



Record of Decision

DEC 21-H111

In the Matter of

Applicant Ontario Power Generation Inc.

Subject Request for Authorization to Restart Pickering Nuclear Generating Station B Unit 5 following a forced outage

Date of Decision October 12, 2021

Record of Decision Date December 6, 2021

RECORD OF DECISION – DEC 21-H111

Applicant: Ontario Power Generation Inc.

Address/Location: 700 University Avenue, Toronto ON, M5G 1X6

Purpose: Request for Authorization to Restart Pickering Nuclear Generating Station B Unit 5

Application received: September 17, 2021

Hearing: Public Hearing in Writing – Notice of Hearing in Writing published on September 28, 2021

Date of decision: October 12, 2021

Panel of Commission: Ms. R. Velshi, Chair
Dr. M. Lacroix
Ms. I. Maharaj

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Decision: Authorization granted to restart Pickering NGS B Unit 5 following any outage

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1.0 INTRODUCTION

1. Ontario Power Generation Inc. (OPG) has applied to the Canadian Nuclear Safety Commission¹ (CNSC) for authorization to return Pickering Nuclear Generating Station (NGS) B Unit 5 (Unit 5) to service following a forced outage where the potential existed for a cooling down of the primary heat transport system. Pickering Unit 5 is [subject to a CNSC order](#)² (the order) that requires the licensee to obtain authorization from the Commission prior to restart following any outage that results in the cooldown of the heat transport system. The Pickering NGS is located in Pickering, Ontario, and is comprised of two reactor facilities – Pickering NGS A and Pickering NGS B – consisting of eight Canada Deuterium Uranium (CANDU) pressurized heavy water reactors and their associated equipment.
2. A CNSC designated officer issued the order to OPG after elevated hydrogen equivalent concentrations ([Heq]) in pressure tubes were reported to the CNSC. The discovery of elevated [Heq] at Bruce Power Inc.’s Bruce NGS A and B, Units 3 and 6 respectively, was considered by the designated officer to put into question the predictive capability of the model for the [Heq] levels in operating reactors with pressure tubes in extended operation. The Commission amended the order following a proceeding on [September 10, 2021](#).

Hearing in writing

3. Pursuant to section 22 of the NSCA, the President of the Commission established a Panel of the Commission over which she would preside, including Commission Members Dr. Marcel Lacroix and Ms. Indra Maharaj, to decide on the request. A [notice of hearing in writing](#) was published on October 14, 2021³. The hearing in writing was conducted in accordance with the [Canadian Nuclear Safety Commission Rules of Procedure](#). The Commission considered written submissions from OPG ([CMD 21-H111.1](#), [21-H111.1A](#), [CMD 21-H111.1B](#), [CMD 21-H111.1C](#), and [CMD 21-H111.1D](#)) and CNSC staff ([CMD 21-H111](#)). The Commission also received a written submission from the Commission’s [External Advisory Committee on Pressure Tubes](#)⁴ ([CMD 21-H111.2](#)).

¹ The *Canadian Nuclear Safety Commission* is referred to as the “CNSC” when referring to the organization and its staff in general, and as the “Commission” when referring to the tribunal component.

² The Commission confirmed this order on September 22, 2021; refer to the Summary Record of Decision DEC 21-H11, *Review by the Commission of the Designated Officer Orders Issued to Bruce Power and Ontario Power Generation Inc. on July 26-27, 2021; and Requests to Restart Reactors subject to the Orders*, September 22, 2021.

³ In accordance with the *Rules of Procedure*, the Commission decided to vary the Rules to consider the matter before it as informally and expeditiously as the circumstances and the considerations of fairness permit. Due to a publication delay, the Notice was posted on the CNSC website after the hearing had taken place. The Commission is satisfied that this did not result in material harm to persons interested in the matter being considered.

⁴ Established on July 30, 2021, the External Advisory Committee on Pressure Tubes was created by the Commission, under its statutory authority to establish advisory committees, to complement the expertise of Commission members, and to provide an external perspective for the benefit of Commission members in their role as decision-makers.

4. The Commission Secretary communicated the Commission's decision on this matter to OPG on [October 12, 2021](#).⁵ This *Record of Decision* provides the detailed reasons for that decision.

Issues

5. The Commission considered whether OPG satisfied the conditions of the order, which provides that:

Prior to the restart of any of Units 5, 6, 7 or 8, following any outage that results in the cooldown of the heat transport system, OPG shall obtain authorization from the Commission to restart.

Prior to seeking such authorization, OPG shall either:

- a. carry out inspection and maintenance activities that demonstrate with a high degree of confidence that pressure tube [Heq] is within OPG's licensing basis, per licence condition G.1, and submit results of such activities to CNSC staff;

or

- b. carry out inspection and maintenance activities that demonstrate with a high degree of confidence that no flaws are present in the region of pressure tubes where the models failed to conservatively predict the elevated [Heq], and submit results of such activities to CNSC staff.

6. The Commission has also considered the application of licence condition 15.3 of OPG's CNSC licence, PROL 18.01/2028, to this request for restart. That condition provides:

Before hydrogen equivalent concentrations exceed 120 ppm (parts per million), the licensee shall demonstrate that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm.

2.0 DECISION

7. Based on its consideration of the matter, with respect to the restart of Pickering NGS Unit 5 from its current forced outage, the Commission concludes that OPG has:
 - demonstrated a low likelihood of flaws deeper than 0.15 mm in the region of interest of the uninspected pressure tubes of Pickering Unit 5 that could lead to crack initiation; and

⁵ Email from M. Leblanc (CNSC) to S. Irvine, M. Knutson and J. Vecchiarelli (OPG), *OPG Pickering 5 – Summary decision*, October 12, 2021.

- demonstrated with a high degree of confidence that no flaws that could call into question the fitness for service of Unit 5 pressure tubes are present in the region of pressure tubes where the models failed to conservatively predict the elevated [Heq], satisfying Option (b) of the conditions set in the order.

The Commission authorizes OPG to restart Pickering Nuclear Generation Station B Unit 5 from any outage where cooling down the primary heat transport system is necessary, subject to all other pressure tube fitness for service requirements in the licensing basis being satisfied. As a result of this decision, OPG will no longer be required to request authorization to restart Unit 5 pursuant to the order.

3.0 ISSUES AND COMMISSION FINDINGS

8. In conducting this hearing in writing, the Commission invited the EAC to comment on the submissions from OPG, and the analysis and recommendations of CNSC staff, who were in turn provided an opportunity to respond. In order to obtain additional information in a fair and expeditious manner, the Commission decided to hold a virtual question and answer session via [transcribed](#) videoconference, with representatives from OPG, CNSC staff and EAC members in attendance. The responses provided during the question and answer session addressed the Commission's questions.

Conditions of the Order

9. The Commission assessed whether OPG had complied with the conditions of the order. Prior to seeking authorization to restart Unit 5, OPG was required to satisfy either option (a) or (b) of the order. CNSC staff had previously established the following restart criteria for each option:

Criteria for option (a):

1. Licensee shall demonstrate an understanding of the mechanism leading to high Hydrogen equivalent [Heq] concentration in the region of interest⁶, and are able to conservatively model [Heq] concentration in this region.

Criteria for option (b):

1. Sufficient inspection data shall be available for the reactor unit to justify, with a high degree of certainty, that no flaws are present in the region of interest greater than 0.15 mm in depth; and
2. Corrective actions shall be implemented for tubes containing flaws greater than the specified depth.

⁶ For the Pickering NGS, the “region of interest” is the region of the pressure tubes defined as 60 mm inboard from the outlet burnish mark and 360° of the pressure tube circumference.

10. With respect to defining the region of interest to assess the request for authorization to restart Pickering Unit 5, CNSC staff recommended that an axial length of 60 mm from the outlet burnish mark is appropriate. CNSC staff stated that there is high confidence that [Heq] concentrations do not exceed 120 ppm beyond the 60 mm region of interest, and that there is adequate conservatism for the evaluation of flaws in this region of interest. CNSC staff explained that OPG has consistently obtained [Heq] concentration scrapes from an axial location of approximately 50 to 55 mm inboard of the burnish mark, and that none of these samples had measured [Heq] concentration values that exceeded 120 ppm. CNSC staff further reported that the [Heq] concentration measurements in this region were consistent with model predictions.
11. With respect to the 0.15 mm depth specified in the criteria for option (b) and identified in CSA standard N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*⁷, a representative from OPG informed the Commission that the 0.15 mm depth is scientifically based and represents the threshold at which a flaw is considered to be unconditionally acceptable. In other words, any flaw less than 0.15 mm deep is structurally sound and fit for service. A representative from the EAC affirmed this fact.
12. The Commission is satisfied that the restart criteria established by CNSC staff are appropriate and provide reasonable bases on which to demonstrate confidence. The Commission is of the view that compliance with these criteria would demonstrate that the risk associated with elevated high [Heq] concentration in the region of interest is low. The Commission is satisfied that the 60 mm region of interest for Pickering Unit 5 is appropriate, as measured [Heq] concentrations in this region are below 120 ppm and consistent with model predictions.
13. This decision will focus on the criteria for option (b). Satisfying option (a) would require strengthening the predictive capability of the model that has been called into question. OPG indicated that it is working with Bruce Power and others in the nuclear industry to better understand the cause of the elevated [Heq]. While the Commission acknowledges OPG's progress in its analysis to satisfy this criterion, there is insufficient information to support option (a) at this time.

Option (b), Criterion 1

14. In its CMD, CNSC staff specified that, to satisfy Option (b), the licensee must demonstrate, through an evaluation of the inspection history data and knowledge of the potential flaw formation mechanisms, that in the region of interest, flaws deeper than 0.15 mm are unlikely to exist in the population of pressure tubes in a reactor that have not been inspected. CNSC staff's assessment is that OPG's inspection data and statistical analysis satisfy restart criterion 1 for option (b) of the order.

⁷ CSA N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*, CSA Group, 2020.

15. The Commission asked for further information regarding the mechanisms and characteristics of flaws that would pose a risk to pressure tube integrity. A representative of the EAC stated that the primary concern is that a flaw could develop into a crack, and that the three factors to consider are [Heq], flaw depth, and flaw sharpness. The EAC representative explained that sharper flaws would have a smaller area, or root radius, into which [Heq] can concentrate, which would increase stress, and thus be more susceptible to forming a crack.
16. OPG submitted that it has inspected 299 pressure tubes for flaws in Pickering Units 1, 4, 5, 6, 7 and 8, and observed 6 flaws with a depth greater than 0.15 mm in the defined region of interest in this population of pressure tubes. OPG further submitted that it has determined that these flaws do not impact the safe operation of pressure tubes because they would not lead to crack initiation. OPG attributed 5 of the identified flaws to bearing pad frets due to cross flow during fueling activities. CNSC staff agreed with OPG's assessment of these 5 flaws. CNSC staff reported that, in 2015, OPG implemented procedures to limit the formation of these flaws during the remainder of the operating lives of the Pickering units, and that no flaws of this type have been observed since the change in procedure.
17. The sixth flaw, identified as P5O05-IND1, is located in the region of interest in a Pickering Unit 5 pressure tube, and is reported to measure 0.17 mm deep, 4.6 mm in length and 1.2 degrees in width. OPG detected this flaw and reported it to the CNSC in 1999. OPG explained that P5O05-IND1 was not due to a mechanism that was likely to be repeated in other pressure tubes, that no other similar flaws have been detected in any of the other 299 Pickering pressure tubes, and that the location of flaw P5O05-IND1 is covered by the shield plug during normal operation.
18. CNSC staff submitted that P5O05-IND1 would not challenge the safe operation of the Unit 5 pressure tube. CNSC staff explained that OPG is required to disposition all flaws in accordance with regulatory requirements, including CSA standard N285.8, and that OPG had done so for P5O05-IND1, as well as the other 5 flaws in the region of interest of Pickering NGS pressure tubes. CNSC staff further stated that it independently reviews OPG's assessments to ensure that requirements have been met.
19. The Commission sought additional information with respect to the assessment of P5O05-IND1. Representatives from OPG explained that this flaw was identified during an inspection, and conservatively assessed as a debris flaw, having a sharper radius than was actually measured. OPG representatives stated that OPG is confident that this flaw will not grow in size or in shape. OPG representatives further stated that OPG predicts that this flaw will have an end-of-life upper bound [Heq] of approximately 75 ppm, which is below the 120 ppm licence limit.
20. With respect to the significance of the shield plug, OPG representatives explained that there is only a small space between the shield plug and the pressure tube, which limits the size of any debris that could fit between the two, and thus any potential flaw caused by debris would be limited in size. OPG's assessment is that the maximum depth of

such a flaw would be 0.17 mm. CNSC staff confirmed that the shield plug covers the entire region of interest, and that it would be difficult for debris to enter the space to cause a flaw.

21. OPG also submitted statistical analysis demonstrating that the probability of a flaw in the region of interest for uninspected Unit 5 pressure tubes was low. CNSC staff stated that OPG's statistical analysis, based on inspection data gathered from Pickering NGS units, demonstrates that the expected number of flaws deeper than 0.15 mm in the population of Unit 5 pressure tubes that have not been inspected is less than 1.0, which is within the safety case for the Pickering NGS, as approved by the Commission. CNSC staff further submitted that pressure tube flaws deeper than 0.15 mm are not likely to develop in the region of interest, as the potential drivers for the formation of such flaws are limited.
22. CNSC staff indicated that it had verified that OPG's statistical analysis, which used a 95th percentile bounding calculation, was appropriate. CNSC staff acknowledged that different methodologies could yield different results, depending on the level of conservatism and the amount of data included in the analysis. The Commission is satisfied that CNSC staff performed sufficient analyses to verify OPG's results.
23. With respect to Pickering Unit 5, the Commission concludes that OPG has satisfied criterion 1 for Option (b) of the order. The Commission finds that:
 - flaw P5O05-IND1 has been appropriately dispositioned and does not pose a risk to pressure tube integrity;
 - OPG has demonstrated, with a high degree of confidence, that flaws deeper than 0.15 mm are unlikely to exist in the region of interest in the population of pressure tubes that have not been inspected; and that
 - pressure tube flaws deeper than 0.15 mm are not likely to develop in the region of interest.

Option (b), Criterion 2

24. The second criterion that CNSC staff set out for satisfying option (b) of the order requires that corrective actions be implemented for pressure tubes containing flaws greater than the specified depth (0.15 mm). CNSC staff submitted that there are no flaws that would necessitate invoking criterion 2. CNSC staff reported to the Commission its advice that the evaluation completed for P5O05-IND1 generated significant safety margins against pressure tube failure.
25. Taking the above into consideration, and as discussed in the previous section, although there is a known flaw in the region of interest in a Pickering Unit 5 pressure tube (P5O05-IND1), the Commission is satisfied that it would not challenge pressure tube integrity. The Commission therefore concludes that corrective measures are not required, and that OPG has satisfied both criteria for option (b) of the order.

Compliance with Licence Condition 15.3

26. Licence condition 15.3 of OPG's licence for the Pickering NGS, PROL 48.01/2028, requires that:

“Before hydrogen equivalent concentrations exceed 120 ppm, the licensee shall demonstrate that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm”.

CNSC staff submitted that, in satisfying option (b) of the order, OPG has demonstrated that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm.

27. Acknowledging the limitations of the model that has been called into question, the Commission understands that OPG has not had a pressure tube with a measured [Heq] in excess of the licence limit. The Commission is satisfied that OPG has demonstrated, for the purposes of licence condition 15.3 in relation to the restart request, that pressure tube fracture toughness is sufficient for safe operation.

Scope of Restart Request

28. On its own initiative, the Commission considered whether the restart authorization should be applicable to future outages for Unit 5, beyond the current unplanned outage. The Commission finds that, in satisfying option (b) of the order for Unit 5, OPG has:
- demonstrated a low likelihood of flaws deeper than 0.15 mm in the region of interest of the uninspected pressure tubes of Pickering Unit 5 that could lead to crack initiation; and
 - demonstrated with a high degree of confidence that no flaws that could call into question the fitness for service of Unit 5 pressure tubes are present in the region of pressure tubes where the models failed to conservatively predict the elevated [Heq].
29. The Commission's view is that, barring unforeseen future pressure tube inspection results outside the licensing basis, it is reasonable to expect that the conditions in the Pickering Unit 5 pressure tubes will not significantly change for the remainder of the operating life of the reactor unit. That is, the Commission is satisfied that the Unit 5 pressure tubes are likely to remain fit for service, within the licensing basis. The Commission therefore authorizes OPG to restart Pickering NGS B Unit 5 from any outage where cooling down the primary heat transport system is necessary, subject to all other pressure tube fitness for service requirements in the licensing basis being satisfied.

30. As a result of this decision, OPG will no longer be required to request authorization to restart Unit 5 pursuant to the order.

Velshi,
Rumina

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Rumina Velshi
President,
Canadian Nuclear Safety Commission

December 6, 2021

Date