act of 2018, Public Law 115-254, defines unmanned aircraft as an aircraft that is operated without the possibility of direct human intervention from within the aircraft.

Although the FAA does not place additional regulatory guidance on unmanned aircraft systems, as compared to aircraft used for commercial purposes, the law specifies that model aircraft must not interfere with the safety of the National Airspace System and must comply with airspace restrictions, temporary flight restrictions and other guidance.

7. Many high-density SFP physical environment and chemical reaction scenarios, which were described in the petition, may result from a loss of SFP coolant and could lead to spent fuel zirconium fires, which may be severe.

   PRB Response
   NRC requirements, such as the MBDBE rule, are in place to ensure licensees have the ability to maintain SFP coolant inventory even in accident scenarios. The PRB affirms that it is an NRC priority to maintain SFP coolant levels during beyond design basis events and the FLEX equipment program was implemented to facilitate this. In addition, the NRC has published studies analyzing SFP accident scenarios and has considered the accelerated transfer of spent fuel assemblies to dry cask storage including in NUREG-2157, "Waste Confidence Generic Environmental Impact Statement: Draft Report for Comment," (ADAMS Accession No. ML14196A105) and in COMSECY 13-0030 (ADAMS Accession No. ML13273A601). The NRC has considered these studies and subsequently concluded that the accelerated transfer of spent fuel assemblies is not required of the licensees. The concerns and questions included in Sections III.B through III.K of your petition have been considered and are addressed in NUREG-2157 Volume 2 (ML14196A107). The PRB has verified that the NUREG-2157 Volume 2 responses are still applicable. The conclusion of these previous studies is that the risk to public safety from a spent fuel pool fire is low because, while the consequences from a spent fuel pool fire could be severe, the probability of a spent fuel fire occurring is low.

I am happy to offer you the opportunity to clarify or supplement your petition in a virtual public meeting with the PRB. If you decide to take advantage of this opportunity, the meeting with the PRB would be conducted consistent with the format described in MD 8.11 Section III.F. The PRB will consider your statements and information presented at the meeting, along with the original petition, in making its final determination on whether to accept your petition for review. Please indicate by August 4, 2023, whether you wish to have this public meeting before we close the petition.

If you have any questions regarding this e-mail, please feel free to contact me at Perry.Buckberg@nrc.gov.

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