



Record of Decision

DEC 21-H110

In the Matter of

Applicant Bruce Power Inc.

Subject Request for Authorization to Restart Bruce Nuclear Generating Station A Unit 3 following its current planned outage

Date of Decision October 5, 2021

Record of Decision Date November 10, 2021

RECORD OF DECISION – DEC 21-H110

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

Application received: September 17, 2021

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

Date of decision: October 5, 2021

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

Request to Restart Bruce NGS A Unit 3 following its current planned outage: Approved

Table of Contents

1.0 INTRODUCTION..... 1
2.0 DECISION..... 2
3.0 ISSUES AND COMMISSION FINDINGS 3

1.0 INTRODUCTION

1. Bruce Power Inc. (Bruce Power) has applied to the Canadian Nuclear Safety Commission¹ (CNSC) for an authorization to return Bruce Nuclear Generating Station (NGS) A Unit 3 (Unit 3) to service, following its current planned outage (outage A2131). Bruce Unit 3 is [subject to a CNSC order](#)² 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 750-megawatt Canada Deuterium Uranium (CANDU) reactors (Units 1-4) and their associated equipment, and is located on the Bruce Nuclear Power Development site in the Municipality of Kincardine, Ontario. The Commission Secretary communicated the Commission's decision to Bruce Power on October 5, 2021.³ This *Record of Decision* provides the detailed reasons for that decision.
2. A CNSC designated officer issued the order to Bruce Power 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 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 confirmed the designated officer order following a proceeding on [September 10, 2021](#).

Issues

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

Prior to the restart of any of Units 3, 4, 5, 7 or 8, 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

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 Email from M. Leblanc (CNSC) to M. Burton (Bruce Power), *Bruce Unit 3 restart request - Commission decision*, October 5, 2021.

- 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.
4. 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.

Hearing in writing

5. 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. Indira Maharaj, to decide on the request. A [notice of hearing in writing](#) was published on September 28, 2021. 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 21-H110.1](#), [21-H110.1A](#), and [CMD 21-H110.1B](#)) and CNSC staff ([CMD 21-H110](#)). The Commission also received a written submission from the Commission's [External Advisory Committee on Pressure Tubes](#)⁴ (captured in [CMD 21-H110Q](#)).

2.0 DECISION

6. Based on its consideration of the matter, with respect to the restart of Bruce NGS Unit 3 from its current planned outage, the Commission concludes that Bruce Power has:
 - demonstrated with a high degree of confidence that no service-induced flaws 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; and
 - demonstrated to the Commission's satisfaction that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm, satisfying licence condition 15.3 of . PROL 18.01/2028 for the purposes of operation arising from this restart.

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.

Therefore, the Commission authorizes Bruce Power to restart Bruce Nuclear Generation Station A Unit 3 from its current planned outage.

7. The Commission does not authorize the restart of Bruce NGS A Unit 3 from any future outage. In keeping with its September 22, 2021 decision, the Commission will consider any such request upon the submission of a specific request by the licensee. Similarly, the Commission's satisfaction that the licensee has demonstrated sufficient pressure tube fracture toughness to ensure safe operation beyond 120 ppm, for the purposes of licence condition 15.3, applies only to this restart of this unit.

3.0 ISSUES AND COMMISSION FINDINGS

8. In conducting this hearing in writing, the Commission invited the EAC to comment on the submissions from Bruce Power, and the analysis and recommendations of CNSC staff, who were in turn provided an opportunity to respond. In addition, the Commission, through the Commission Secretary, sent questions to Bruce Power and CNSC staff. All of these exchanges are documented in [CMD 21-H110Q](#). The responses addressed the Commission's questions to a degree that allowed the Commission to reach a decision.
9. The scope of this decision is limited to Bruce Power's request for Commission approval to return Unit 3 to service following the current planned outage, as identified in CMD 21-H110.1.

Conditions of the Order

10. The Commission assessed whether Bruce Power had complied with 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 interest⁵, 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.

⁵ The "region of interest" is the region of the pressure tubes defined as 75 mm inboard from the outlet burnish mark and 360° of the pressure tube circumference.

11. 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.
12. During its current outage Bruce Power discovered [Heq] in Unit 3 pressure tubes in excess of the licence limit. As the [Heq] in Unit 3 is outside of the licensing basis, Bruce Power cannot satisfy the criteria for option (a). Satisfying option (a) would require strengthening the predictive capability of the model that has been called into question, but option (a) cannot apply where more than 120 ppm is the measured result. This decision will focus on the criteria for option (b).

Option (b), Criterion 1

13. Bruce Power submitted that it is confident that there are no flaws⁶ in the region of interest of Unit 3 pressure tubes. This assessment is based on the results of previous inspections, re-verifications and additional inspections to confirm the presence of flaws. Bruce Power explained that it carries out extensive inspections on Unit 3, and provided substantial evidence that the hydrogen isotope and flaw distributions in the outlet rolled joint regions of both Unit 3 and other units at Bruce Power are well understood. CNSC staff's assessment was that Bruce Power had demonstrated that there were no flaws greater than 0.15 mm deep in the region of interest of the 111 Unit 3 pressure tubes volumetrically inspected by Bruce Power.
14. Bruce Power further submitted statistical analysis demonstrating that the probability of a flaw in the region of interest for Unit 3 pressure tubes was low. Bruce Power submitted that the probability of the existence of at least one such flaw in the region of interest is less than 0.5%, and that the risk of having a significant flaw in the region of interest that could challenge pressure tube fitness for service is also low. In addition, according to Bruce Power, the configuration of fuel bundles in the pressure tubes in the Bruce NGS units is unlikely to cause flaws in the region of interest.
15. CNSC staff's assessment is that Bruce Power's inspection data and statistical analysis justify, with a high degree of certainty, that no service-induced flaws are present in the region of interest greater than 0.15 mm in depth, and that this satisfied restart criterion 1 for option (b) of the order. CNSC staff explained that the statistical analysis based on inspection data gathered from Bruce NGS Units 3 to 8 demonstrates that the expected number of flaws deeper than 0.15 mm in the population of Unit 3 pressure tubes that

⁶ 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*. CSA standard N285.8 also allows for operation with deeper flaws if licensees can disposition the flaws in accordance with the standard. "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.

have not been inspected is less than 1.0, which is within the safety case for the Bruce 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.

16. In its CMD, CNSC staff modified criterion 1 for option (b), adding “[service-induced]”, as follows: “...with a high degree of certainty, that no [service-induced] flaws greater than 0.15 mm are present in the region of interest.” The Commission sought clarification with respect to CNSC staff’s usage of the term “service-induced.” CNSC staff responded that the addition of “service-induced” does not change the criterion’s intent. CNSC staff explained that “service-induced” reflects that the Unit 3 pressure tubes contain scrape marks greater than 0.15 mm deep – also referred to as “witness marks” by Bruce Power – as a result of inspection activities. Bruce Power introduced several scrape marks in the region of interest during the current outage. CNSC staff noted that scrape marks are different from flaws induced during operation, such as due to fretting.
17. Bruce Power submitted that scrape marks are not susceptible to crack initiation because the geometry of scrape marks is deliberately benign to avoid concentrating stress. CNSC staff concurred with Bruce Power’s assertion, and submitted that the likelihood that such marks will initiate cracks with subsequent reactor operation, including during heat-up and cooldown cycles, is low. CNSC staff informed the Commission that Bruce Power had completed a stress analysis demonstrating that the resulting stress concentration associated with the scrape marks is insufficient to accumulate hydrogen at levels that would lead to crack initiation based on current crack initiation models. CNSC staff noted, however, that given the elevated [Heq] concentrations in Unit 3, it was important that Bruce Power continue with its plans to test materials with elevated [Heq] to fully validate the crack initiation models at [Heq] levels above 120 ppm.
18. The Commission recognizes that there is a distinction between “service-induced flaws”, which may have a variety of geometric features, and “scrape marks” that are a result of inspection activities, and which have a known geometry that is not likely to result in crack formation. The Commission is satisfied that the addition of “service-induced” does not alter the intent of the criterion. With that in mind, the Commission is satisfied that Bruce Power has demonstrated, with a high degree of certainty, that no service-induced flaws are present in the region of interest greater than 0.15 mm in depth. The Commission concludes that Bruce Power has satisfied criterion 1 for Option (b) of the order.

Option (b), Criterion 2

19. 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 there are no flaws that would necessitate invoking criterion 2. Notwithstanding that, Bruce Power has proposed operational measures to improve operational safety margins during heat-up and cooldown, as well as during cold Primary Heat Transport conditions where there is limited potential for overpressure conditions to occur.
20. The Commission concludes 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”.

The compliance verification criteria for licence condition 15.3, as outlined in Section 15.3 of LCH 18.01/2028-R002, establish that:

“Bruce Power shall obtain approval from the Commission before operating any pressure tube with a measured [Heq] greater than 120 ppm, or beyond the time any pressure tube is predicted to have a [Heq] greater than 120 ppm...”

22. Bruce Power’s discovery of [Heq] in Unit 3 pressure tubes in excess of the licence limit was not predicted by current modeling. Bruce Power submitted that although it identified elevated [Heq] concentrations in the region of interest, the overall uptake of hydrogen in the pressure tubes is not increasing beyond the predicted rate, and that hydrogen concentrations are below the limit for the balance of the pressure tubes. The Commission’s view is that Bruce Power did not knowingly operate Unit 3 with [Heq] in excess of the licence limit, and that the consequent regulatory action taken by the CNSC, including the designated officer order, has been appropriate.
23. In authorizing the restart of Unit 3, the Commission would be authorizing the operation of a reactor with a pressure tube with a 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.
24. CNSC staff’s assessment is that in satisfying option (b) of the order, Bruce Power has demonstrated that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm. As such, it is CNSC staff’s view that Bruce Power has complied with the intent of Licence Condition 15.3, and that Unit 3 could be safely returned to service following the current planned outage.

25. The Commission is satisfied that Bruce Power has demonstrated, for the purposes of licence condition 15.3 in relation to this restart, that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm. Consequently, the Commission approves the restart and operation of Unit 3 following the current planned outage.

Scope of Restart Request

26. The Commission considered whether the restart request should be applicable to future outages for Unit 3, beyond outage A2131. Bruce Power requested Commission approval to return Unit 3 to service following the current planned outage. In its August 13, 2021 letter to the Commission Secretary, referenced in 21-H110.1 and captured in [CMD 21-H11.2](#), Bruce Power stated that:

“Bruce Power is also seeking acknowledgement that by demonstrating the return to service of Unit 3 is compliant with the Order that this unit will operate to its planned Major Component Replacement in the first quarter of 2023. During this short interval, the unit may need to return to service from an unplanned outage and also from the Bruce A Vacuum Building and Station Containment Outage in 2022 and the authorization to return to service would be applicable to these circumstances as well.”

27. Bruce Power submitted that the risk of a pressure tube rupture resulting from a through-wall flaw in Bruce Unit 3 prior to the commencement of the Major Component Replacement is very low. Bruce Power’s view is that it has demonstrated flaw stability for up to 250 ppm [Heq].
28. CNSC staff’s view is that the fitness for service of the pressure tubes containing scrape marks should be evaluated to support restart from future outages, as crack initiation from a flaw is most likely to occur during a reactor cooldown cycle. CNSC staff explained that the known scrape marks will not impact safe restart and subsequent full power operation following the current outage since there is no mechanism for crack formation while the unit is depressurized or during heat-up as part of the restart process.
29. As noted previously in this decision, Bruce Power will conduct confirmatory tests to fully validate its crack initiation models at [Heq] levels above 120 ppm. CNSC staff explained that additional work is planned to confirm the accuracy of the models for elevated levels of [Heq], up to 220 ppm, to support continued operation of tubes with scrape marks in locations of elevated [Heq]. CNSC staff stated that the first of these test results are expected prior to the end of 2021.

30. While the Commission is satisfied that Bruce Power has demonstrated that pressure tube fracture toughness will be sufficient for safe operation beyond 120 ppm for its current outage, the Commission will reassess any future Unit 3 restart requests with up-to-date validation information. Therefore, the Commission does not authorize the restart of Bruce NGS A Unit 3 from any future outage. In keeping with its September 22, 2021 decision, the Commission will consider any such request upon the submission of a specific request by the licensee.

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Velshi,
Rumina

November 10, 2021

Rumina Velshi
President,
Canadian Nuclear Safety Commission

Date