



UNCLASSIFIED/NON CLASSIFIÉ

**ORIGINAL/ORIGINAL**

**CMD: 23-H103**

**Date signed/Signé le : 15 MARCH 2023**

A Licence Amendment

Modification d'un permis

**Bruce Power Inc.**

**Bruce Power Inc.**

**Bruce Nuclear  
Generating Stations A  
and B**

**Centrales nucléaires de  
Bruce-A et Bruce-B**

Hearing in writing based solely on  
written submissions

Audience par écrit fondée uniquement  
sur des mémoires

Scheduled for:

Prévue pour :

April 2023

Avril 2023

Submitted by:

Soumis par :

CNSC Staff

Le personnel de la CCSN

**Summary**

This CMD presents information about the following matters of regulatory interest with respect to Bruce Power Inc.:

- Application to amend the Power Reactor Operating Licence (PROL) for the Bruce Nuclear Generating Stations A and B to remove Licence Condition 15.3 and to consolidate all requirements for fitness for service applicable to pressure tubes under Licence Condition 6.1

CNSC staff recommend the Commission consider taking the following actions:

- Amend the PROL to remove Licence Condition 15.3 related to pressure tube fracture toughness and include a new Licence Condition 6.2 related to a fitness for service program for fuel channels in extended operation

The following items are attached:

- The proposed PROL 18.03/2028
- The draft section of the Licence Conditions Handbook reflective of the proposed PROL
- The current PROL 18.02/2028

**Résumé**

Le présent CMD fournit de l'information sur les questions d'ordre réglementaire suivantes concernant Bruce Power Inc. :

- Demande de modification du permis d'exploitation d'un réacteur de puissance (PERP) pour les centrales nucléaires de Bruce-A et de Bruce-B afin de supprimer la condition de permis 15.3 et consolider toutes les exigences liées à l'aptitude fonctionnelle des tubes de force sous la condition de permis 6.1.

La Commission pourrait considérer prendre les mesures suivantes :

- Modifier le PERP afin de supprimer la condition de permis 15.3 liée à la ténacité à la rupture des tubes de force et ajouter la condition de permis 6.2 liée à l'aptitude fonctionnelle des canaux de combustible en exploitation prolongée.

Les pièces suivantes sont jointes :

- Le PERP 18.03/2028 proposé
- L'ébauche de la section du manuel des conditions de permis reflétant le PERP proposé
- Le PERP 18.02/2028 actuel

**Signed/Signé le**

15 March 2023/ 15 mars 2023

**Viktorov,  
Alexandre**

Digitally signed by Viktorov, Alexandre  
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Alexandre"  
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Date: 2023.03.15 07:17:31-04'00'  
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Alexandre Viktorov

**Director General**

Directorate of Power Reactor Regulation

**Directeur général**

Direction de la réglementation des centrales nucléaires

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## EXECUTIVE SUMMARY

The Bruce Nuclear Generating Stations (NGS) A and B are located in the Municipality of Kincardine, in the County of Bruce, Ontario and are part of the Bruce Nuclear Power Development site on the shores of Lake Huron. The Canadian Nuclear Safety Commission (CNSC) acknowledges that the Bruce NGS A and B are located in the traditional territory of the Anishinabek Nation: the peoples of the three fires known as Ojibway, Odawa and Pottawatomie Nations. The CNSC also acknowledges the Chippewas of Saugeen and the Chippewas of Nawash, together now known as the Saugeen Ojibway Nation, as the traditional keepers of this land. The Bruce region is also homeland to the Historic Saugeen Métis and to the Métis Nation of Ontario.

In October 2022, Bruce Power Inc. (hereinafter Bruce Power or licensee) submitted an application to amend the Power Reactor Operating Licence (PROL) 18.02/2028 to remove licence condition (LC) 15.3, Pressure Tube Fracture Toughness, and to consolidate all fitness for service requirements applicable to pressure tubes under LC 6.1, Fitness for Service Program.

CNSC staff assessed Bruce Power's licence amendment application. In light of recent Commission decisions following the discovery of elevated Heq in some pressure tubes in Bruce A Unit 3 and Bruce B Unit 6 and CNSC staff assessments related to elevated Heq in pressure tubes, CNSC staff are of the view that LC 15.3 no longer serves its intended purpose. CNSC staff recommend that the Commission include a new LC 6.2 in the amended PROL for Bruce NGS A and B to require that Bruce Power implement and maintain an enhanced fitness-for-service program for fuel channels in extended operation.

CNSC staff recommend that this new LC be set out under the safety and control area of Fitness for Service, section 6 of the PROL, to capture all requirements for fitness for service applicable to Bruce Power under the same section. CNSC staff also recommend that LC 6.2 remain in place until Bruce Power can demonstrate to the Commission's satisfaction that it can meet the criteria for fitness for service under LC 6.1 applicable to the regions of interest of pressure tubes.

CNSC staff will continue to monitor Bruce Power's performance in respect of pressure tube fitness for service, through their proposed compliance verification activities in relation to LCs 6.1 and 6.2. CNSC staff will continue to update the Commission on pressure tube fitness for service at the Bruce NGS A and B through Commission-requested Commission meeting items, the annual regulatory oversight report and other reporting mechanisms, as appropriate.

Referenced documents in this CMD are available to the public upon request, subject to confidentiality considerations.

## CMD STRUCTURE

This Commission Member Document (CMD) is presented in 2 parts.

**Part One of this CMD** includes:

1. an overview of Bruce Power's application for licence amendment;
2. overall conclusions and overall recommendations;
3. general discussion pertaining to the safety and control areas (SCAs) that are relevant to this CMD;
4. discussion about other matters of regulatory interest; and
5. appendices that complement items 1 through 4.

**Part Two of this CMD** provides other relevant information pertaining directly to the current and proposed licence not otherwise set out in Part One.

## PART ONE

### 1. OVERVIEW

The purpose of this Commission Member Document (CMD) is to provide CNSC staff's conclusions and recommendations arising from the review of Bruce Power's Application [1]. Bruce Power requested an amendment of its Power Reactor Operating Licence, PROL 18.02/2028, to remove Licence Condition (LC) 15.3 and to consolidate all fitness for service requirements applicable to pressure tubes under LC 6.1, with associated compliance verification criteria (CVC) consolidated under section 6.1 of the Licence Conditions Handbook (LCH), Fitness for Service Program. Bruce Power is seeking this licence amendment to reflect recent Commission decisions ([DEC 21-H113](#) and [DEC 22-H100](#)) and advancements in understanding related to pressure tube behaviour.

#### 1.1 Background

At the time of Bruce Power's licence renewal in 2018, the upper hydrogen equivalent concentration (Heq) limits of the fracture toughness model in CSA standard N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*<sup>1</sup>[2] was 120 parts per million (ppm) by weight. It was projected that the end-of-life Heq values for some pressure tubes in extended operation<sup>2</sup> would exceed the 120 ppm limit. CNSC staff recommended to the Commission that, for better transparency and to provide Bruce Power with clear compliance criteria, a licence condition be placed on Bruce Power to maintain pressure tube fracture toughness sufficient for safe operation.

As a result, the Commission included LC 15.3 in the Bruce Nuclear Generating Stations (NGS) A and B PROL 18.00/2028: *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*. In its [decision dated September 27, 2018](#), the Commission required that Bruce Power obtain approval from the Commission to operate with pressure tubes in excess of 120 ppm of Heq. Bruce Power was expected to extend the validity of the fracture toughness model to a predicted end of operational life Heq level of approximately 160 ppm using results of a laboratory testing program. The compliance verification criteria established for this licence condition required that Bruce Power:

- Obtain Commission approval before operating pressure tubes with Heq levels above 120 ppm
- Submit annual reports indicating when reactor units were expected to have pressure tubes with Heq levels exceeding 120 ppm

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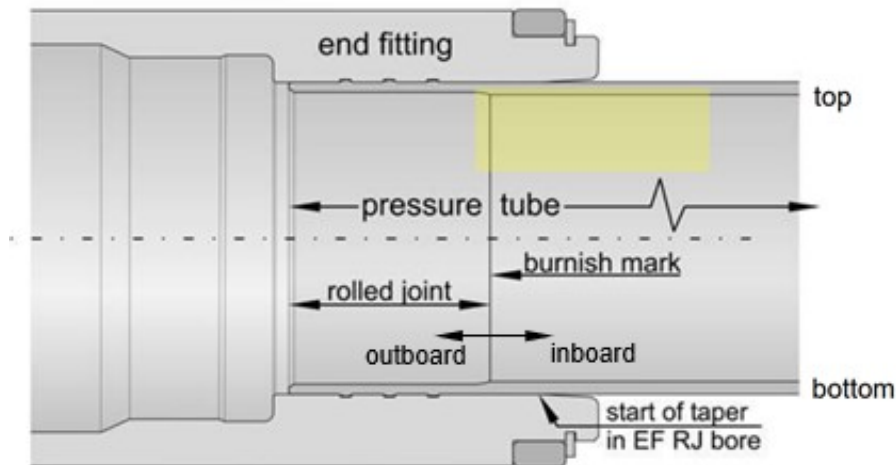
<sup>1</sup> The Revision 1 model was included in the 2015 edition of CSA standard N285.8. Update No. 1 to the 2015 edition was issued in 2019 and included an additional Heq limit of 80 ppm with 1.5 m of the front end of a pressure tube.

<sup>2</sup> In other words, reactors operating beyond 210,000 equivalent full power hours (EFPH)

- Provide status reports for and results of the fracture toughness burst testing program
- Submit fracture protection and Leak-Before-Break evaluations for pressure tubes with Heq levels predicted to exceed 120 ppm using an updated fracture toughness model.

In May 2022, CNSC staff conditionally accepted Bruce Power's technical basis for a revision of the fracture toughness model for pressure tubes [3]. CNSC staff's assessment was that Bruce Power had completed sufficient testing to demonstrate the validity of the fracture toughness model for deterministic pressure tube evaluations for material with Heq up to a maximum of 140 ppm, except for material within 1.5 m of the front end of the pressure tube which is restricted to a maximum of 100 ppm. CNSC staff requested that Bruce Power continue material testing and model development to confirm that the revised model can be applied to material with higher Heq values and to remove conditions imposed by CNSC staff associated with the use of the model for probabilistic pressure tube evaluations for flaws.

However, in 2021 and 2022, Bruce Power reported to the CNSC its findings related to elevated Heq (exceeding 160 ppm) in some pressure tubes that were in extended operation. The elevated Heq concentrations were discovered near the outlet and inlet rolled joint (ORJ and IRJ, respectively) burnish marks of the pressure tubes (Figure 1) and exceeded the LC 15.3 limit and the limit established for the accepted pressure tube fracture toughness model at the time of the events.



**Figure 1: Schematic diagram of a pressure tube at the end fitting**

During the Commission proceedings in which CMDs [21-M39](#), [CMD 21-M37](#), [CMD 22-M16](#), [CMD 22-M37](#), [CMD 21-H110](#), [CMD 21-H113](#) and [CMD 22-H100](#) were presented, CNSC staff submitted that these findings posed a low risk for nuclear safety for the affected units in the near term.



The Heq discovery findings did put into question the full efficacy of Level 1 and Level 2 defence in depth with respect to the operation of the affected units (i.e., Bruce NGS units 3, 4, 5, 7, 8). CNSC staff were unable to confirm that the fitness for service CVC for potentially affected pressure tubes established in Section 6.1 of the LCH were satisfied. In July 2021, in response to the ORJ elevated Heq findings, a [CNSC Designated Officer \(DO\) order](#) was issued to Bruce Power requiring the licensees to obtain authorization from the Commission prior to the restart of the units with pressure tubes in extended operation following any outage that results in the cooldown of the heat transport system (HTS).

Following two hearings held in November 2021 and January 2022, the Commission concluded that pressure tube fracture toughness in the ORJ region was sufficient for safe operation beyond 120 ppm in reactors in extended operation based on the low likelihood of flaws in the region of interest that would lead to crack initiation. The Commission agreed that a reduction in fracture toughness was only a concern for regions of pressure tubes where cracks can form. In [DEC 21-H113](#) and [DEC 22-H100](#), the Commission authorized Bruce Power to restart the Bruce NGS units 3, 4, 5, 7 and 8 following any outage that results in the cooldown of the HTS and concluded that the requirements of the DO order had been satisfied.

In [CMD 22-M37](#), CNSC staff provided the results of its risk assessment of elevated Heq at the IRJ region of pressure tubes in reactors in extended operation. CNSC staff determined that the risk due to the issue of elevated Heq at the IRJ region of pressure tubes is negligible for up to 3 years of continued operation.

In addition, Bruce Power has introduced operational changes and additional training to minimize the possibility of transients that lead to the highest risk of pressure tube failure.

## 1.2 Highlights

Based on the recent Commission decisions and CNSC staff assessments relating to elevated Heq in pressure tubes, CNSC staff are of the view that LC 15.3 is no longer applicable. CNSC staff recommend that the Commission amend Bruce Power's PROL to remove LC 15.3. However, because of the continuing work on pressure tube fitness for service, CNSC staff are also recommending that the Commission include in the PROL LC 6.2 to require that Bruce Power implement and maintain a fitness for service program for fuel channels in extended operation. Specifically, the proposed LC 6.2 will address fitness for service concerns associated with regions of elevated hydrogen equivalent concentration. The associated CVC in the Bruce Power LCH will reflect the Commission's decisions and CNSC staff assessments.

## 2. MATTERS FOR CONSIDERATION

### 2.1 Environmental Assessment

An Environmental Assessment (EA) under the [NSCA](#) is not required; no new licence activities are proposed by Bruce Power and CNSC staff's recommendation include existing licensing requirements.

### 2.2 Regulatory and Technical Basis

CNSC staff have reviewed the Application [1] and are of the view that the request to remove LC 15.3 is acceptable since the LC no longer serves its intended purpose. Licence Condition 15.3 had been placed on Bruce Power for better transparency and to provide Bruce Power with clear acceptance criteria for maintaining pressure tube fracture toughness sufficient for safe operation. However, the concentration of Heq in some pressure tubes was found by Bruce Power to be higher than 120 ppm; therefore, Bruce Power cannot, at this time, conclusively confirm that all other pressure tubes in reactors in extended operation are operating with concentration of Heq below the limit established in LC 15.3. Since the discovery findings, the Commission approved the operation of Units 3, 4, 5, 7 and 8 with pressure tubes in excess of 120 ppm of Heq based on the low likelihood of flaws in the region of interest that would lead to crack initiation. Furthermore, CNSC staff have determined through a risk assessment that the risk due to the issue of elevated Heq at the IRJ of pressure tubes where flaws are known to exist is negligible for up to 3 years of continued operation. The CVC for pressure tubes in extended operation has evolved and is focused on Bruce Power updating fitness for service evaluation methodologies for flaws in the regions where Heq is potentially elevated to levels observed near the rolled joints of some Unit 3 and Unit 6 pressure tubes. This work is expected to take approximately three years to complete. In the meantime, Bruce Power will be required to demonstrate that the alternative criteria adopted following the Unit 3 and Unit 6 events remains valid.

The fitness for service program requirements under LC 6.1 have been demonstrated to be effective for assuring safe operation of pressure tubes. However, many of the models and the evaluation processes used to assess pressure tube fitness for service in CSA standard N285.8 have not been validated for levels of Heq that have been observed near the rolled joint burnish marks in some Bruce NGS pressure tubes in extended operation.

Heq is a key input parameter to the models used to assess crack initiation, crack growth, fracture toughness and fracture initiation toughness. Recent experience has shown that the Heq in regions of the pressure tube near the IRJ and ORJ (also referred to as regions of interest or ROIs) in some Bruce Power pressure tubes in extended operation have exceeded the values that were estimated prior to 2021 for the end-of-life conditions. The applicability of the crack initiation, crack growth and fracture toughness models for the Heq levels in the ROIs still needs to be demonstrated. Bruce Power has undertaken a research and development (R&D)

program to extend the Heq limits for the models used to demonstrate pressure tube fitness for service.

Since the fitness for service criteria established in Section 6.1 cannot be applied for the ROIs of pressure tubes, CNSC staff recommend that the Commission include a new LC 6.2 in the Bruce NGS A and B PROL to require that Bruce Power implement and maintain an enhanced fitness for service program for fuel channels in extended operation. To reflect the Commission's recent decisions, CNSC staff's proposed CVC for this new LC will establish the requirements for Bruce Power to report on the status of its R&D activities and the compliance verification approaches relating to the safe operability of pressure tubes when the validity of the fitness for service criteria established in LC 6.1 cannot be confirmed.

CNSC staff recommend that the Commission include this new LC 6.2 under the safety and control area of Fitness for Service, section 6 of the PROL, in order to capture all fitness for service requirements under the same section of the PROL. CNSC staff recommend that LC 6.2 remain in place until the R&D work committed to by Bruce Power is complete and until Bruce Power can demonstrate to the Commission's satisfaction that the fitness for service criteria under LC 6.1 applicable to the ROIs of pressure tubes can be met.

CNSC staff will continue to monitor Bruce Power's performance in respect of pressure tube fitness for service, through the compliance verification activities proposed by CNSC in relation to LCs 6.1 and 6.2. CNSC staff will also continue to update the Commission on pressure tube fitness for service at the Bruce NGS A and B through Commission meeting items, the annual regulatory oversight report and other reporting mechanisms, as appropriate.

## 2.3 Indigenous Consultation

The common-law duty to consult with Indigenous Nations and communities applies when the Crown contemplates actions that may adversely affect potential or established Indigenous and/or treaty rights. The CNSC ensures that all of its licence decisions under the [NSCA](#) uphold the honour of the Crown and consider Indigenous peoples' potential or established Indigenous and/or treaty rights pursuant to section 35 of the [Constitution Act, 1982](#).

CNSC staff are committed to building long-term relationships with Indigenous Nations and communities who have interest in CNSC-regulated facilities within their traditional and/or treaty territories. The CNSC's Indigenous engagement practices include sharing information, discussing topics of interest, seeking feedback and input on CNSC processes, and providing opportunities to participate in environmental monitoring. The CNSC also provides funding support (through the CNSC's Participant Funding Program) for Indigenous peoples to meaningfully participate in Commission proceedings and ongoing regulatory activities.

Based on the information provided in Bruce Power's Application [1], CNSC staff have determined that the licence amendment request is administrative in nature, is not for a new project, and is not likely to cause adverse impact to Indigenous

and/or treaty rights. Therefore, the duty to consult does not arise in relation to the Application.

### 3. OVERALL CONCLUSIONS AND RECOMMENDATIONS

#### 3.1 Overall Conclusions

CNSC staff have reviewed Bruce Power's application and have determined that the requested licence amendment would update the PROL to reflect recent Commission decisions and advancements in understanding related to pressure tube behaviour.

However, CNSC staff highlight the fitness for service criteria established in Section 6.1 cannot be confirmed in the ROIs of pressure tubes. Therefore, removing the existing LC 15.3 and consolidating all fitness for service CVC under LC 6.1 is not appropriate without addressing issues presented by the elevated Heq in the ROIs. As such, CNSC staff recommend that the Commission include in the Bruce NGS A and B PROL a new LC 6.2, under the Fitness for Service SCA, to require that Bruce Power implement and maintain an enhanced fitness for service program for fuel channels in extended operation.

CNSC staff will continue to monitor Bruce Power's performance in respect of pressure tube fitness for service, through compliance verification activities established in relation to LCs 6.1 and, if approved by the Commission, 6.2. CNSC staff will also continue to update the Commission on pressure tube fitness for service at the Bruce NGS A and B through Commission meeting items, the annual regulatory oversight report and other reporting mechanisms, as appropriate.

#### 3.2 Overall Recommendations

CNSC staff recommend that the Commission:

1. **Conclude**, pursuant to paragraphs 24(4)(a) and (b) of the [Nuclear Safety and Control Act](#) (NSCA) that Bruce Power:
  - a) is qualified to carry on the activities authorized by the amended licence
  - b) will continue to make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed under the amended licence.
2. **Amend** the current Bruce Nuclear Generating Stations A and B Power Reactor Operating Licence, PROL 18.02/2028, to
  - a) **Remove** licence condition 15.3, Pressure Tube Fracture Toughness: *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; and*

- b) **Include** licence condition 6.2, Fitness for Service Program for Fuel Channels in Extended Operation: *The licensee shall implement and maintain an enhanced fitness for service program for fuel channels in extended operation.*

If the Commission accepts CNSC staff's recommendations, CNSC staff will, in the Bruce NGS A and B LCH:

- remove CVC related to LC 15.3; and
- add CVC to the Bruce NGS A and B LCH to reflect the removal of LC 15.3 and the inclusion of LC 6.2. This CVC will consolidate Commission decisions and establish the requirements for reporting the status of Bruce Power's R&D activities, as well as the interim approaches to assessing the safe operability of pressure tubes when the validity of the fitness for service criteria established in LC 6.1 cannot be confirmed.

## References

- [1] Bruce Power Letter, M. Burton to D. Saumure, “Application for the Amendment of the Power Reactor Operating Licence”, October 11, 2022, BP-CORR-00531-01842, e-Doc 6889090.
- [2] CSA Group, CSA N285.8-15, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*.
- [3] CNSC Letter, L. Sigouin to M. Burton, “Bruce A and B: CNSC Review of the Revision 2 Engineering Fracture Toughness Model for Pressure Tubes”, May 12, 2022, e-Doc 6795110.

## Glossary

For definitions of terms used in this document, see [REGDOC-3.6, Glossary of CNSC Terminology](#), which includes terms and definitions used in the Nuclear Safety and Control Act and the Regulations made under it, and in CNSC regulatory documents and other publications.

Additional terms and acronyms used in this CMD are listed below.

<b>CMD</b>	Commission Member Document
<b>CNSC</b>	Canadian Nuclear Safety Commission
<b>CVC</b>	compliance verification criteria
<b>DO</b>	Designated Officer
<b>EA</b>	Environmental Assessment
<b>EFPH</b>	effective full power hours
<b>Heq</b>	hydrogen equivalent concentration
<b>HTS</b>	Heat transport system
<b>IRJ</b>	inlet region of interest
<b>LC</b>	licence condition
<b>LCH</b>	Licence Conditions Handbook
<b>NGS</b>	nuclear generating stations
<b>NSCA</b>	<i>Nuclear Safety and Control Act</i>
<b>ORJ</b>	outlet rolled joint
<b>ppm</b>	parts per million (by weight)
<b>PROL</b>	Power Reactor Operating Licence
<b>R&amp;D</b>	Research and development
<b>ROI</b>	Region of interest
<b>SCA</b>	Safety and Control Area

## A. Basis for the Recommendation(s)

### A.1 Regulatory Basis

The recommendations presented in this CMD are based on compliance objectives and expectations associated with the relevant SCAs and other matters. The regulatory basis for the matters that are relevant to this CMD are as follows.

- [Nuclear Safety and Control Act](#), subsection 24(2).
- Nuclear Power Reactor Operating Licence, Bruce Nuclear Generating Stations A and B, PROL 18.02/2028
- Bruce Nuclear Generating Stations A and B Licence Conditions Handbook, LCH-PR-18.02/2028-R003, in particular the regulatory documents and standards identified as compliance verification criteria
- Record of Decision, [DEC 21-H113](#), Request for Authorization to Restart Bruce Nuclear Generating Station A Unit 4 and Bruce NGS B Units 5, 7 and 8 following future outages, November 12, 2021
- Record of Decision, [DEC 22-H100](#), Request for Authorization to Restart Bruce Nuclear Generating Station A Unit 3 following future outages, March 9, 2022

### A.2 Detailed Summary of CNSC Assessment of Application

CNSC's staff assessment of Bruce Power's Application [1] included a completeness check, a sufficiency check, and a technical assessment against regulatory requirements. The completeness check verified whether the application included the prescribed information in accordance with the [Nuclear Safety and Control Act](#) and applicable regulations. For all facilities (i.e., Class I and Class II facilities), it is important to consider and address all licence application requirements within the applicable CNSC regulations.

The sufficiency check verified whether the application included sufficient and quality information in order for CNSC staff to conduct the technical assessment. The technical assessment verified whether the application included adequate safety and control measures to address CNSC requirements. Documents originally submitted as part of the application may have been revised, updated, or replaced over the course of the assessment to address CNSC requirements.



<b>Pursuant to Section 6 of the <u>General Nuclear Safety and Control Regulations</u></b> <b>Licences – Application for Amendment, Revocation, or Replacement of Licence</b>	<b>Location in application or supporting document(s) as noted by Bruce Power</b>	<b>Complete?</b>	<b>Sufficient?</b>	<b>Adequate?</b>
An application for the amendment, revocation or replacement of a licence shall contain the following information:				
(a) a description of the amendment, revocation or replacement and of the measures that will be taken and the methods and procedures that will be used to implement it	Attachment A and References A1-A3 of the Application	Y	Y	Y
(b) a statement identifying the changes in the information contained in the most recent application for the licence	Attachment A and Reference A5-A7 of the Application	Y	Y	Y
(c) a description of the nuclear substances, land, areas, buildings, structures, components, equipment and systems that will be affected by the amendment, revocation or replacement and of the manner in which they will be affected; and	Attachment A and Reference A5 of the Application	Y	Y	Y
(d) the proposed starting date and the expected completion date of any modification encompassed by the application.	Attachment A of the Application	Y	Y	Y

## PART TWO

**Part 2** of this CMD provides all relevant information pertaining directly to the licence, including:

1. The current licence, PROL 18.02/2028;
2. Any proposed changes to the conditions, licensing period, or formatting of the existing licence;
3. The proposed licence, PROL 18.03/2028; and
4. The draft section of the licence conditions handbook reflective of the proposed PROL.

## Current Licence

The current licence (PROL 18.02/2028) is provided on the following pages of the document.

Word: e-Doc 6411221	PDF: e-Doc 6462573
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## NUCLEAR POWER REACTOR OPERATING LICENCE

### BRUCE NUCLEAR GENERATING STATIONS A AND B

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- I) **LICENCE NUMBER:** **PROL 18.02/2028**
- II) **LICENSEE:** Pursuant to section 24 of the [Nuclear Safety and Control Act](#) this licence is issued to:
- Bruce Power Inc.**  
**P.O. Box 1540, R.R. #2**  
**Building B10, 177 Tie Road**  
**Municipality of Kincardine**  
**Tiverton, Ontario**  
**N0G 2T0**
- III) **LICENCE PERIOD:** This licence is valid from October 1, 2018 to September 30, 2028, unless suspended, amended, revoked or replaced.
- IV) **LICENSED ACTIVITIES:**
- This licence authorizes the licensee to:
- (i) operate the Bruce Nuclear Generating Stations A and B (hereinafter “Bruce A and B”) comprised of reactor units 1 to 4 and 5 to 8 respectively, at the Bruce site located in the County of Bruce in the regional municipality of Kincardine, Province of Ontario; and,
    - (1) possess, transfer, use, package, manage and store nuclear substances that are required for, associated with, or arise from the activities described in (i), except for booster fuel assemblies;
    - (2) possess, transfer and use prescribed equipment that is required for, associated with, or arises from the activities described in (i);
    - (3) possess and use prescribed information that is required for, associated with, or arises from the activities described in (i);
  - (ii) operate a Class II nuclear facility at the Bruce site; and,
    - (1) possess, transfer, use, package, manage and store nuclear substances that are required for, associated with, or arise from the activities described in (ii);
    - (2) possess, transfer and use prescribed equipment that is required for, associated with, or arises from the activities described in (ii);

- (iii) possess, transfer, use, manage and store nuclear substances and prescribed equipment to perform industrial radiography throughout the Bruce site;
- (iv) import and export nuclear substances and prescribed equipment, except controlled nuclear substances and controlled nuclear equipment, that are required for, associated with, or arise from the activities described in (i), (ii) and (iii);
- (v) possess, manage and store booster fuel assemblies at Bruce A; and
- (vi) produce Cobalt-60 and Lutetium-177; and
  - (1) possess, transfer, use, package, manage and store nuclear substances that are required for, associated with, or arise from the activities described in (vi).

[Amended  
2021-09]

## V) EXPLANATORY NOTES:

- (i) Nothing in this licence shall be construed to authorize non-compliance with any other applicable legal obligation or restriction.
- (ii) Unless otherwise provided for in this licence, words and expressions used in this licence have the same meaning as in the [Nuclear Safety and Control Act](#) and associated Regulations.
- (iii) The BRUCE NGS A AND B LICENCE CONDITIONS HANDBOOK (LCH) provides compliance verification criteria including the Canadian standards and regulatory documents used to verify compliance with the conditions in the licence. The LCH also provides information regarding delegation of authority, applicable versions of documents and non-mandatory recommendations and guidance on how to achieve compliance.

## VI) CONDITIONS:

### G. General

- G.1 The licensee shall conduct the activities described in Part IV of this licence in accordance with the licensing basis, defined as:
  - (i) the regulatory requirements set out in the applicable laws and regulations;
  - (ii) the conditions and safety control measures described in the facilities' licence and the documents directly referenced in that licence;
  - (iii) the safety and control measures described in the licence applications and the documents needed to support those licence applications;unless otherwise approved in writing by the Canadian Nuclear Safety Commission (CNSC) (hereinafter "the Commission").
- G.2 The licensee shall give written notification of changes to the facilities or their operation, including deviation from design, operating conditions, policies, programs and methods referred to in the licensing basis.
- G.3 The licensee shall control the use and occupation of any land within the exclusion zones.
- G.4 The licensee shall provide, at the Bruce site and at no expense to the Commission, office space for employees of the Commission who customarily carry out their functions on the premises of Bruce A and B (onsite Commission staff).
- G.5 The licensee shall implement and maintain a public information and disclosure program.

**1. Management System**

1.1 The licensee shall implement and maintain a management system.

**2. Human Performance Management**

2.1 The licensee shall implement and maintain a human performance program.

2.2 The licensee shall implement and maintain the minimum shift complement and control room staffing for Bruce A and B.

2.3 The licensee shall implement and maintain training programs for workers.

2.4 The licensee shall implement and maintain certification programs in accordance with [Amended CNSC regulatory document [REGDOC-2.2.3, PERSONNEL CERTIFICATION, VOLUME III: CERTIFICATION OF PERSONS WORKING AT NUCLEAR POWER PLANTS](#), 2020-03]

Persons appointed to the following positions require certification:

- (i) authorized health physicist;
- (ii) authorized nuclear operator;
- (iii) control room shift supervisor;
- (iv) Unit 0 control room operator; and
- (v) shift manager.

**3. Operating Performance**

3.1 The licensee shall implement and maintain an operations program, which includes a set of operating limits.

3.2 The licensee shall not restart a reactor after a serious process failure without the prior written approval of the Commission, or prior written consent of a person authorized by the Commission.

3.3 The licensee shall notify and report in accordance with CNSC regulatory document [REGDOC-3.1.1 REPORTING REQUIREMENTS FOR NUCLEAR POWER PLANTS](#).

**4. Safety Analysis**

4.1 The licensee shall implement and maintain a safety analysis program.

**5. Physical Design**

5.1 The licensee shall implement and maintain a design program.

5.2 The licensee shall implement and maintain a pressure boundary program and have in place a formal agreement with an Authorized Inspection Agency.

5.3 The licensee shall implement and maintain an equipment and structure qualification program.

**6. Fitness for Service**

6.1 The licensee shall implement and maintain a fitness for service program.

**7. Radiation Protection**

7.1 The licensee shall implement and maintain a radiation protection program, which includes a set of action levels. When the licensee becomes aware that an action level has been reached, the licensee shall notify the Commission within seven days.

**8. Conventional Health and Safety**

8.1 The licensee shall implement and maintain a conventional health and safety program.

**9. Environmental Protection**

9.1 The licensee shall implement and maintain an environmental protection program, which includes a set of action levels. When the licensee becomes aware that an action level has been reached, the licensee shall notify the Commission within seven days.

**10. Emergency Management and Fire Protection**

10.1 The licensee shall implement and maintain an emergency preparedness program.

10.2 The licensee shall implement and maintain a fire protection program.

**11. Waste Management**

11.1 The licensee shall implement and maintain a waste management program.

11.2 The licensee shall notify the Commission of any changes regarding the obligations of decommissioning and financial guarantees under the Lease Agreement with Ontario Power Generation Inc., as described in 15.1.

**12. Security**

12.1 The licensee shall implement and maintain a nuclear security program.

**13. Safeguards and Non-Proliferation**

13.1 The licensee shall implement and maintain a safeguards program.

**14. Packaging and Transport**

14.1 The licensee shall implement and maintain a packaging and transport program.

**15. Nuclear Facility-Specific**

15.1 The licensee shall inform the Commission in writing of any amendments to the Amended and Restated Lease Agreement between Ontario Power Generation Inc., Bruce Power L.P., OPG-Huron A Inc./OPG-Huron B Inc./OPG-Huron Common Facilities Inc., British Energy PLC, Cameco Corporation, TransCanada Pipelines Limited, BPC Generation Infrastructure Trust and Ontario Municipal Employees Retirement Board dated February 14, 2003.

15.2 The licensee shall implement the Integrated Implementation Plan.

15.3 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.

15.4 The licensee shall implement a return-to-service plan for Major Component Replacement.

- 15.5 The licensee shall obtain the approval of the Commission, or consent of a person authorized by the Commission, prior to the removal of established regulatory hold points.
- 15.6 The licensee shall conduct and implement a periodic safety review.
- 15.7 The licensee shall inform the Commission of any reactor to be removed from commercial operations at Bruce A and B, and shall provide a plan describing the activities and timeline for transitioning from operations to safe storage.
- 15.8 The licensee shall store and manage booster fuel assemblies at Bruce A in a manner that ensures their physical security.
- 15.9 The licensee shall implement and maintain a nuclear criticality safety program.
- 15.10 The licensee shall implement and maintain a program for the production of the nuclear substances Cobalt-60 and Lutetium-177. [Amended 2021-09]
- 15.11 The licensee shall implement and maintain a program for the operation of the Class II nuclear facility.
- 15.12 The licensee shall implement and maintain a program for nuclear substances and prescribed equipment.

SIGNED at OTTAWA on September 24, 2021

Velshi,  
Rumina

Digitally signed by Velshi, Rumina  
DN: C=CA, O=GC, OU=CNSC-CCSN, CN="Velshi, Rumina"  
Reason: I am the author of this document  
Location: your signing location here  
Date: 2021-09-24 12:05:02  
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**Rumina Velshi**  
**President**  
**CANADIAN NUCLEAR SAFETY COMMISSION**



## Proposed Licence Changes

### Overview

The changes being recommended in the Bruce Nuclear Generating Station (NGS) A and B Power Reactor Operating Licence (PROL) and the Licence Conditions Handbook (LCH) support the implementation of an enhanced fitness for service program for fuel channels in extended operation.

### Licence Conditions

Considering recent Commission decisions and advancements in understanding of pressure tube behaviour, CNSC staff recommend removing Licence Condition (LC) 15.3 and adding a new LC 6.2.

PROPOSED LICENCE CHANGES		
Existing PROL	Proposed PROL	Reasons for Change
15.3 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.	15.3 (Removed)	LC 15.3 is no longer applicable based on the recent Commission decisions and results of CNSC staff assessments of findings of elevated Heq in some pressure tubes in extended operation.
	6.2 The licensee shall implement and maintain an enhanced fitness for service program for fuel channels in extended operation.	Since the fitness for service criteria established in Section 6.1 cannot be confirmed in the regions of interest of pressure tubes, a new LC 6.2 is recommended to establish the requirements for reporting the status of Bruce Power's R&D activities, as well as the interim approaches to assessing the safe operability of pressure tubes when the validity of the fitness for service criteria established in LC 6.1 cannot be confirmed.

### Licence Format

No change to the licence format is being requested or recommended.

### Licence Period

No change to the licence period is being requested or recommended.

## Proposed Licence

The proposed licence (PROL 18.03/2028) is provided on the following pages of the document.

Word: e-Doc 6973656	PDF: e-Doc 6992624
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## NUCLEAR POWER REACTOR OPERATING LICENCE

### BRUCE NUCLEAR GENERATING STATIONS A AND B

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- I) **LICENCE NUMBER:** **PROL 18.03/2028**
- II) **LICENSEE:** Pursuant to section 24 of the [Nuclear Safety and Control Act](#) this licence is issued to:
- Bruce Power Inc.**  
**P.O. Box 1540, R.R. #2**  
**Building B10, 177 Tie Road**  
**Municipality of Kincardine**  
**Tiverton, Ontario**  
**N0G 2T0**
- III) **LICENCE PERIOD:** This licence is valid from October 1, 2018 to September 30, 2028, unless suspended, amended, revoked or replaced.
- IV) **LICENSED ACTIVITIES:**
- This licence authorizes the licensee to:
- (i) operate the Bruce Nuclear Generating Stations A and B (hereinafter “Bruce A and B”) comprised of reactor units 1 to 4 and 5 to 8 respectively, at the Bruce site located in the County of Bruce in the regional municipality of Kincardine, Province of Ontario; and,
    - (1) possess, transfer, use, package, manage and store nuclear substances that are required for, associated with, or arise from the activities described in (i), except for booster fuel assemblies;
    - (2) possess, transfer and use prescribed equipment that is required for, associated with, or arises from the activities described in (i);
    - (3) possess and use prescribed information that is required for, associated with, or arises from the activities described in (i);
  - (ii) operate a Class II nuclear facility at the Bruce site; and,
    - (1) possess, transfer, use, package, manage and store nuclear substances that are required for, associated with, or arise from the activities described in (ii);
    - (2) possess, transfer and use prescribed equipment that is required for, associated with, or arises from the activities described in (ii);

- (iii) possess, transfer, use, manage and store nuclear substances and prescribed equipment to perform industrial radiography throughout the Bruce site;
- (iv) import and export nuclear substances and prescribed equipment, except controlled nuclear substances and controlled nuclear equipment, that are required for, associated with, or arise from the activities described in (i), (ii) and (iii);
- (v) possess, manage and store booster fuel assemblies at Bruce A; and
- (vi) produce Cobalt-60 and Lutetium-177; and
  - (1) possess, transfer, use, package, manage and store nuclear substances that are required for, associated with, or arise from the activities described in (vi).

[Amended  
2021-09]**V) EXPLANATORY NOTES:**

- (i) Nothing in this licence shall be construed to authorize non-compliance with any other applicable legal obligation or restriction.
- (ii) Unless otherwise provided for in this licence, words and expressions used in this licence have the same meaning as in the [Nuclear Safety and Control Act](#) and associated Regulations.
- (iii) The BRUCE NGS A AND B LICENCE CONDITIONS HANDBOOK (LCH) provides compliance verification criteria including the Canadian standards and regulatory documents used to verify compliance with the conditions in the licence. The LCH also provides information regarding delegation of authority, applicable versions of documents and non-mandatory recommendations and guidance on how to achieve compliance.

**VI) CONDITIONS:****G. General**

- G.1 The licensee shall conduct the activities described in Part IV of this licence in accordance with the licensing basis, defined as:
  - (i) the regulatory requirements set out in the applicable laws and regulations;
  - (ii) the conditions and safety control measures described in the facilities' licence and the documents directly referenced in that licence;
  - (iii) the safety and control measures described in the licence applications and the documents needed to support those licence applications;
 unless otherwise approved in writing by the Canadian Nuclear Safety Commission (CNSC) (hereinafter "the Commission").
- G.2 The licensee shall give written notification of changes to the facilities or their operation, including deviation from design, operating conditions, policies, programs and methods referred to in the licensing basis.
- G.3 The licensee shall control the use and occupation of any land within the exclusion zones.
- G.4 The licensee shall provide, at the Bruce site and at no expense to the Commission, office space for employees of the Commission who customarily carry out their functions on the premises of Bruce A and B (onsite Commission staff).
- G.5 The licensee shall implement and maintain a public information and disclosure program.

**1. Management System**

1.1 The licensee shall implement and maintain a management system.

**2. Human Performance Management**

2.1 The licensee shall implement and maintain a human performance program.

2.2 The licensee shall implement and maintain the minimum shift complement and control room staffing for Bruce A and B.

2.3 The licensee shall implement and maintain training programs for workers.

2.4 The licensee shall implement and maintain certification programs in accordance with CNSC regulatory document [REGDOC-2.2.3, PERSONNEL CERTIFICATION, VOLUME III: CERTIFICATION OF PERSONS WORKING AT NUCLEAR POWER PLANTS.](#) [Amended 2020-03]

Persons appointed to the following positions require certification:

- (i) authorized health physicist;
- (ii) authorized nuclear operator;
- (iii) control room shift supervisor;
- (iv) Unit 0 control room operator; and
- (v) shift manager.

**3. Operating Performance**

3.1 The licensee shall implement and maintain an operations program, which includes a set of operating limits.

3.2 The licensee shall not restart a reactor after a serious process failure without the prior written approval of the Commission, or prior written consent of a person authorized by the Commission.

3.3 The licensee shall notify and report in accordance with CNSC regulatory document [REGDOC-3.1.1 REPORTING REQUIREMENTS FOR NUCLEAR POWER PLANTS.](#)

**4. Safety Analysis**

4.1 The licensee shall implement and maintain a safety analysis program.

**5. Physical Design**

5.1 The licensee shall implement and maintain a design program.

5.2 The licensee shall implement and maintain a pressure boundary program and have in place a formal agreement with an Authorized Inspection Agency.

5.3 The licensee shall implement and maintain an equipment and structure qualification program.

**6. Fitness for Service**

6.1 The licensee shall implement and maintain a fitness for service program.

6.2 The licensee shall implement and maintain an enhanced fitness for service program for fuel channels in extended operation. [Amended 2023-##]

**7. Radiation Protection**

7.1 The licensee shall implement and maintain a radiation protection program, which includes a set of action levels. When the licensee becomes aware that an action level has been reached, the licensee shall notify the Commission within seven days.

**8. Conventional Health and Safety**

8.1 The licensee shall implement and maintain a conventional health and safety program.

**9. Environmental Protection**

9.1 The licensee shall implement and maintain an environmental protection program, which includes a set of action levels. When the licensee becomes aware that an action level has been reached, the licensee shall notify the Commission within seven days.

**10. Emergency Management and Fire Protection**

10.1 The licensee shall implement and maintain an emergency preparedness program.

10.2 The licensee shall implement and maintain a fire protection program.

**11. Waste Management**

11.1 The licensee shall implement and maintain a waste management program.

11.2 The licensee shall notify the Commission of any changes regarding the obligations of decommissioning and financial guarantees under the Lease Agreement with Ontario Power Generation Inc., as described in 15.1.

**12. Security**

12.1 The licensee shall implement and maintain a nuclear security program.

**13. Safeguards and Non-Proliferation**

13.1 The licensee shall implement and maintain a safeguards program.

**14. Packaging and Transport**

14.1 The licensee shall implement and maintain a packaging and transport program.

**15. Nuclear Facility-Specific**

15.1 The licensee shall inform the Commission in writing of any amendments to the Amended and Restated Lease Agreement between Ontario Power Generation Inc., Bruce Power L.P., OPG-Huron A Inc./OPG-Huron B Inc./OPG-Huron Common Facilities Inc., British Energy PLC, Cameco Corporation, TransCanada Pipelines Limited, BPC Generation Infrastructure Trust and Ontario Municipal Employees Retirement Board dated February 14, 2003.

15.2 The licensee shall implement the Integrated Implementation Plan.

15.3 (Removed)

[Amended  
2023-##]

15.4 The licensee shall implement a return-to-service plan for Major Component Replacement.

- 15.5 The licensee shall obtain the approval of the Commission, or consent of a person authorized by the Commission, prior to the removal of established regulatory hold points.
- 15.6 The licensee shall conduct and implement a periodic safety review.
- 15.7 The licensee shall inform the Commission of any reactor to be removed from commercial operations at Bruce A and B, and shall provide a plan describing the activities and timeline for transitioning from operations to safe storage.
- 15.8 The licensee shall store and manage booster fuel assemblies at Bruce A in a manner that ensures their physical security.
- 15.9 The licensee shall implement and maintain a nuclear criticality safety program.
- 15.10 The licensee shall implement and maintain a program for the production of the nuclear substances Cobalt-60 and Lutetium-177. [Amended 2021-09]
- 15.11 The licensee shall implement and maintain a program for the operation of the Class II nuclear facility.
- 15.12 The licensee shall implement and maintain a program for nuclear substances and prescribed equipment.

SIGNED at OTTAWA \_\_\_\_\_

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**Rumina Velshi**  
**President**  
**CANADIAN NUCLEAR SAFETY COMMISSION**

## Draft Licence Conditions Handbook

The Bruce NGS A and B Licence Conditions Handbook (LCH) is based on CNSC staff's standard LCH template. The proposed substantive changes to the LCH due to this CMD are to section 15.3, which will be removed, and to section 6.2, which will be added. The consequent changes to the LCH due to the recommended updated PROL are shown in the table below.

To ensure that Bruce Power operates within the Commission-approved licensing basis, the Bruce NGS A and B LCH contains compliance verification criteria specific to the operation of fuel channels in extended operation.

PROPOSED LICENCE CONDITIONS HANBOOK CHANGES	
Existing 15.3 (LCH-PR-18.02/2028-R003)	Proposed 6.2 (LCH-PR-18.03/2028-R004)
<b>15.3 Pressure Tube Fracture Toughness</b>	<b>6.2 Fitness for Service Program for Fuel Channels in Extended Operation</b>
<p><b><u>Licence Condition 15.3:</u></b> 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.</p>	<p><b><u>Licence Condition 6.2:</u></b> The licensee shall implement and maintain an enhanced fitness for service program for fuel channels in extended operation.</p>
<p><b><u>Preamble:</u></b> Bruce Power submits assessments for fuel channel components to support safe operation and satisfy compliance verification criteria in CSA N285.4-14 and CSA N285.8-15 Update 1 as outlined in Section 6.1. These assessments rely on models intended to conservatively predict the current and future conditions of fuel channel components. Fracture toughness models are used to assess risk of pressure tube failure from postulated flaws in uninspected pressure tubes. The current model for fracture toughness in CSA N285.8-15 Update 1 has an upper bound for hydrogen equivalent concentration, [H<sub>eq</sub>], in pressure tubes of 120 parts per million (ppm). To reach Major Component Replacement target dates, Bruce Power currently predicts that some pressure tubes will operate with [H<sub>eq</sub>] in excess of 120 ppm and has proposed the development and validation of a new fracture toughness model in support of satisfying this licence condition. To meet</p>	<p><b><u>Preamble:</u></b> The hydrogen equivalent concentration (Heq) is a key input parameter to the models used to assess crack initiation, crack growth, fracture toughness and fracture initiation toughness. Recent experience has indicated that the Heq in regions of the pressure tube near the inlet and outlet rolled joints (referred to as regions of interest or ROIs) in some Bruce Power pressure tubes in extended operation have exceeded the values that were estimated prior to 2021 for the end-of-life conditions. Furthermore, the existing crack initiation, crack growth and fracture toughness models are not validated for the Heq levels in the regions of interest.</p> <p>The compliance verification criteria described below establish the</p>



<p>compliance verification criteria for pressure tubes with <math>[H_{eq}]</math> greater than 120 ppm: i) a new fracture toughness model (hereafter referred to as the Fracture Toughness Model) needs to be developed and accepted by CNSC staff prior to use; and ii) the licensee must periodically demonstrate that fracture protection and Leak-Before-Break assessments of Bruce Power pressure tubes (using predictions of the Pressure Tube Fracture Toughness) satisfy CSA N285.8-15 Update 1 acceptance criteria.</p>	<p>requirements for reporting the status of the licensee’s R&amp;D activities, as well as the interim approaches to assessing the safe operability of pressure tubes when the validity of the fitness for service criteria established in Section 6.1 cannot be confirmed for the ROIs.</p>
<p><b><u>Compliance Verification Criteria:</u></b></p> <ol style="list-style-type: none"> <li>1. For continued operation of units containing pressure tubes with a <math>[H_{eq}]</math> exceeding 120 ppm between the inlet and outlet burnish marks:             <ol style="list-style-type: none"> <li>a. Bruce Power shall obtain approval from the Commission before operating any pressure tube with a measured <math>[H_{eq}]</math> greater than 120 ppm, or beyond the time any pressure tube is predicted to have a <math>[H_{eq}]</math> greater than 120 ppm,                 <ol style="list-style-type: none"> <li>i. Predictions of maximum <math>[H_{eq}]</math> shall be determined utilizing the hydrogen prediction model applied to the unit in the most recent report submitted to the CNSC under CSA N285.4, Clause 12.3.6.2. Revisions to the hydrogen prediction model used in the most recent report shall be accepted by the CNSC.</li> </ol> </li> <li>b. Bruce Power shall submit annual reports by July 1 of each year indicating when each unit is predicted to reach a maximum <math>[H_{eq}]</math> of 120 ppm.</li> </ol> </li> <li>2. Criteria for the development of the Fracture Toughness Model:</li> </ol>	<p><b><u>Compliance Verification Criteria:</u></b></p> <p><i>Applicable Heq Limits</i></p> <p>The current Heq limits of applicability for the relevant fitness for service models are:</p> <ul style="list-style-type: none"> <li>• Fracture toughness: 100 ppm within 1.5 meters of the front end of a pressure tube and 140 ppm for the remainder of the length of the tube</li> <li>• Delayed hydride cracking, hydride region overload and fatigue crack initiation models: 120 ppm</li> <li>• Delayed hydride cracking growth rate models: 120 ppm</li> <li>• Fracture initiation toughness: 120 ppm</li> </ul> <p>For regions of pressure tubes with Heq levels below these values, the compliance verification criteria in Section 6.1 shall apply for fitness for service evaluations.</p> <p>The limits for the models used in the fitness for service evaluations can be modified as supported by the results of the R&amp;D programs [1], subject to confirmation by CNSC staff [2].</p> <p>References:</p>

<p>On May 19, 2021, Bruce Power submitted a revision to the fracture toughness model for use in pressure tubes with <math>[H_{eq}]</math> exceeding 120 ppm (Bruce Power letter, M. Burton to L. Sigouin, “Bruce A and B: Technical Basis for Revision 2 of Cohesive-Zone Based Fracture Toughness Model”, May 19, 2021, BP-CORR-00531-01570, e-Doc 6568008). CNSC staff are currently reviewing the document.</p> <p>Until the Fracture Toughness Model is accepted for use, Bruce Power shall report, on a semi-annual basis, the following:</p> <ol style="list-style-type: none"> <li>a. status updates on the validation of the Fracture Toughness Model,</li> <li>b. a quantitative assessment of uncertainties for the Fracture Toughness Model as new test data is added; and</li> <li>c. updates to the test plan, which includes: <ol style="list-style-type: none"> <li>i. status of findings and outcomes from previous fracture toughness tests;</li> <li>ii. additions and changes to the test plan i.e., schedule of fracture toughness tests;</li> <li>iii. changes to the Test Strategy; and</li> <li>iv. results of fracture toughness tests including, as a minimum, material tested, test conditions, the results, whether the test objective has been met, and the tests planned for the next six months.</li> </ol> </li> </ol> <p>3. Criteria for demonstration of sufficient pressure tube fracture toughness:</p>	<p>[1] Bruce Power Letter, M. Burton to A. Viktorov and D. Saumure, “Bruce A and B: Update to the Commission regarding Elevated Hydrogen Equivalent Concentrations – Action Item 2022-07-23135”, July 19, 2022, BP-CORR-00531-02909, e-Doc 6844485.</p> <p>[2] CNSC Letter, M. Hornof to M. Burton, “Bruce NGS A and B: Detailed Plan to Further Evaluate the Effect of Elevated Hydrogen Equivalent Concentration on Pressure Tube Fitness for Service – New Action Item 2023-07-27173”, March 10, 2023, e-Doc 6959554.</p> <p>The compliance verification criteria established in this section apply on an interim basis for the ROIs where these Heq limits may be exceeded. Based upon available information, the ROIs adopted for the interim evaluations of safe operability of pressure tubes are defined as follows:</p> <ul style="list-style-type: none"> <li>• Inlet region of interest (IROI): The region encompassing the full circumference of a pressure tube extending 20 mm axially inboard of the inlet rolled joint burnish mark.</li> <li>• Outlet region of interest (OROI): The region encompassing the full circumference of a pressure tube extending 75 mm axially inboard of the outlet rolled joint burnish mark.</li> </ul> <p>The definitions of the regions of interest may be modified as supported by results of the R&amp;D program, subject to confirmation by CNSC staff.</p>
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<p>Bruce Power shall submit assessments of fracture protection and Leak-Before-Break, using the new fracture toughness model, to the CNSC prior to the predicted <math>[H_{eq}]</math> exceeding 120 ppm in one or more pressure tubes in any unit. The assessments shall be submitted for each unit no earlier than 1 year and no later than 6 months prior to the date that the <math>[H_{eq}]</math> for a pressure tube in the given unit is predicted to exceed 120 ppm.</p> <p>Fracture protection assessments shall address the requirements of CSA N285.8-15 Update 1 Clauses 7.2.1 and 7.2.2, unless an assessment methodology/acceptance criteria for probabilistic fracture protection has received prior acceptance by CNSC.</p> <p>Guidance for performing Leak-Before-Break assessments is offered below.</p>	<p><i>Approach for Assessments of the Safe Operation of Pressure Tubes in Extended Operation</i></p> <p>Bruce Power shall provide the following:</p> <ul style="list-style-type: none"> <li>• For the IROI, assessment confirming that new research findings do not impact the conclusions of the Deterministic Safety Analysis or Probabilistic Safety Assessment of a reactor with potential flaws in the region of interest. This assessment is to be provided semi-annually with the research progress reports</li> <li>• For the OROI, assessment confirming that the likelihood of the existence of flaws that would lead to crack initiation remains acceptably low. This assessment shall be part of the inspection reports submitted in accordance with Clause 12.2.6 of CSA Standard N285.4-14.</li> </ul> <p><i>Research and Development Program</i></p> <p>The licensee shall implement the research and development program described in [1] subject to the conditions in [2]. Progress reports shall be submitted to CNSC staff on six-month intervals.</p> <p>Modifications to the scope and schedule of the research and development program are subject to review by CNSC staff.</p> <p>References:</p> <p>[1] Bruce Power Letter, M. Burton to A. Viktorov and D. Saumure, "Bruce A and B: Update to the Commission regarding Elevated</p>
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Hydrogen Equivalent Concentrations – Action Item 2022-07-23135”, July 19, 2022, BP-CORR-00531-02909, e-Doc 6844485.

[2] CNSC Letter, M. Hornof to M. Burton, “Bruce NGS A and B: Detailed Plan to Further Evaluate the Effect of Elevated Hydrogen Equivalent Concentration on Pressure Tube Fitness for Service – New Action Item 2023-07-27173”, March 10, 2023, e-Doc 6959554.

**Guidance:**

Guidance Publications			
Org	Document Title	Document #	Version
COG	Fuel Channel Life Management – Third Party Review of Probabilistic Fracture Protection Evaluation Methodology Acceptance Criteria	COG-JP-4491-V197	2017
COG	Theory Manual for the Evaluation Module of Probabilistic Core Assessment Computer Code SCEPTR V1.2e	COG-JP-4452-V119	2015
Bruce Power	Letter, F. Saunders to K. Lafrenière related to fitness-for-service of pressure tubes to support licence renewal application	NK21-CORR-00531-13981/ NK29-CORR-00531-14657 (e-Doc 5412860)	Dec. 8, 2017

**Attributes of an acceptable fracture toughness model**

To support the licensing application of the updated model(s), the licensee should demonstrate that the model can:

1. explicitly account for actual hydride orientation;
2. account for the variation in hydride morphology from pressure tube inlet to outlet;
3. predict hydride fracture, as a function of hydride length and temperature;
4. predict the transition-to-upper shelf temperature;
5. account for hydride length and orientation (using improved fracture path and ligament rupture models);
6. explicitly model the fissures initiating at zirconium-chlorine-carbon precipitates; and
7. make use of the conventional traction-separation rule applied to finite-element cohesive-zone analyses.

**Acceptable demonstration of Leak-Before-Break**

To satisfy LC 15.3, the licensee should perform a Method 2 probabilistic assessment of Leak-Before-Break (PLBB) in accordance with procedures detailed in COG-JP-4452-

**Guidance:**

Not applicable to this LC.

<p>V119-R0. In conducting these assessments, Bruce Power should:</p> <ul style="list-style-type: none"> <li>• Determine the toughness of (hypothetical) pressure tubes using either the Fracture Toughness Model or, pending CNSC acceptance of the Model, using Bruce Power’s contingency plan [1].</li> <li>• Incorporate, where appropriate, mutually-agreed upon improvements to the Method 2 PLBB methodology arising from on-going discussions with CNSC.</li> <li>• Incorporate, where appropriate, any changes to the Method 2 PLBB methodology recommended by industry’s planned “Final Report”, documenting resolution of the Probabilistic Core Assessment (PCA) flaw removal issue [2].</li> </ul> <p>References:</p> <p>[1] Letter, F. Saunders to K. Lafrenière, “Response to CNSC review of supplement to the Application for the Renewal of the Power Reactor Operating Licence: Fitness-for-Service of Pressure Tubes”, NK21-CORR-00531-13981/NK29-CORR-00531-14657, December 8, 2017, e-Doc 5412860.</p> <p>[2] Attachment 1 to Letter, W. S. Woods to N. Riendeau and A. Viktorov, “Darlington and Pickering NGS: Response to CSA N285.8 Compliance Plan Item on the Probabilistic Core Assessment Flaw Removal Issue”, N-CORR-00531-18894, October 27, 2017, e-Doc 5384059.</p> <p><u>Uncertainty Analysis</u></p> <p>To support the licensing application of the Fracture Toughness Model, a quantitative assessment of uncertainties should be conducted. The assessment should utilize the approach in sections A.1, A.2 and A.5 of Appendix A to COG-JP-4491-V197 [1].</p> <p>Reference:</p>	
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[1] COG Report, COG-JP-4491-V197, “Fuel Channel Life Management: Third Party Review of Probabilistic Fracture Protection Evaluation Methodology and Acceptance Criteria”, e-Doc 5230291.

Predicted maximum hydrogen equivalent concentration

The predicted  $[H_{eq}]$  at the inlet and outlet burnish marks at the end of the evaluation period should be determined through a station or unit-specific model. The initial hydrogen concentration should be from off-cut measurements and be channel-specific, the unit-specific bounding value, or the station-specific bounding value. Operating conditions such as temperature and fast flux, where applicable to the model or its components, should be channel-specific, the unit-specific bounding combination, or the station-specific bounding combination. If any inputs are sampled from a distribution, the inputs as well as their percentiles should be justified. For a probabilistic Monte Carlo approach, the upper-bound percentile for the  $[H_{eq}]$  prediction at the end of the evaluation period should be justified. In accordance with Clauses 12.3.4.6 and 12.4.4.6 of CSA N285.4, Bruce Power should report all of the parametric data used in the determination and prediction of the  $[H_{eq}]$  values.