



# Record of Decision

DEC 22-H100

In the Matter of

Applicant Bruce Power Inc.

Subject Request for Authorization to Restart Bruce Nuclear Generating Station A Unit 3 following future outages

Date of Decision March 9, 2022

**RECORD OF DECISION – DEC 22-H100**

Applicant: Bruce Power Inc.

Address/Location: P.O. Box 1540, Building B10, 177 Tie Road, Municipality of Kincardine, Tiverton, Ontario, N0G 2T0

Purpose: Request for Authorization to Restart Bruce Nuclear Generating Station A Unit 3 following future outages

Application received: December 17, 2021

Hearing: Public Hearing in Writing – Notice of Hearing in Writing published on January 25, 2022

Date of decision: February 22, 2022

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

**Decision:** Authorization granted to restart Bruce NGS A Unit 3 following any future outage

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## 1.0 INTRODUCTION

1. Bruce Power Inc. (Bruce Power) has applied to the Canadian Nuclear Safety Commission<sup>1</sup> (CNSC) for authorization to return Bruce Nuclear Generating Station (NGS) A Unit 3 to service following any future outage that results in the cooldown of the heat transport system. Bruce NGS A Unit 3 is [subject to a CNSC order](#)<sup>2</sup> 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 Bruce NGS A comprises four Canada Deuterium Uranium (CANDU) reactors (Units 1-4) and their associated equipment. The Bruce NGS A is located on the Bruce Nuclear Power Development site in the Municipality of Kincardine, Ontario, and on the traditional territory of the Anishinabek Nation: the peoples of the three fires known as Ojibway, Odawa and Pottawatomie Nations. The Bruce region is also homeland to the Historic Saugeen Métis and to the Métis Nation of Ontario.
2. A CNSC designated officer issued the order to Bruce Power after the discovery of elevated hydrogen equivalent concentration ([Heq]) levels at Bruce NGS A Unit 3 and Bruce NGS B Unit 6.<sup>3</sup> The designated officer considered the discovery to put into question the predictive capability of the model for [Heq] levels in operating reactors that have pressure tubes in extended operation. The Commission confirmed the designated officer order following a proceeding on [September 10, 2021](#).

### Hearing in writing

3. Pursuant to section 22 of the [Nuclear Safety and Control Act](#) (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 for authorization to restart Unit 3. A [notice of hearing](#) in writing was published on January 25, 2022. The hearing in writing was conducted in accordance with the [Canadian Nuclear Safety Commission Rules of Procedure](#). The Commission considered written submissions from Bruce Power ([CMD 22-H100.1](#) and [CMD 22-H100.1A](#)) and CNSC staff ([CMD 22-H100](#) and [CMD 22-H100.A](#)). The Commission also received a written submission from the Commission's [External Advisory Committee on Pressure Tubes](#)<sup>4</sup> (EAC) ([CMD 22-H100.2](#)).

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<sup>1</sup> 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.

<sup>2</sup> The Commission confirmed this order on September 22, 2021; refer to the [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.

<sup>3</sup> Unit 6 is not subject to the order as it is shut down for its Major Component Replacement project, which includes the replacement of all pressure tubes.

<sup>4</sup> 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.

## Issues

4. The Commission must determine whether Bruce Power has satisfied the conditions of the order, which provides that:

Prior to the restart of any of Units 3, 4, 5, 7 or 8<sup>5</sup>, following any outage that results in the cooldown of the heat transport system, Bruce Power shall obtain authorization from the Commission to restart.

Prior to seeking such authorization, Bruce Power shall either:

- a. carry out inspection and maintenance activities that demonstrate with a high degree of confidence that pressure tube [Heq] is within Bruce Power'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.

5. The Commission has also considered the application of licence condition 15.3 of Bruce Power'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**

6. Based on its consideration of the matter, with respect to the request for authorization for the restart of Bruce NGS A Unit 3 following any outage that results in the cooldown of the heat transport system, the Commission concludes that Bruce Power has:

- demonstrated with a high degree of confidence that no flaws that could call into question the fitness for service of Unit 3 pressure tubes are present in the region of pressure tubes where the models failed to conservatively predict the elevated [Heq];
- demonstrated a low likelihood of flaws deeper than 0.15 mm in the region of interest of the uninspected pressure tubes of Unit 3 that could lead to crack

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<sup>5</sup> On [November 12, 2021](#), the Commission determined that Bruce Power satisfied the terms of the order with respect to Bruce NGS Units 4, 5, 7 and 8. Consequently, Units 4, 5, 7, and 8 are no longer subject to the order.

- initiation, satisfying Option (b) of the conditions set in the order; and
- demonstrated, for the purposes of licence condition 15.3 in relation to the restart request, that pressure tube fracture toughness is presently sufficient for safe operation.

The Commission therefore authorizes Bruce Power to restart Bruce NGS A Unit 3 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, Bruce Power will no longer be required to request authorization to restart Unit 3 pursuant to the order. As the Commission [previously authorized](#) the restart of Bruce NGS Units 4, 5, 7, and 8 following any future outage, the Commission considers the order to have been satisfied.

### **3.0 ISSUES AND COMMISSION FINDINGS**

7. In conducting this hearing in writing, the Commission invited the EAC to comment on the submissions from Bruce Power, and on 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 February 22, 2022, with representatives from Bruce Power, CNSC staff and EAC members in attendance. The responses provided during the virtual question and answer session addressed the Commission's remaining questions in a satisfactory manner.

#### Conditions of the Order

8. The Commission assessed whether Bruce Power had satisfied the conditions of the order. Prior to seeking authorization to restart Unit 3, Bruce Power 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, 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.

9. CNSC staff defined the region of interest of the Bruce NGS pressure tubes as 75 mm inboard from the outlet burnish mark and 360° of the pressure tube circumference. The EAC commented on a discrepancy between CNSC staff's definition of the region of interest and Bruce Power's submission that inspection data has shown that the circumference of the region of interest could be localized to the top 120° of the pressure tube. CNSC staff concurred that inspection data to date support Bruce Power's position; however, CNSC staff explained that it was more prudent to use the more conservative definition of the region of interest until a model is available that rules out future expansion of the region of interest. The Commission agrees with CNSC staff's more conservative definition of the region of interest, and considers the region of interest to include the full 360° circumference.
10. 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*<sup>6</sup>, 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.
11. The Commission is satisfied that the restart criteria established by CNSC staff are appropriate and provide reasonable bases on which to demonstrate that the conditions of the order have been satisfied. The Commission is of the view that compliance with these criteria would demonstrate that the risk associated with elevated [Heq] in the region of interest is low.
12. Bruce Power and CNSC staff did not submit information in support of Bruce Power satisfying option (a) of the order. Satisfying option (a) would require strengthening the predictive capability of the model that has been called into question. Bruce Power stated that it may take up to two years to update and fully validate the model to accurately predict hydrogen uptake in the region of interest. The Commission anticipates receiving updated information on this matter from CNSC staff in Fall 2022. This decision will focus on the criteria for option (b).

*Option (b), Criterion 1*

13. CNSC staff submitted 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 have not been inspected. CNSC staff's assessment is that Bruce Power's inspection data and statistical analysis satisfy restart criterion 1 for option (b) of the order.

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<sup>6</sup> CSA N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*, CSA Group, 2020.

14. Bruce Power reported that it had inspected 111 pressure tubes in Unit 3 and has identified no service-induced<sup>7</sup> flaws greater than 0.15 mm deep in the region of interest of any inspected tube. Bruce Power submitted a statistical analysis of the potential existence of flaws deeper than 0.15 mm in the region of interest of uninspected pressure tubes in Unit 3. The analysis used inspection data gathered from Bruce NGS Units 3 to 8 and estimated that fewer than 1 flaw deeper than 0.15 mm exists within the region of interest of Unit 3 pressure tubes that have not been inspected. CNSC staff submitted that this result remains within the safety case for the Bruce NGS, as approved by the Commission.
15. On the creation of service-induced flaws, CNSC staff submitted that there is a low likelihood for service-induced flaws deeper than 0.15 mm deep to be formed in Unit 3 pressure tubes. CNSC staff explained that pressure tube flaws greater than 0.15 mm deep are typically associated with locations where a fuel bundle's bearing pads contact the surface of the pressure tube as fretting flaws can occur at these contact points. CNSC staff noted that there are no bearing pad contact locations within the region of interest during normal operation of Bruce NGS reactors. CNSC staff also submitted that all Bruce NGS units are equipped with a fuel carrier which prevents flaw formation due to cross flow conditions during fueling operations.
16. The Commission [previously authorized](#) the restart of Bruce NGS A Unit 3 after its 2021 planned outage. In its decision on that matter, the Commission concluded that the fitness for service of the Unit 3 pressure tubes containing scrape marks should be evaluated prior to authorizing the restart of Unit 3 from any future outage, as crack initiation from a flaw is most likely to occur during a reactor cooldown cycle. Bruce Power submitted that scrape marks are the result of inspection activities and, though their depth is greater than 0.15 mm, they have a known geometry that is not likely to result in crack formation in the presence of elevated [Heq]. Following the Commission's earlier restart authorization decision, Bruce Power submitted a technical evaluation on crack initiation and the geometry of scrape marks. CNSC staff submitted that Bruce Power's evaluation demonstrates that scrape marks in the region of interest of Unit 3 pressure tubes are not at risk of crack initiation.
17. The Commission sought further input regarding the results of Bruce Power's crack initiation evaluation. CNSC staff explained that, while crack initiation tests demonstrated that elevated [Heq] could reduce the threshold to crack initiation, the stress intensity associated with scrape marks is not significant enough to initiate cracking. The EAC submitted that it found the technical evaluation provided by Bruce Power to be sound and that the results demonstrate that scrape marks in the region of interest present a low risk of crack initiation.

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<sup>7</sup> Service-induced flaws refer to flaws caused during in-service operation of the reactor unit which may have a variety of geometric features.

18. Notwithstanding its recommendation, CNSC staff highlighted the importance of further testing to better characterize the effects of elevated [Heq] on the crack initiation behaviour of pressure tube material. The Commission asked Bruce Power about its plans for further pressure tube testing. Bruce Power stated that it plans to continue both crack initiation testing of pressure tube material and burst testing of pressure tubes which have been removed from a reactor unit. Bruce Power reported that to date, it has completed crack initiation tests on un-irradiated pressure tube material and that it plans to complete irradiated testing in 2023.
19. With respect to Bruce NGS A Unit 3, the Commission concludes that Bruce Power has satisfied criterion 1 for Option (b) of the order. The Commission finds that:
- Bruce Power has identified no flaws in the region of interest of the 111 pressure tube that have been inspected across Unit 3;
  - Bruce Power has demonstrated, with a high degree of confidence through statistical analysis, 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;
  - Bruce Power has provided evidence, to the satisfaction of the Commission, that scrape marks present in the region of interest are not likely to cause crack initiation; and that
  - pressure tube flaws deeper than 0.15 mm are not likely to develop in the region of interest.

*Option (b), Criterion 2*

20. 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). The analysis for criterion 1 demonstrates that Bruce Power has not identified any flaws in Unit 3 that would necessitate invoking criterion 2. The Commission therefore concludes that corrective measures are not required, and that Bruce Power has satisfied both criteria for option (b) of the order.

Compliance with Licence Condition 15.3

21. Licence condition 15.3 for PROL 18.01/2028 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, Bruce Power has demonstrated that pressure tube fracture toughness will be sufficient for safe operation of Unit 3 beyond [Heq] of 120 ppm.

22. The Commission notes that Bruce NGS Unit 3 has had pressure tubes with measured [Heq] in excess of the licence limit. In authorizing the restart of Unit 3 following future outages, the Commission would be authorizing the continued operation of a reactor with measured [Heq] greater than 120 ppm. The Commission must therefore be satisfied that Bruce Power has demonstrated that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm [Heq].
23. Taking into consideration the submissions by CNSC staff and Bruce Power, the Commission finds that, in satisfying option (b) of the order, Bruce Power has demonstrated that pressure tube fracture toughness in the region of interest will be sufficient for safe operation beyond 120 ppm [Heq]. The Commission notes that operation in exceedance of 120 ppm [Heq] applies to the region of interest only; outside of the region of interest [Heq] can be predicted by existing models. The licensing basis has not changed. The Commission is satisfied that Bruce Power has complied with the requirement of licence condition 15.3 for the purposes of restart, and that Unit 3 could be safely returned to service following future outages. The Commission expects CNSC staff to continue regulatory oversight activities to ensure that pressure tube fitness for service requirements in the licensing basis remain satisfied.

#### Scope of Restart Request

24. Bruce Power is seeking authorization to return Bruce NGS A Unit 3 to service following any future outage that results in the cooldown of the heat transport system. CNSC staff recommended that the Commission authorize the restart of Unit 3 following future outages. As Unit 3 is the last unit subject to the order, CNSC staff further recommended that the Commission find that Bruce Power has satisfied the terms of the order for all Bruce Power units. The EAC agreed with CNSC staff's recommendation. The Commission considered the evidence on the record for this hearing as it applies to the restart of the Unit 3 from future outages and the closure of the order.
25. The Commission finds that, in satisfying option (b) of the order and licence condition 15.3 for Unit 3, Bruce Power has:
  - demonstrated with a high degree of confidence that no flaws deeper than 0.15 mm are present within the region of pressure tubes where the models failed to conservatively predict the elevated [Heq] and that no significant mechanisms exist to create flaws deeper than 0.15 mm in that region; and
  - demonstrated that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm [Heq].

The Commission is satisfied that Bruce Power has demonstrated the fitness for service of Unit 3 pressure tubes containing scrape marks and, in doing so, has provided the additional information requested by the Commission following its previous

authorization to restart Unit 3 after its 2021 planned outage. The Commission therefore authorizes Bruce Power to restart Bruce NGS A Unit 3 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. The Commission notes that Bruce Power's operation of Unit 3 is still subject to standard regulatory oversight activities. The Commission considers all of the requirements of the order to have been satisfied.

_____	March 9, 2022
Rumina Velshi	Date
President,	
Canadian Nuclear Safety Commission	