[7590-01-P]
DD-16-01

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

William M. Dean, Director

In the Matter of	)	Docket Nos. 50-271 and 50-305
	)	
	)	
ENTERGY NUCLEAR OPERATIONS, INC.	)	
DOMINION ENERGY KEWAUNEE, INC.	)	License Nos. DPR-28 and DPR-43
	)	
	)	
	)	
	)	
Vermont Yankee Nuclear Power Station	)	
Kewaunee Power Station	)	

DIRECTOR'S DECISION UNDER 10 CFR 2.206

I. Introduction

By letter dated March 25, 2014 [sic] (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15090A487), Michael Mulligan (the petitioner) filed a petition under Title 10 of the *Code of Federal Regulations* (10 CFR) 2.206, "Requests for Action under This Subpart," related to the Vermont Yankee Nuclear Power Station (VY) and the Kewaunee Power Station (KPS).

The petition was supplemented by e-mails dated July 7, 2015 (ADAMS Accession No. ML15198A091), and September 9, 2015 (ADAMS Accession No. ML15286A003).

Actions Requested for the March 25, 2014 [sic], Petition

The petitioner requested that the U.S. Nuclear Regulatory Commission (NRC or the Commission) take a number of actions with regard to VY and KPS, both of which have been permanently shut down and are currently undergoing decommissioning. These included the following:

- Conduct exigent and immediate full-scale ultrasonic inspections on the VY and the KPS reactor pressure vessels (RPVs), with similar or better technology, as conducted on the RPVs at Doel 3 and Tihange 2, which revealed thousands of cracks.
- Take large borehole samples out of both the VY and KPS RPVs and transport them to a respected metallurgic laboratory for comprehensive offsite testing.
- Issue an immediate NRC report and hold a public meeting on any identified vulnerabilities.
- Ultrasonically test all RPVs in U.S. plants within 6 months if distressed and unsafe results are discovered at VY or KPS.

As the basis for this request, the petitioner states that the requested actions should be taken to determine whether foreign operating experience (OpE)—specifically several thousand cracks that have been discovered during testing on the Doel 3 and Tihange 2 RPVs—could have implications on U.S. operating reactors. The petitioner also requested several related actions of the NRC, such as collaboration with the Belgian regulator, and posed several questions related to water chemistry and the discovered cracks.

The petitioner spoke with the Petition Review Board on May 19, 2015, to clarify the bases for the petition. The NRC treats the transcript of this teleconference as a supplement to the petition (ADAMS Accession No. ML15181A127), and it is available for inspection at the NRC's Public Document Room (PDR), located at One White Flint North, Room O1-F21,

11555 Rockville Pike, Rockville, MD 20852. Publicly available documents created or received at the NRC are accessible electronically through ADAMS in the NRC Library at http://www.nrc.gov/reading-rm/adams.html. Persons who do not have access to ADAMS or who encounter problems in accessing the documents should contact the NRC's PDR reference staff by telephone at 1-800-397-4209 or 301-415-4737, or by e-mail to pdr.resource@nrc.gov.

The NRC's acknowledgement letter to the petitioner for the March 25, 2014 [sic], petition, dated August 20, 2015 (ADAMS Accession No. ML15181A099), informed the petitioner that his request for conducting exigent and immediate full-scale ultrasonic inspections on the VY and KPS RPVs was denied and that the remaining issues in the petition were being referred to the Office of Nuclear Reactor Regulation (NRR) for appropriate action. The NRC denied the petitioner's request to conduct immediate ultrasonic inspections at VY and KPS for the following reasons. The identified facilities have ceased operations, and there is no safety concern at those facilities that justifies enforcement-related action (i.e., to modify, suspend, or revoke the licenses) for the NRC to have reasonable assurance of the adequate protection of public health and safety. Furthermore, with respect to the operating fleet, the NRC issued Information Notice (IN) 2013-19, "Quasi-Laminar Indications in Reactor Pressure Vessel Forgings," dated September 22, 2013 (ADAMS Accession No. ML13242A263). The purpose was to inform industry of the quasi-laminar indications that were identified in 2012 at two European commercial nuclear power plants during the ultrasonic inspections of those RPV forgings.

The NRC sent a copy of the proposed director's decision to the petitioner and to Entergy Nuclear Operations, Inc. (for VY), and Dominion Energy Kewaunee, Inc. (for KPS), for comment on January 20, 2016 (ADAMS Accession Nos. ML15286A235, ML15286A265, and ML15286A258, respectively). The petitioner responded with comments by e-mail on February 12, 2016 (ADAMS Accession No. ML16054A311). The comments and the NRC staff's

response to the comments are included in this director's decision. The NRC staff did not receive any comments on the proposed director's decision from either licensee.

II. Discussion

Disposition of the March 25, 2014 [sic], Petition

Under the 10 CFR 2.206(b) petition review process, the Director of the NRC office with responsibility for the subject matter shall either institute the requested proceeding or shall advise the person who made the request in writing that no proceeding will be instituted, in whole or in part, with respect to the request, and the reason for the decision. Accordingly, the decision of the NRR Director is provided below.

It is the policy of the NRC to have an effectively coordinated program to promptly and systematically review domestic and applicable international OpE information gained from the nuclear power industry, research and test reactors, and new reactor construction. The program supplies the means for assessing the significance of OpE information, offering timely and effective communication to stakeholders, and applying the lessons learned to regulatory decisions and programs affecting nuclear reactors. This program is referred to as the Reactor OpE Program, as described in NRC Management Directive (MD) 8.7, "Reactor Operating Experience Program" (ADAMS Accession No. ML122750292). Specific implementation of the Reactor OpE Program is addressed in NRR Office Instruction (OI) LIC-401, "NRR-NRO [Office of New Reactors] Reactor Operating Experience Program" (ADAMS Accession No. ML12192A058).

One of the sources of OpE is the International Atomic Energy Agency/Nuclear Energy Agency International Reporting System (IRS) for Operating Experience. The Doel 3 experience was reported to the IRS. Subsequently, the report was updated to include the Tihange 2 experience. In accordance with the process described in OI LIC-401, the NRC OpE program

staff ensured that the appropriate technical experts within the NRC were aware of the issue and performing evaluations for relevance to the U.S. industry. In addition, the NRC has strong collaboration with the international community and was separately in contact with the Belgian regulatory authority, the Federal Agency for Nuclear Control (FANC), to discuss this issue.

The NRC staff has been following the issue and has taken numerous actions. Most recently, the NRC staff used its risk-informed decisionmaking process contained in NRR OI LIC-504, Revision 4, "Integrated Risk-Informed Decision-Making Process for Emergent Issues" (ADAMS Accession No. ML14035A143) to evaluate this issue. The evaluation (ADAMS Accession No. ML15282A218) is summarized below.

Description of the Issue

In July 2012, ultrasonic inspections of RPV ring forgings at the Doel 3 and Tihange 2 nuclear power plants in Belgium revealed thousands of indications.[1] After extensive investigation, the Belgian licensee, Electrabel, concluded the indications consisted of hydrogen flakes that originated during fabrication. Hydrogen flakes are planar discontinuities produced during fabrication in steels that have elevated hydrogen content before forging. In the Doel 3 and Tihange 2 inspections, the identified flakes were approximately circular disc-shaped cracks, were on average 10 millimeters in diameter, and were oriented approximately parallel to the vessel wall. Electrabel performed deterministic flaw evaluation and probabilistic fracture mechanics (PFM) analyses and concluded: (1) the indications would have been acceptable according to the requirements of the construction codes in effect when the vessels were

[1] In an ultrasonic examination, indications are features inside the inspection volume that reflect sound above a threshold established as part of the examination procedure. Generally, the inspection procedure will define thresholds of reflectivity that examiners use to categorize indications, with more reflective indications being categorized as more significant. Indications that reflect enough sound to be detected are termed "detectable." Detectable indications that reflect sound above a certain threshold, such that the procedure requires them to be recorded, are termed "recordable." Generally, recordable indications must be evaluated. Applicable codes and standards referenced in the procedure or design specification establish criteria to determine if recorded indications are "acceptable" or "rejectable." Rejectable indications are termed "flaws" or "defects" that, per the American Society of Mechanical Engineers (ASME) practice, must be repaired. Rejectable indications are "reportable" to the regulatory authority.

fabricated (as well as the codes in effect today), and (2) the indications did not pose a challenge to RPV structural integrity. The licensee started a program of materials research and operational inspections to further validate the structural integrity determination of the RPV forgings. FANC initially approved restart of the two reactors in May 2013. Information related to this issue is publicly available on the FANC Web site at http://www.fanc.fgov.be/nl/page/dossier-pressure-vessel-doel-3-tihange-2/1488.aspx?LG=2.

While the Doel 3 and Tihange 2 reactors were shut down for outages in 2014, the ring forgings were reinspected for quasi-laminar flaws. During the 2012–2013 campaign, the licensee quantified the number of recordable indications, but it recognized that many indications were detected that returned signal responses below the procedurally established recording threshold. For the 2014 examination, the licensee adjusted the ultrasonic inspection procedure by changing recording thresholds and increasing sensor gain. The objective was to record essentially all detectable indications. Newly recorded indications included cases where multiple indications spaced closely together, which were previously recorded as one large indication, could now be distinguished as several discrete indications. Most of these newly recorded indications were detected, but not recorded, during the previous exam because they were too small to meet the previously used recording criteria. After comparing the indications from the 2012 and the 2014 inspections, the Belgian licensee concluded that the actual number and size of detected indications did not change over the period.

In March 2014, FANC received the results from the ongoing Electrabel materials investigation. The results from one of the materials tested showed a greater amount of embrittlement than assumed in its safety case. Consequently, the licensee elected to place both Doel 3 and Tihange 2 into an early maintenance outage to conduct further investigation. The material with the higher-than-expected embrittlement was a modern steel made to a specification similar to that used for the Doel 3 and Tihange 2 RPVs. The component was a

steam generator shell that had been rejected because of hydrogen flaking and was, therefore, included as part of the Electrabel investigation. After the March 2014 results, Electrabel performed several materials irradiation experiments that included the steam generator material, as well as other materials thought to be more representative of RPV steels in Doel 3 and Tihange 2.

On November 17, 2015, FANC reported that Electrabel demonstrated that the unexpected test results of March 2014 were probably caused by the specific material properties of the sample. Tests on another material specimen with hydrogen flakes and on the material of the reactor vessels themselves have shown that prolonged irradiation has had no abnormal effect on the mechanical properties of the reactor vessels of Doel 3 and Tihange 2. FANC concluded that the structural integrity of the reactor vessels of Doel 3 and Tihange 2 lies within the required safety standards, and the presence of hydrogen flakes does not adversely affect the safety of the plants.

Initial Actions by the NRC and the U.S. Nuclear Industry

In September 2013, the NRC issued IN 2013-19 to inform industry of the quasi-laminar indications observed in the Belgian RPV forgings. Additionally, the NRC hosted a public meeting with industry and stakeholders on March 5, 2013, to discuss these indications (ADAMS Accession No. ML13066A725). The industry presented plans to the NRC staff to investigate the type of ultrasonic examination techniques used during construction and to perform a PFM evaluation of the structural integrity effect on U.S. reactors of potentially undiscovered quasi-laminar indications.

Subsequently (October 2013), the industry published a report of its findings, titled, “Materials Reliability Program [MRP]: Evaluation of the Reactor Vessel Beltline Shell Forgings of Operating U.S. PWRs [Pressurized-Water Reactors] for Quasi-Laminar Indications (MRP-367)” (ADAMS Accession No. ML14064A411 (nonproprietary version)). The objectives of

the report were two-fold: (1) to evaluate whether RPV forgings in U.S. plants were likely to have indications similar to those found in Doel 3 and Tihange 2, and (2) to evaluate the structural significance of indications if they did exist in an RPV. The report concluded that the ultrasonic techniques used during construction of U.S. vessels were capable of detecting quasi-laminar indications, and the reporting requirements would have caused the indications to be recorded if they were present. The report included a PFM analysis of a set of conditions based on data from Doel 3 and Tihange 2. The industry concluded that, even if quasi-laminar indications were present in a U.S. reactor vessel forging, the incremental increase in the vessel failure probability under pressurized thermal shock loading is negligible.

Summary of the NRC's Evaluation

The NRC staff's evaluation consisted of reviewing the analyses performed by the Belgian licensee, as well as the two-pronged approach performed by the industry. Specifically, the NRC staff reviewed evaluations of the nondestructive examination records performed by the U.S. industry to determine the likelihood of the presence of the quasi-laminar indications in U.S. RPVs. Furthermore, the NRC staff reviewed the structural evaluations performed to determine the safety significance, even if the quasi-laminar indications were present. This was followed by applying the approach to risk-informed decisionmaking, as outlined in NRR OI LIC-504.

The Belgian licensee for Doel 3 and Tihange 2 performed deterministic flaw evaluations, which concluded that the quasi-laminar flaws observed in the RPV ring forgings were acceptable and did not compromise the structural integrity of the vessel. The Belgian licensee's PFM analyses using very conservative assumptions returned a crack initiation frequency below the NRC threshold for through-wall cracking frequency (TWCF). The NRC staff reviewed the analyses and found the analyses provided reasonable assurance that, even if a significant number of quasi-laminar indications existed in an RPV forging, the forging would be fully

capable of performing its safety function with an extremely low probability of failure. The Electric Power Research Institute (EPRI) MRP performed a PFM analysis and concluded that the TWCF associated with quasi-laminar indications was sufficiently low that the TWCF would meet NRC-risk criteria. The NRC staff performed a high-level review of the industry analyses and concluded that the inputs were conservative with respect to flaw number and flaw size, at least relative to the information currently available concerning such flaws. The NRC staff has concluded that the EPRI analyses provided reasonable assurance that, even if a significant number of quasi-laminar indications existed in an RPV forging, the forging would be capable of performing its safety function with an extremely low probability of failure.

The Pressurized-Water Reactor Owners Group (PWROG) reviewed ultrasonic examinations performed during construction and determined the inspection equipment and techniques used at the time of construction were capable of detecting quasi-laminar indications. Furthermore, the PWROG determined that the inspection recording criteria required the presence of quasi-laminar indications to be documented in nondestructive examination reports. The PWROG submitted summaries of its assessments to the NRC staff in MRP-367. Based on its assessment of the available information related to construction ultrasonic examinations, the NRC staff agrees that the ultrasonic examination techniques would have detected quasi-laminar indications and, if present, indications would have been required to be recorded.

The PWROG retrieved ultrasonic testing inspection records and concluded that the records indicated no quasi-laminar indications were recorded during fabrication examinations for any vessel beltline ring forging in U.S. nuclear power plants. The NRC staff reviewed a sampling of those records and verified that no quasi-laminar indications were recorded in the reviewed reports. From these results, along with the PWROG's report that its record exams found no quasi-laminar indications, the NRC staff concludes that it is unlikely that significant numbers of quasi-laminar indications exist in U.S. RPV forgings.

In February 2015, publications in *The Energy Daily* and a press release by *Greenpeace* cited concerns raised by two materials science professors—Professor W. Bogaerts, of the University of Leuven, in Belgium, and Professor D. MacDonald, of the University of California at Berkeley. Professors Bogaerts and MacDonald took issue with the initial findings from the Belgian licensee and the assessment by the Belgian regulator that concluded that the quasi-laminar indications have been present from the time Doel 3 and Tihange 2 were fabricated, and that they are not evolving (that is, increasing in number or getting bigger) over time. Professors Bogaerts and MacDonald have suggested that continued hydrogen ingress to the quasi-laminar indications could cause them to grow over time. The NRC staff is aware of this crack growth mechanism being common in some environments (for example, down-hole service in the oil and gas industry). However, the NRC staff is not aware of any current scientific information that would suggest that the conditions characteristic of nuclear pressure vessel service could generate partial-pressures of hydrogen that are high enough to cause such evolution during the operation of a reactor vessel.

Although these evaluations provide useful information for the two specific vessels in question, to evaluate the effects of the potential existence of quasi-laminar indications in RPV forgings in all U.S. vessels, the NRC staff used an analysis approach, based on PFM, and examined them within the context of the NRC's approach to risk-informed decisionmaking process described in NRR OI LIC-504. For this review, the NRC staff considered the following five principles:

- **Principle 1:** The proposed change must meet the current regulations unless it is explicitly related to a requested exemption or rule change.
- **Principle 2:** The proposed change shall be consistent with the defense-in-depth philosophy.
- **Principle 3:** The proposed change shall maintain sufficient safety margins.

- **Principle 4:** When the proposed changes result in an increase in core damage frequency or risk, the increases should be small and consistent with the intent of the Commission's safety goals.
- **Principle 5:** Monitoring programs should be in place.

The NRC staff considered three options to address, for the U.S. fleet of operating nuclear reactors, the recent operational experience from the Doel 3 and Tihange 2 reactors in Belgium:

1. Evaluate, communicate, and follow developments with no other required actions.
2. Initiate actions to require ultrasonic examination for quasi-laminar indications.
3. Immediately shut down potentially affected plants.

Consideration of Option 1: This option would entail acquiring information from FANC, Electrabel, U.S. industry, and other relevant sources as it becomes available. The information would be evaluated to assess whether quasi-laminar indications present a significant challenge to RPV structural integrity. If the risk is sufficiently small, then no other action would be required for NRC licensees. As part of this option, the NRC staff would continue its review of the industry conclusions concerning the nonexistence of such flaws in U.S. plants and of the industry conclusion that the risk associated with these flaws, were they to exist, is small. The NRC staff would use material property information available from surveillance programs to assess the potential for greater-than-expected embrittlement revealed in some tests reported by Electrabel. In addition, the NRC staff would continue to assess new information as it becomes available and communicate new information, subject to limitations imposed by proprietary information rights and other nondisclosure agreements.

Consideration of Option 2: This option would encompass the actions in Option 1, but it adds a development effort to require licensees to perform ultrasonic inspections of RPV forgings. The timeframe for inspection would depend on the potential for indications to

exist and the risk significance if they did exist. If the risk significance was high, as determined using risk metrics, such as large early release frequency (LERF) being greater than or on the order of $1x10^{-4}$/year, licensees may be required to perform inspections at the next refueling outage, or even shut down and perform inspections immediately. If the risk significance was low, then licensees could wait to perform inspections during the next inservice examination outage.

Consideration of Option 3: This option would consist of shutting down some or all operating reactors until inspections and analyses were conducted to provide reasonable assurance that the calculated risk levels were acceptable. This option would be preferable if there was an immediate safety issue, such that the risk to operating plants was clearly demonstrated to be large and immediate.

As the estimated risk associated with quasi-laminar indications is less than 1×10^{-6}/year, far below the 1×10^{-4}/year LERF guideline in NRR OI LIC-504, no immediate action was warranted, and Option 3 was dismissed without an evaluation of the five principles of risk-informed decisionmaking.

Even if quasi-laminar indications similar to those discovered at Doel 3 and Tihange 2 existed at U.S. nuclear power plants, the indications are not expected to significantly affect RPV integrity under accident conditions. The basis for this conclusion is the industry analysis, as described in MRP-367, which indicates a vessel with 10 times as many indications as observed in the worst forging at Doel 3 would have a risk of TWCF less than 1×10^{-6}/year, far below the 1×10^{-4}/year LERF guideline[2] in NRR OI LIC-504 for immediate action and below the

[2] By equating TWCF and LERF, it is possible to use the LERF risk guidelines in NRR OI LIC-504 to conservatively identify an acceptable TWCF. This is conservative because TWCF is an estimate of the frequency of cracks that leak. However, not all leaks lead to core damage. Furthermore, core damage does not always lead to large early release. As a result, TWCF is less than LERF. The fraction of time that core damage or large early release was prevented could be calculated, but it is conservative and computationally convenient to assume that all through-wall cracks lead to large early release.

criteria for requiring additional action, as contained in 10 CFR 50.61a, “Alternate Fracture Toughness Requirements for Protection against Pressurized Thermal Shock Events.”

Based on the NRR OI LIC-504 evaluation, the NRC staff concluded that no additional testing is necessary at this time. The NRC staff decided that there was not a significant risk difference between Option 1 and Option 2. However, because Option 2 would require physical activities associated with inspections, it would also require increased expenditure of licensee resources and increased radiation exposure to plant personnel. Given two options having essentially equal risk with different resource needs, the staff determined that Option 1 was the more appropriate option. Given that no results were obtained that exceeded the NRC’s risk guidelines, the NRC did not require all U.S. nuclear power plants be ultrasonically tested with the same or better technology. This addresses the petitioner’s first request, as well as the petitioner’s fourth request for testing of all operating reactors.

With respect to the petitioner’s request—to take large borehole samples out of both the VY and KPS RPVs and transport them to a respected metallurgic laboratory for comprehensive offsite testing—the NRC staff notes that acquisition and subsequent testing of irradiated and aged plant material from decommissioned plants could be a valuable research activity that might offer useful scientific information related to understanding the progress of aging mechanisms. However, the harvesting of reactor vessel material from plants that have been permanently shut down can be a complex and radiation-dose intensive effort. The NRC, through its Office of Nuclear Regulatory Research, has previously obtained samples appropriate for testing from shut-down plants. With respect to this request, the NRC may, in the future, seek to purchase samples. However, the identified facilities have ceased operations, and there is no safety concern at those facilities that justifies enforcement-related action (i.e., to modify, suspend, or revoke the license) for the NRC to have reasonable assurance of the adequate

protection of public health and safety. Therefore, the NRC will not require VY or KPS to remove large boreholes from their reactor vessels.

The petitioner requested that the NRC issue a report and hold a public meeting on the vulnerabilities. The NRC staff considers the NRR OI LIC-504 evaluation as satisfying the request for the agency to issue a report on the vulnerabilities. Furthermore, the NRC already held a public meeting on this topic on March 5, 2013.

The following information addresses the remaining requested actions and questions raised by the petitioner that appear in ***bold italic type***:

> ***How has the average concentration of hydrogen in the coolant changed over the recent decades? Would an increasing concentration of hydrogen in the coolant lead to more hydrogen ions getting injected into the vessel iron?***

The average concentration of hydrogen in coolant has not changed significantly over the past several decades in PWRs. Doel 3 and Tihange 2 are PWRs. With no change in average hydrogen concentration, there would be no change in hydrogen ingress into PWR pressure beltline steel.

The average concentration of hydrogen in boiling-water reactors (BWRs) has increased over the past several decades to concentrations closer to those used in PWRs. However, this does not result in an appreciable increase in the hydrogen content in BWR reactor pressure steel.

Does noble chemistry increase or decrease this kind of corrosion? Are there other chemicals added to the coolant that could make this kind corrosion worst? [sic]

Noble metal chemistry is a water chemistry technique used to suppress corrosion reactions that cause stress-corrosion cracking in portions of BWR coolant systems. However, this does not result in an appreciable increase in the hydrogen content in BWR reactor pressure steel.

What are they talking about here: "However, as Belgian [sic] continues to debate the fate of the reactors, prolonged studies on the steel used in the construction of the reactors revealed unprecedented embrittlement—unusual swelling—that can compromise the integrity of the plant and possibly cause ruptures, spewing dangerous radioactive material equivalent to an atomic bomb."

The NRC and nuclear industry are well aware of embrittlement of the steel used in RPV fabrication. It is the primary factor that limits both the operable lifetime and the operating safety of the RPV. This embrittlement is caused by exposure to neutron irradiation, which occurs as an unavoidable consequence of the production of steam by nuclear fission to generate electricity. The nuclear industry uses several means to ensure that the RPV steel maintains adequate toughness throughout its operating lifetime. These are as follows:

1. The degree of neutron embrittlement is tracked throughout the operating lifetime of the plant. This is achieved using a surveillance program in which small samples (coupons) of the RPV steel are exposed to neutron irradiation inside the reactor.
2. The NRC establishes screening criteria on the degree of embrittlement allowed and on plant operating temperatures and pressures. Several NRC rules and regulatory guides,

as well as Section XI of the ASME *Boiler and Pressure Vessel Code* (Code), collectively limit the combinations of embrittlement and operating temperatures and pressures so as to ensure safe nuclear power plant operations.

I understand all US nuclear plants have coupons and I consider them irrelevant to this problem.

The NRC staff recognizes the coupons are not relevant to the possibility of quasi-laminar indications.

Request the NRC coordinate with the Belgian Federal Agency for Nuclear Control (FANC).

The NRC staff is actively coordinating with FANC.

Request detailed inspection on the condition of the reactor cladding and an explanation of any defects.

By way of this director's decision and the references provided within, the NRC staff considers this request met.

Additionally, in the supplement dated September 9, 2015, the petitioner requested the NRC staff to consider, ***"As part of the NRC review and approval of IPEC 3 [Indian Point Nuclear Generating Unit No. 3] Reactor Vessel Heatup and Cooldown curves, in ML15226A159 dated 9-3-15, was the possible adverse affects of this change considered in regard to IN 2013-19 Quasi Laminar Indications in RPV Forgings?"***

The IPEC 3 RPV beltline is fabricated from rolled plates, not forgings. Because the manufacturing process used to produce plates differs from those used to produce forgings, any

indications remaining after the manufacturing process in a vessel fabricated from plates would be laminar (that is, fully parallel to the plate surface), not quasi-laminar. As a result of this difference in orientation, any indications in the IPEC 3 would have no detrimental effect on the operating safety of the reactor vessel. Thus, the IPEC 3 reactor vessel heatup and cooldown curves are not affected by quasi-laminar indications.

Summary of the Petitioner's Comments

The petitioner responded to the NRC's request for comment on the proposed director's decision by e-mail dated February 12, 2016 (ADAMS Accession No. ML16054A311). Overall, the petitioner stated, "I give the NRC an A plus on this report. It accurately captured the issue and the NRC clearly stated their decisions. My job has always been to get things written down on the official documents that are missing. I am very happy with the job. Although, I disagree with the NRC's analysis." The comments discussed below did not result in changes from the proposed director's decision.

A summary of the comments (***in bold italic type***) and the Agency's disposition of the comments are as follows:

The petitioner inferred from the conversation with the petition manager that the NRC was prevented from publishing its evaluation.

The NRC disagrees with the statement that "the system prevented them from discussing the issues unless outsiders provoked the agency with an inquiry." As stated in the proposed director's decision, the NRC initially issued IN 2013-19 to inform industry of the quasi-laminar indications observed in the Belgian RPV forgings. Furthermore, IN 2013-19 and industry's response to the events led to the industry-published report MRP-367. The publication of the IN demonstrates the NRC's commitment to disseminating pertinent information surrounding

operating experience. Before receipt of the petition, the NRC staff already initiated an NRR OI LIC-504 evaluation. The NRC is not prohibited from making the results of the NRR OI LIC-504 evaluation publicly available.

The petitioner challenged the conclusion by the Belgian licensee that the actual number and size of detected indications did not change over the period.

As stated in this director's decision, based on the analysis, Electrabel determined from the mapping of the indications that the number and size of the cracks did not increase; rather, the criteria for recording the indications changed so that more indications were recorded. Data from earlier and later examinations were compared to verify that number and size of the indications did not change.

Electrabel has indicated it will continue to measure the indications in future outages to detect if any future growth of the indications occurs.

The petitioner expressed concern on how the industry and the NRC calculates risk and that the agency is not very transparent to members of the public.

The NRC staff recognizes the complexity of risk assessment in regulation and has devoted a specific Web page to the topic: http://www.nrc.gov/about-nrc/regulatory/risk-informed.html.

The petitioner requested additional information regarding past efforts in which the NRC, through the Office of Nuclear Regulatory Research, has taken samples from shutdown plants.

The NRC has evaluated steam generator tubes removed from service at a number of plants. The NRC performed research on control rod drive mechanism (CRDM) housing and

weld material removed from the Davis-Besse Nuclear Power Station (Davis-Besse) RPV head. The NRC acquired samples of internals from the decommissioned Jose Cabrera Nuclear Power Plant and the San Onofre Nuclear Generating Station, Unit 1, internals. The NRC performed research on material removed from the Shoreham Nuclear Power Station RPV. The NRC performed research on nozzles from a pressurizer that was removed from service and replaced. The NRC has not removed samples from a plant that had an RPV with hydrogen flakes because the NRC is unaware that any such retired plant exists.

The petitioner challenged the NRC staff's argument that performing exigent testing and removing borehole samples would result in excessive radiation dose.

The director's decision discusses excessive radiation dose from performing exigent testing and taking samples to remind the petitioner that these requests are not trivial. The request would involve resources and would expose personnel to ionizing radiation. As stated in this director's decision, based on the NRR OI LIC-504 evaluation, the NRC staff concluded no additional testing is necessary at this time. The NRC staff considered that there was not a significant risk difference between Option 1 and Option 2. However, because Option 2 would require physical activities associated with inspections, it also would increase expenditure of licensee resources and radiation exposure to plant personnel. Given two options having essentially equal risk with different resource needs, the staff determined that Option 1 was the more appropriate option.

The petitioner requested the NRC staff to identify all known steel vessel vulnerabilities, including all corrosion mechanisms, and asked whether another

steam/CRDM/crack corrosion mechanism like that at Davis-Besse could pop out of nowhere and interact with the hydrogen flakes.

Reactor pressure vessel steel can be affected by the following damage mechanisms: overload, fatigue, embrittlement, and corrosion. Overload is prevented by adherence to the ASME Code by use of relief valves. Fatigue is evaluated by counting loading transients. Embrittlement is monitored by tracking accumulated neutron fluence and using fabrication material property information, such as original toughness and chemistry, to calculate changes in toughness. Corrosion is monitored by routine inspection for leakage and by programs that seek to prevent leakage.

The corrosion observed on the head at Davis-Besse would not have interacted with or been affected by hydrogen cracks.

The petitioner expressed concern that the industry cannot contrast an old vessel x-ray and a new ultrasonic testing at the identical area to detect any changes over time.

In this director's decision, the NRC staff states that the indications should have been detected, if present, and should have been recorded if detected. Therefore, in the U.S. fleet, the NRC does not anticipate having hydrogen flakes. The director's decision also states that if hydrogen flakes were present in an RPV as a result of the orientation of the indications, they would not challenge the structural integrity of the vessel.

Radiography would not detect hydrogen flakes because the flakes are oriented parallel to the x-ray film. Radiography detects changes in density, and quasi-laminar indications or hydrogen flakes do not result in a change in density in the direction through the vessel wall sufficient to be detected by radiography. As a result, a comparison of ultrasonic testing results and radiography would be meaningless for quasi-laminar indications in an RPV forging.

Lastly, the petitioner expressed concern that there are no periodical means (like ultrasonic testing) to detect cracks anywhere on the core.

The NRC staff presumes by the use of the term "core" that the petitioner means the RPV adjacent to the core. This region of the vessel is inspected periodically per the requirements of 10 CFR 50.55a, "Codes and Standards," and the ASME Code. These inspections are sufficient to detect quasi-laminar indications or hydrogen flakes in the area that is inspected, which is all of the welds and associated base materials, within a few inches of the weld seams.

III. Conclusion

Based on the above, the NRR Director will not be instituting the proceeding requested by the petitioner, either in whole or in part. The NRC staff will continue to evaluate, communicate, follow developments, and take appropriate action, if deemed necessary.

As provided in 10 CFR 2.206(c), a copy of this director's decision will be filed with the Secretary of the Commission for the Commission to review. As provided for by this regulation, the decision will constitute the final action of the Commission 25 days after the date of the decision unless the Commission, on its own motion, institutes a review of the decision within that time.

Dated at Rockville, Maryland, this 29th day of March 2016.

For the U.S. Nuclear Regulatory Commission.

/RA/

Michele G. Evans, Deputy Director,
Office of Nuclear Reactor Regulation