Record of Decision

DEC 21-H112

In the Matter of

Applicant	Ontario Power Generation Inc.
Subject	Request for Authorization to Restart Pickering Nuclear Generating Station B Units 6-8 following future outages
Date of Decision	November 5, 2021
Record of Decision Date	December 22, 2021

RECORD OF DECISION – DEC 21-H112

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 Units 6-8 following future outages
Application received:	September 29, 2021
Hearing:	Public Hearing in Writing – Notice of Hearing in Writing published on September 28, 2021
Date of decision:	November 5, 2021
Panel of Commission:	Ms. R. Velshi, Chair Dr. M. Lacroix Ms. I. Maharaj

Ontario Power Generation Represented By		**Document Number**
J. Vecchiarelli	Vice President, Nuclear Regulatory Affairs	CMD 21-H112.1 CMD 21-H112.1A
M. Knutson	Chief Enterprise Engineering and Chief Nuclear Engineer	
J. Franke	Senior Vice President, Pickering Nuclear Generating Station	
S. Gregoris	Senior Vice President, Darlington Nuclear Generating Station	
S. Granville	Chief Operating Officer and Chief Nuclear Officer	
CNSC staff		**Document Number**
R. Jammal	Executive Vice-President and Chief Regulatory Operations Officer	CMD 21-H112 CMD 21-H112.A
A. Viktorov	Director General, Directorate of Power Nuclear Regulation	
B. Carroll	Technical Specialist, Operational Engineering Assessment Division, Directorate of Assessment and Analysis	

External Advisory Committee on Pressure Tubes		Document Number
Dr. J. Luxat	Chair, External Advisory Committee	NA
Dr. M. Daymond	External Advisory Committee member	
Dr. P. Spekkens	External Advisory Committee member	

Decision: Authorization granted to restart Pickering NGS B Units 6, 7 and 8 following any outage

Table of Contents

1.0 INTRODUCTION

1. Ontario Power Generation Inc. (OPG) has applied to the Canadian Nuclear Safety Commission[1] (CNSC) for authorization to return Pickering Nuclear Generating Station (NGS) B Units 6, 7 and 8 (Units 6-8) to service following any unplanned outage that results in the cooldown of the heat transport system, as well as for authorization to return Unit 7 to service following its planned outage in fall 2021. Pickering Units 6-8 are 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. The discovery of elevated hydrogen equivalent concentrations [Heq] at Bruce Power Inc.'s Bruce NGS A and B, Units 3 and 6 respectively, was considered by a CNSC designated officer to put into question the predictive capability of the model for [Heq] levels in all operating reactors in Canada with pressure tubes in extended operation[3]. The CNSC designated officer issued the order to OPG in July 2021, and 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, 2021, specific to the restart of Pickering Unit 7 following its current planned outage. A revised notice of hearing in writing was published on November 4, 2021 to reflect consideration of the restart of Pickering Units 6 to 8 from future outages. 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-H112.1 and CMD 21-H112.1A) and CNSC staff (CMD 21-H112 and CMD 21-H112.A). The Commission also received a written submission from the Commission's External Advisory Committee on Pressure Tubes[4] (CMD 21-H112.2).

---

[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 amended this order on September 22, 2021; refer to the Detailed 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*, November 10, 2021.
[3] Extended operation of pressure tubes refers to operation beyond 210,000 equivalent full power hours (EFPH).
[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 November 5, 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 B Units 6, 7 and 8 following any unplanned outage that results in the cooldown of the heat transport system, 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 Units 6-8 that could lead to crack initiation; and

[5] Email from M. Leblanc (CNSC) to S. Irvine, M. Knutson, J. Vecchiarelli and J. Franke (OPG), *OPG Pickering and Darlington Requests for restart - Summary decision*, November 5, 2021.

- demonstrated with a high degree of confidence that no flaws that could call into question the fitness for service of Unit 6-8 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 Units 6-8 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 Units 6-8 pursuant to the order. As the Commission previously authorized the restart of Pickering Unit 5[6,7] following any outage, the Commission considers the order to have been satisfied.

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 on November 5, 2021, 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 satisfied the conditions of the order. Prior to seeking authorization to restart Units 6-8, 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 interest[8], 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

[6] Email from M. Leblanc (CNSC) to S. Irvine, M. Knutson and J. Vecchiarelli (OPG), *OPG Pickering 5 – Summary decision*, October 12, 2021.
[7] Record of Decision DEC 21-H111, *Request for Authorization to Restart Pickering Nuclear Generating Station B Unit 5 following a forced outage*, December 6, 2021
[8] 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.

2. Corrective actions shall be implemented for tubes containing flaws greater than the specified depth.

10. With respect to defining the region of interest to assess the request for authorization to restart Pickering Units 6-8, CNSC staff recommended that an axial length of 60 millimetres (mm) from the outlet burnish mark is appropriate. CNSC staff had previously used a 75 mm length, however, 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 conservativism 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. The Commission notes that the 0.15 mm depth specified in the criteria for option (b) is based on CSA standard N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*[9], and represents the threshold at which a flaw is considered to be unconditionally acceptable. The Commission understands that the primary mechanisms and characteristics of flaws that would pose a risk to pressure tube integrity are [Heq], flaw depth, and flaw sharpness.

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 Units 6-8 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 has 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 criterion 1 of 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

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

has 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.

15. OPG submitted that, over time through its ongoing pressure tube inspection program, OPG 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. CNSC staff reported that OPG had appropriately dispositioned all flaws in accordance with regulatory requirements, including CSA standard N285.8.

16. OPG attributed 5 of the identified flaws to bearing pad frets due to cross flow during fueling activities. In response to comments from the EAC, OPG stated that this flaw mechanism is precluded in other pressure tubes as OPG made a procedural change to restrict the time that fuel bundles are in cross flow conditions. No flaws have been observed since this change in procedure. CNSC staff's assessment aligned with OPG's. CNSC staff confirmed that, in 2015, OPG implemented procedures to limit the formation of these flaws during the remainder of the operating lives of the Pickering units.

17. The Commission sought additional information regarding whether the 5 cross flow flaws could recur or worsen over time. CNSC staff's view is that OPG's measures to prevent this type of flaw from recurring have been effective, and that it is unlikely that a similar flaw could develop in the future. CNSC staff added that OPG monitors conditions to identify and control cross flow; as a result, OPG can prevent flaws from forming and verify through follow-up inspection. With respect to the existing flaws, representatives from OPG stated that OPG's follow-up inspections have found little-to-no change in their characteristics, which supports the position that the flaws are not worsening and are not likely to worsen. The Commission is satisfied that the flaw mechanism that led to the formation of the 5 cross flow flaws in the region of interest in Pickering NGS pressure tubes has been addressed and is not likely to be repeated. The Commission is further satisfied that the identified flaws have been dispositioned and do not pose a risk to pressure tube integrity.

18. The sixth flaw, identified as P5O05-IND1, is located in the region of interest in a Pickering Unit 5 pressure tube. OPG detected this flaw and reported it to the CNSC[10] in 1999. OPG explained that P5O05-IND1was 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 298 inspected Pickering pressure tubes. The Commission is satisfied that the flaw mechanism that led to the formation of P5O05-IND1 is not likely to be repeated in Pickering Units 6-8.

[10] In 1999, the organization that would become the CNSC was the Atomic Energy Control Board (AECB)

19. CNSC staff noted that a flaw in Pickering Unit 6, P6N04-IND9, resides outside of the 60 mm long region of interest but within the previously assessed 75 mm region of interest. CNSC staff reported that OPG had dispositioned this flaw and demonstrated that [Heq] concentrations are below 120 ppm in this region. The Commission is satisfied that P6N04-IND9 has been dispositioned and that it resides outside the 60 mm region of interest.

20. OPG also submitted statistical analysis in order to demonstrate that the probability of a flaw in the region of interest for uninspected Unit 6-8 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 6-8 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.

21. Asked for more information concerning the statistical analysis, CNSC staff explained that it performed different sensitivity analyses, which provided consistent results. The Commission is satisfied that CNSC staff performed sufficient analyses to verify OPG's results. The Commission also notes that the EAC indicated that OPG and CNSC staff had adequately addressed the EAC's comments.

22. With respect to Pickering Units 6-8, the Commission concludes that OPG has satisfied criterion 1 for Option (b) of the order. The Commission finds that:

- identified flaws have been appropriately dispositioned and do 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

23. 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). There are no flaws in Units 6-8 that would necessitate invoking criterion 2. 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

24. 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.

25. 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

26. OPG is seeking authorization to return:

- Pickering Units 6-8 to service following any unplanned outage that results in the cooldown of the heat transport system; and
- Pickering Unit 7 to service following its planned outage in fall 2021.

CNSC staff stated that its recommendations would be applicable to any outage – planned or unplanned – provided that future inspection findings continue to verify the results of OPG's evaluations that were submitted to address option (b) of the order. CNSC staff noted that the Commission would be informed if any unexpected results are identified in future pressure tube inspections.

27. The Commission considered whether the restart authorization should be applicable to any future outage for Units 6-8. In response to questions from the Commission, CNSC staff explained that regardless of the type of outage, it is the warm-up process during the restart of a reactor with a cooled-down heat transport system that necessitates the restrictions to prevent crack initiation. In the event that a reactor is rapidly cooled during an unplanned outage, additional assessments are required to ensure that the rector is safe to restart. CNSC staff noted that such assessments are a normal part of operational procedures.

28. The Commission sought OPG's perspective with respect to the scope of the restart request. A representative from OPG stated that OPG limited the scope of its request to focus on more time-sensitive restart scenarios. OPG's view is that the information it submitted supports restart following unplanned and planned outages for all units.

29. The Commission finds that, in satisfying option (b) of the order for Units 6-8, 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 Units 6-8 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 6-8 pressure tubes are present in the region of pressure tubes where the models failed to conservatively predict the elevated [Heq].

30. 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 6-8 pressure tubes will not significantly change for the remainder of their operating lives. That is, the Commission is satisfied that the pressure tubes in Pickering Units 6-8 are likely to remain fit for service, within the licensing basis. The Commission therefore authorizes OPG to restart Pickering NGS B Units 6-8 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.

31. As a result of this decision, OPG will no longer be required to request authorization to restart Units 6-8 pursuant to the order. As the Commission previously authorized the restart of Pickering Unit 5 following any outage, the Commission considers the order to have been satisfied.

Velshi, Rumi

Digitally signed by Velshi, Rumina
...=CA, O=GC, OU=CNSC-CCSN, CN="Velshi, ..."
...: I am approving this document
...n: your signing location here
...021-12-22 09:33:17
Foxit PhantomPDF Version: 9.7.1

December 21, 2021

Rumina Velshi
President,
Canadian Nuclear Safety Commission

Date