



Record of Decision

DEC 21-H11

In the Matter of

Licensees
Subject to
Order

Bruce Power Inc.
Ontario Power Generation Inc.

Subject

Review by the Commission of 3 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

Public Hearing
Date

September 10, 2021

Summary
Record of
Decision Date

September 22, 2021

Detailed
Record of
Decision Date

November 10, 2021

DETAILED RECORD OF DECISION – DEC 21-H11

Licensee Subject to Order: Bruce Power Inc.
 Address/Location: P.O. Box 1540, Building B10, 177 Tie Road, Municipality of Kincardine, Tiverton, Ontario, N0G 2T0

Licensee Subject to Orders: Ontario Power Generation Inc.
 Address/Location: 700 University Avenue, Toronto ON, M5G 1X6

Purpose: 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

Orders Issued: July 26-27, 2021

Date of public hearing: September 10, 2021

Location: Virtual

Commission: President R. Velshi,
 M. Lacroix
 I. Maharaj

Secretary: M.A. Leblanc
 Recording Secretary: C. Moreau
 Senior General Counsel: L. Thiele

Bruce Power Represented By		Document Number
J. Scongack	Executive Vice President, Operation Services	CMD 21-H11.2 CMD 21-H11.2A CMD 21-H11.2B
C. Mudrick	Chief Nuclear Officer	
G. Newman	Chief Nuclear Engineer	

Ontario Power Generation Represented By		Document Number
J. Vecchiarelli	Vice President, Nuclear Regular Affairs	CMD 21-H11.1 CMD 21-H11.1A CMD 21-H11.1B
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-H11 CMD 21-H11.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	

Designated Officer Order to Bruce Power for its Bruce NGS: Confirmed
Designated Officer Order to OPG for its Pickering NGS: Amended
Designated Officer Order to OPG for its Darlington NGS: Confirmed
Requests to Restart: Not Approved. To be considered on a unit-by-unit, or group of units, basis.

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1.0 INTRODUCTION

1. On July 26, 2021, a Canadian Nuclear Safety Commission¹ (CNSC) designated officer (DO) issued an order to Bruce Power Inc. (Bruce Power), in respect of the [Bruce Nuclear Generating Station](#) (NGS) (Power Reactor Operating Licence PROL18.01/2028), after elevated hydrogen equivalent concentrations ([Heq]) in pressure tubes were reported to the CNSC. The discovery of elevated [Heq] at Bruce NGS A and B, Units 3 and 6 respectively, was considered by the DO to put into question the predictive capability of the model for the [Heq] levels in operating reactors with pressure tubes in extended operation. The DO subsequently issued orders to Ontario Power Generation Inc. (OPG) in respect of the [Darlington NGS](#) (PROL 13.02/2025) and the [Pickering NGS](#) (PROL 48.01/2028) on July 27, 2021.
2. The orders apply to the following reactors:
 - Bruce NGS Units 3, 4, 5, 7 and 8;
 - Pickering NGS Units 1, 4, 5, 6, 7 and 8; and
 - Darlington NGS Units 1 and 4

The orders include measures that the DO considered necessary to demonstrate compliance with the licensing basis for the designated NGS units. The orders require Bruce Power and OPG to obtain authorization from the Commission prior to the restart of designated NGS units following any outage that results in the cooldown of the heat transport system.

3. Pursuant to subsection 37(6) of the [Nuclear Safety and Control Act \(NSCA\)](#), the DO referred the orders to the Commission for review to confirm, amend, revoke or replace the orders. Pursuant to paragraph 40(1)(d) of the NSCA, the Commission provided an opportunity to be heard to the licensees subject to the orders, and the licensees took that opportunity. In respect of the provisions of the orders, both licensees also applied to the Commission for approval to restart.

Issues

4. Pursuant to subsection 37(6) of the NSCA, the Commission was required to review the orders and confirm, amend, revoke or replace each of them.
5. In the hearing to review the orders, the Commission also considered the requests for restart submitted by Bruce Power and OPG pursuant to the terms of the orders. Both licensees requested authorization to restart designated NGS units following any outage that results in the cooldown of the heat transport system.

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.

Hearing

6. Pursuant to section 22 of the NSCA, the President established a panel, consisting of herself, Dr. Marcel Lacroix and Ms. Indra Maharaj, to review the orders and consider the requests for restart. The Commission, in making its decision, considered information presented for a one-part public hearing held virtually on September 10, 2021. The public hearing was conducted in accordance with the [*Canadian Nuclear Safety Commission Rules of Procedure*](#).² The Commission, in making its decision, considered the DO orders made on July 26 and 27, 2021. The Commission also considered submissions from Bruce Power ([CMD 21-H11.2](#), [CMD 21-H11.2A](#) and [CMD H-21-11.2B](#)), OPG ([CMD 21-H11.1](#), [CMD 21-H11.1A](#) and [CMD 21-H11.1B](#)), and CNSC staff ([CMD 21-H11](#) and [CMD 21-H11.A](#)). The Commission also heard oral submissions from the Commission's [External Advisory Committee on Pressure Tubes](#)³ (EAC). A *Summary Record of Decision*, was issued on September 22, 2021⁴. This *Record of Decision* provides the detailed reasons for that decision.

2.0 DECISIONS

7. Details of the Commission's rationale are provided in the following sections of this *Record of Decision*. Based on its consideration of the matter,

the Commission, pursuant to subsection 37(6) of the *Nuclear Safety and Control Act*, confirms the DO order issued to Bruce Power Inc. on July 26, 2021, in respect of Bruce Nuclear Generation Stations A and B;

the Commission, pursuant to subsection 37(6) of the *Nuclear Safety and Control Act*, confirms the DO order issued to Ontario Power Generation Inc. on July 27, 2021, in respect of the Darlington Nuclear Generating Station; and

the Commission, pursuant to subsection 37(6) of the *Nuclear Safety and Control Act*, amends the DO order issued to Ontario Power Generation Inc. on July 27, 2021, in respect of the Pickering Nuclear Generating Station by removing Pickering NGS A Units 1 and 4.

8. In respect of the licensees' requests for authorization from the Commission to restart designated units following any outage that results in the cooldown of the heat transport system,

² Statutory Orders and Regulations (SOR)/2000-211.

³ 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 *Summary Record of Decision*, in the matter of *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.

the Commission does not, at this time, authorize the restart of any designated reactor unit pursuant to the terms of the orders.

9. The Commission will consider requests to restart a designated reactor unit, or group of units with similar characteristics, on a case-by-case basis, upon the submission of a specific request by a licensee. Any request shall contain qualitative and quantitative analysis to satisfy the conditions of the order.

3.0 ISSUES AND COMMISSION FINDINGS

Review of Orders

10. Pursuant to subsection 37(6) of the NSCA, the Commission reviewed the orders. The Commission considered the actions and measures identified in each order and the information on which each order was based, as identified in the orders. Asked for their views about the orders, representatives from Bruce Power and OPG informed the Commission that they accept the orders as written. Although no licensee contested the orders, they also made submissions in support of requests to satisfy the terms of the orders. The requests to close the orders are addressed later in this *Record of Decision*.
11. The orders require that, prior to seeking authorization to restart a reactor designated in an order, a licensee is required to either:
 - a. carry out inspection and maintenance activities that demonstrate with a high degree of confidence that pressure tube [Heq] is within [Licensee]'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.
12. CNSC staff recommended that the Commission confirm the orders respecting Bruce Power and OPG Darlington, and amend the order respecting OPG Pickering to remove Pickering NGS A Units 1 and 4. CNSC staff explained that the intent of the orders was to enforce the bounding element of the safety cases, in light of the uncertainty around the [Heq] modelling raised by the [Heq] findings at Bruce Units 3 and 6. CNSC staff added that licensees are responsible for safety, and must demonstrate to the CNSC that they are at all times within their licensing basis, which includes the safety cases approved by the Commission.

13. CNSC staff provided information concerning the “region of interest”⁵ where high [Heq] was discovered, near the outlet burnish mark of the pressure tubes. CNSC staff explained that the orders establish the size of the region of interest, and allow for the expansion of the region of interest circumferentially or axially, depending on future information or monitoring, as the cause of the elevated [Heq] and whether it will progress with time is still unknown. CNSC staff added that the orders incorporate safety margins to allow for uncertainties to appear and not immediately put a pressure tube at risk of breaking. CNSC staff further added that the condition of the orders with respect to 120 parts per million (ppm) [Heq] uptake is not bound to the region of interest and that any point of the pressure tube with [Heq] greater than 120 ppm would require Commission approval for restart.
14. CNSC staff informed the Commission that the flaw depth of 0.15 mm in the region of interest, as described in the orders, is based on the depth limit indicated in CSA standard N285.8 *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*⁶. CNSC staff added that CSA standard N285.8 also allows for operation with deeper flaws if licensees can disposition the flaws (dispositionable flaws) in accordance with the standard⁷.
15. With respect to Pickering Units 1 and 4, in CMD 21-H11.1A, OPG explained that [Heq] increases in pressure tubes as a function of time at full power operating temperatures, and submitted that Pickering Units 1 and 4 would continue to have low [Heq] until the end of commercial operation, as these units are not in extended operation.⁸ In CMD 21-H11, the DO recommends that the Commission amend the Order for OPG Pickering by removing Pickering Units 1 and 4, as there is a high degree of confidence that pressure tube [Heq] in Pickering NGS A Units 1 and 4 is and will remain within OPG’s licensing basis.
16. The Commission asked the EAC to provide its advice on the orders. The EAC generally supported the information presented by the licensees and CNSC staff. The EAC indicated that it agreed with the content of the orders, as well as with CNSC staff’s recommendation to amend the order for the Pickering NGS to remove Units 1 and 4.
17. The Commission finds that the discovery of elevated [Heq] at Bruce Units 3 and 6 has put into question the modeling for [Heq] levels in operating reactors with pressure tubes in extended operation. Given the uncertainty in the modeling, the Commission confirms the orders requiring Commission approval before restart after an outage that results in a cooldown of the heat transport system in all reactor units noted in the orders, except for Pickering Units 1 and 4.

⁵ The region of interest is located at the top of the pressure tube, near the outlet [end fitting](#).

⁶ CSA N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*, CSA Group, 2017.

⁷ “Dispositioning” is described in CSA N285.8, and includes evaluating examination results using an accepted fitness for service assessment methodology to determine acceptability for continued operation.

⁸ Extended operation of pressure tubes refers to operation beyond 210,000 equivalent full power hours (EFPH).

18. The Commission noted that laboratory testing shows that the fracture toughness⁹ of pressure tube material is highest at normal full power operating temperatures and is not impacted by the material Heq uptakes. The Commission also noted that at temperatures associated with heatup and cooldown, the fracture toughness of pressure tube material is lower and depends on the [Heq].
19. The Commission notes that [Heq] increases in pressure tubes as a function of time at full power operating temperatures. With respect to Pickering Units 1 and 4, the Commission notes that Pickering Unit 1 and Unit 4 have the youngest operating pressure tubes at the Pickering NGS, as the pressure tubes were replaced in September 1987 and March 1993, respectively. The Commission is satisfied that there is a high degree of confidence that pressure tube [Heq] in these units are and will remain within OPG's licensing basis, until the planned permanent shutdown of these units. The Commission therefore amends the order applicable to OPG's Pickering NGS to remove Pickering NGS A Units 1 and 4.

Restart Requests

20. Bruce Power and OPG both submitted information supporting requests for "blanket" approval (or pre-authorization) for the restart of any and all designated reactor units following any outage that results in the cooldown of the heat transport system. The Commission notes that CNSC staff proposed the following assessment criteria for satisfying the conditions of the orders in order to restart reactors:

Option A:

Licensee shall demonstrate an understanding of the mechanism leading to high Hydrogen equivalent (Heq) concentration in the region of interest, and are able to conservatively model Heq concentration in this region.

or

Option B:

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

21. The Commission enquired about the assessment criteria CNSC staff proposed to be used for a decision on a restart request under the orders. The DO explained that Licence Condition G.1 of each of the licences for the NGSs requires that the licensees conduct their activities in accordance with the licensing basis, and that the licensing basis for the NGSs does not allow operation of a unit that has a concentration of hydrogen in the pressure tubes above 120 ppm without prior approval. The DO added that, to satisfy the conditions of the orders, licensees must provide sufficient information with respect to the safety of the pressure tubes. The DO further added that, in the future, the licensees could apply for a licence amendment to operate at a higher hydrogen concentration than 120 ppm, if they can demonstrate that it is safe to do so.

⁹ Fracture toughness is the ability of the pressure tube material to resist failure if a through-wall crack exists, and is a function of Heq levels and material temperature.

Request from Bruce Power

22. Bruce Power requested authorization to restart Unit 3 upon completion of its current planned outage, and also requested authorization to return Units 4, 5, 7, 8 to service should an unplanned outage be required before their next planned inspection and maintenance outage. Bruce Power submitted information specific to the restart of Bruce Unit 3, and noted that additional information would be submitted on September 17, 2021. With respect to Units 4, 5, 7 and 8, Bruce Power stated that pressure tubes from these units meet a standard of certainty related to hydrogen concentrations verified by maintenance and inspection activities. Bruce Power also submitted that its inspection activities show with a high degree of confidence that no flaws are present within the region of interest for all of its units.
23. In response to a question from the Commission concerning [Heq] levels in Unit 3, a Bruce Power representative stated that Bruce Power had sampled 42 fuel channels in Unit 3, and that 10 of those fuel channels had pressure tubes with [Heq] greater than 120 ppm at the burnish mark.
24. Asked about the confidence in the predictive models for [Heq] concentrations in pressure tubes, a Bruce Power representative stated that Bruce Power was confident in the models for hydrogen uptake, and informed the Commission that Bruce Power had expanded the number of inspected pressure tubes to increase the data in the predictive models. The Bruce Power representative stated that Bruce Power would submit its updated results to the CNSC.

Requests from OPG

25. With respect to the Pickering NGS, OPG submitted that, based on a review of all past measured [Heq] data, [Heq] values for all Pickering NGS units remained within the licensing basis. OPG also submitted that there are two flaws in the region of interest in Unit 5 due to known operational conditions, and that corrective actions were implemented to prevent recurrence. OPG specified that Pickering NGS Units 1 and 4 will not reach extended operations and are not expected to exhibit any hydrogen equivalent concentrations consistent with the levels seen in the Bruce Power reactors.
26. With respect to the Darlington NGS, OPG submitted that the Darlington Units 1 and 4 have no flaws in the region of interest. OPG reported that its existing pressure tube sampling data indicate that high levels of [Heq] have not been observed in any OPG units, and therefore the pressure tubes in its reactors are within the licensing basis. OPG also submitted that the number of flaws in the area of interest is limited and does not represent a concern with respect to fitness for service.
27. OPG informed the Commission that it would provide additional confirmatory evidence of its predictive models for [Heq] concentrations in pressure tubes by October 30, 2021 and experimental validation of the crack initiation model by December 30, 2021.

CNSC staff recommendations

28. With respect to the information submitted to date by the licensees in support of their requests to restart reactors and close the orders, the DO indicated that CNSC staff would need more time to review what had been submitted before making a recommendation to the Commission on whether the licensees met the orders' conditions. CNSC staff's view was that licensees needed to provide additional unit-specific quantitative analysis.

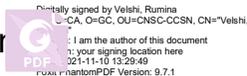
Conclusion on restart requests

29. On the basis of the information available, the Commission does not, at this time, authorize the restart of any designated reactor unit pursuant to the terms of the orders. The Commission is not satisfied that the evidence to date provides the basis for the high degree of certainty that is sought. The Commission is of the view that more information is needed to make an informed decision on any restart requests, and recognizes that more information from the licensees and CNSC staff will be forthcoming in the coming weeks. The Commission also recognizes that CNSC staff will require additional time to assess the new information. The Commission's view is that it is more appropriate to deal with specific requests to restart a designated reactor unit, or group of similar units, on a case-by-case basis. Any such application shall contain sufficient qualitative and quantitative analysis, specific to that unit or group of units with similar characteristics, to demonstrate that the conditions of the order have been met.

4.0 CONCLUSIONS

30. With respect to the review of the DO orders issued to Bruce Power and OPG pursuant to subsection 37(6) of the NSCA, the Commission confirms the DO orders. The Commission amends the order applicable to OPG's Pickering NGS to remove Pickering NGS A Units 1 and 4.
31. The Commission does not, at this time, authorize the restart of any designated reactor unit pursuant to the terms of the orders. The Commission's view is that it is more appropriate to deal with specific requests to restart a designated reactor unit, or group of similar units, on a case-by-case basis. Any such application shall contain sufficient qualitative and quantitative analysis, specific to that unit or group of units with similar characteristics, to demonstrate that the conditions of the order have been met.

Velshi, Rumina



Rumina Velshi
President,
Canadian Nuclear Safety Commission

November 10, 2021

Date