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Written submission from Bruce Power

Mémoire de Bruce Power

In the Matter of the

À l'égard de la

Opportunity to be heard on the orders issued by a Designated Officer to Bruce Power and Ontario Power Generation

Possibilité d'être entendu au sujet des ordres délivrés par un fonctionnaire désigné à Bruce Power et Ontario Power Generation

Commission Public Hearing

Audience publique de la Commission

September 10, 2021

10 septembre 2021

Canada

August 4, 2021

BP-CORR-00531-01908

Mr. M. Leblanc
Secretary
Canadian Nuclear Safety Commission
P.O. Box 1046
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Mr. Leblanc:

Designated Officer Order to Bruce Power – Unplanned Outage Restart Request

The purpose of this letter is to:

1) provide to the Commission, Bruce Power's proposed approach, previously provided in Reference 1, to safely restart Units 4, 5, 7 and 8 from any unplanned outage that results in the cooldown of the heat transport system, consistent with the Designated Officer's order (Reference 2)

2) to request authorization from the Commission, to restart Unit 4, 5, 7, or 8 following any outage that results in the cooldown of the heat transport system, prior to each of their next, respective, planned outages.

While unplanned outages are infrequent and typically short in duration, Bruce Power believes it is important to be pro-active and this can be achieved in a manner that is consistent with the order. Accordingly, Bruce Power seeks authorization from the Commission that the approach, previously provided in Reference 1, meets the requirements of the Order regarding the return to return to service of Units 4, 5, 7 and 8 from an unplanned outage until their next planned inspection. It is important to note that all of these units are already scheduled for upcoming planned outages which include detailed pressure tube inspections to build on the previously obtained wide-range of inspection data (see Attachment B for maintenance outage dates).

In this request, detailed below, Bruce Power demonstrates that Units 4, 5, 7, or 8 can return to service following a forced outage as the pressure tubes meet a standard of certainty related to hydrogen concentrations and verified maintenance and inspection activities confirm, to a high degree of confidence, that no flaws are present within the regions of interest.

In fact, Bruce Power can confirm, with a high degree of confidence based on a large body of inspection results and verified data that in Units 4,5,7 and 8 there continues to consistently be no flaws in the region of the question and high predictability of hydrogen concentration below 120 ppm in >99.5% of the pressure tube. It is for this reason, combined with the predictability of hydrogen concentrations within the working part of the pressure tubes, that Bruce Power believes this unplanned outage proposal clearly meets

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the requirements of the order. In addition to meeting the requirements of the order Bruce Power is also putting additional measures in place to proactively improve margins of safety as detailed in Attachment A.

For clarity, authorization is only being requested for unplanned outages at this time. Bruce Power will, in the near future, separately and distinctly request authorization to restart Unit 3 and other units from planned outages, consistent with the requirements of the order.

Compliance with Licensing Basis

Bruce Power maintains a paramount commitment to safety and reverence for the licensing basis. In Reference 1, Bruce Power provided information regarding the current operation of Units 1, 2, 4, 5, 7 and 8 in light of recent measurements from a surveillance pressure tube removed from Unit 6 and inspection results in Unit 3. This included results from a Technical Operability Evaluation (TOE) of all operating pressure tubes at Bruce A and Bruce B to assess their ability to carry out their safety-related functions.

The TOE concluded the pressure tubes are unconditionally operable and no operating pressure tube has been predicted or measured to be in excess of 120 ppm. As such, the units remain in accordance with the established compliance verification criteria under Licence Condition 15.3. The approach herein is consistent with the outcomes of our TOE and the licensing basis and includes additional measures Bruce Power is taking.

The TOE also confirmed the entire length of all pressure tubes in operating units remain safe to operate based upon the absence of flaws observed in the region of interest and the bounding of measurements by predictions outside of the region of interest. It is important to note that consistent data from inspections of pressure tubes demonstrating no evidence of flaws in the region of interest is a critical safety consideration related to the integrity of the tubes.

The units are safe to operate in any mode such as startup, shutdown and power operation; these changing conditions will not challenge the pressure tube fitness-for-service given the absence of flaws in the region of interest as demonstrated through our inspection program.

Pressure tubes within all operating units on site have been inspected during planned outage inspections. These inspections confirmed the pressure tubes remain fit-for-service and within the licensing basis. This includes measurements of Hydrogen Concentration being well within 120 ppm and inspections for flaws in the pressure tubes. All units were returned to service in accordance with the processes required by Licence Condition 6.1 and Section 6.1 of the Licence Conditions Handbook and supported by fitness-for-service assessments accepted by CNSC staff in accordance with CSA N285.8.

All pressure tube inspections for hydrogen equivalent concentrations in the noted operating units were within 120 ppm and in compliance with the Licence Conditions Handbook, Section 15.3. This is important to note as the discovery condition noted in Units 3 and 6 were both limited to a small number of channels and, in all cases, limited to specific region. This is important to note as the predictability of hydrogen concentrations remains predominately valid as further outlined below.

Pressure Tube Integrity

Hydrogen Concentrations

As the order notes, there is additional data from results in Units 3 and Unit 6 where the hydrogen uptake was higher than predicted. It is important to note this was found in a very small, defined area which is <0.5% of the total pressure tube volume, at the top of the pressure tube near the burnish mark. Results demonstrate the model is accurately predicting in the remainder of the pressure tube and, more importantly, the working part of the pressure tube. In fact, the results from both Units 3 and 6, inclusive of expanded scope in Unit 3 and 'punch samples' in Unit 6, demonstrate the model is fully and accurately predicting in >99.5% of the relevant pressure tube material.

Where the current results from Units 3 and 6 demonstrate the model has not predicted for these specific pressure tubes is limited to the region of interest at the outlet rolled joint at the top of pressure tube. Therefore, as Bruce Power considers the application of hydrogen concentration results to the restart of a unit from an unplanned outage, there is a high degree of confidence in the model's overall prediction and, more importantly, the working part of the pressure tube is conservatively within the 120 ppm outlined in Section 15.3 of the License Condition Handbook. Consistent with the order, the region where it must be demonstrated with a high degree of confidence that no flaws are present is at the top of the pressure tube. Further information is contained in Attachment C.

No Flaws in Region of Interest

Bruce Power has a high degree of confidence there are no flaws in the region of interest based on a large population of measured results. Over the operating life of all pressure tubes, Bruce Power has also performed full length volumetric inspections to detect pressure tube flaws (including inspections of the region of interest). These inspections for flaws use a modern tool setup known as Advanced Non-Destructive Evaluation (ANDE) that carries out extensive imaging of pressure tubes. They also include a significant database of historical Channel Inspection and Gauging Apparatus for Reactors (CIGAR) inspections. The results of the ANDE and CIGAR inspections have demonstrated, and continue to demonstrate, in concert with data from a large population of pressure tubes, that there is no evidence of flaws in the region of interest.

In isolation, elevated levels of equivalent hydrogen concentration do not challenge pressure tube fitness for service. For fitness for service to be challenged, a pressure tube would also need a flaw of significant dimensions introduced to an area with adequate hydrogen concentration and be exposed to high pressure and low temperature.

The area of greatest probability for flaws to occur is the lower hemisphere of the tube because this is the region where fuel bundles are in contact with the pressure tube. When fuel bundles are in a pressure tube during operation, and added or removed during fueling, the bundle pads come in contact predominantly with the bottom of the tube and not the top. Therefore, as evidence has demonstrated, flaws have not developed within the region of interest. This is the same reason that at the top of the pressure tubes there is a high degree of confidence that no flaws exist within the region of interest as the pressure tube contact with fuel is negligible due to gravity. This has been demonstrated historically and confirmed through both a large population of historical inspections and more recently in all operating units through the inspection program.

Bruce Power has performed ~728 pressure tube inspections (including the region of interest) for the life of Bruce Units 3, 4, 5, 6, 7 & 8. This is a very large population of channels and to place this into context would be the equivalent of more than a full unit of tubes on the Bruce Power site. No flaws have ever been detected in the region of interest and there have been no dispositionable flaws detected for all axial and circumferential positions in this portion of the pressure tubes This was also the subject of recent outages for all operating Units 4, 5, 7 and 8 and no flaws were present in the region of interest.

Laboratory Testing Results

It is also important to clarify the issue of 'burst tests' on pressure tubes as part of laboratory testing and what is required for a fracture. When pressure tubes are 'burst tested' as part of industry surveillance activities it is important to note that with Hydrogen concentration increased alone, the pressure tubes do not fracture. The pressure tube does not fracture because no flaw exists.

In order to support testing in a laboratory environment a significant artificial flaw is added to the tube to enable the fracture toughness test to be completed. This confirms that the presence of flaws is a prerequisite for challenges to pressure tube fitness for service.

High Degree of Evidence of Pressure Tube Integrity

Bruce Power can confirm with a high degree of confidence, based on consistency in a large body of inspection results and measured, verified data, that in Units 4, 5, 7 and 8 there continues to be a lack of flaws in the region of interest. It is for this reason, combined with the predictability of hydrogen concentrations within the working part of the pressure tubes that Bruce Power believes this unplanned outage proposal clearly meets the requirements of the order and demonstrates with a high degree of confidence that no flaws are present in the region of pressure tubes where the models failed to predict the elevated [Heq] (supporting information is contained in Attachment D).

Safety Margin Enhancements

Following the submission of Reference 1, which focused on sustained reactor operation under hot conditions, Bruce Power examined beyond steady-state operation to determine what mitigating actions could be taken if there is a desire or need to cool down a unit or if a unit is removed from service in an unplanned manner before its planned maintenance outage to build additional safety margin.

A shutdown and return-to-service strategy has been developed to provide additional assurances that Units 4, 5, 7 and 8 can continue to operate safely in compliance with the licensing basis until their planned maintenance outages. This strategy was submitted to CNSC staff in Reference 1.

Additional measures are being taken to improve safety margin should a unit be removed from service prior to its planned outage date.

Specifically, Bruce Power is making plant configuration and design enhancements, procedural changes and refinement to its operator training. Pursuant to Licence Condition G.2, a summary and rationale for the proposed changes to the shutdown and return-to-service of Units 4, 5, 7 and 8 is provided in Attachment A.

This approach improves margins of safety by applying several proactive and post shutdown measures that systematically prevent reactor states to further reduce risk and provide assurance of safety before returning a unit to service.

The proposed return-to-service approach would remain in place on lead-up to the planned outages. Upcoming planned outages have been included in Attachment B.

Planned Outages

While this request is focused on unplanned outages, it is important to note that, Bruce Power has planned maintenance and inspection outages scheduled for Units 4, 5, 7 and 8 over the course of the next 18-months and will be carrying-out routine and enhanced pressure tube inspection activities as part of the scope for these outages. Unit 3 is in a planned outage and has conducted these routine and enhanced inspections.

This data will be used in both Bruce Power's Unit 3 and other planned outages return-to-service case (which will be communicated in a separate submission) and, given the orientation and location of the expanded pressure tube population will be applied to broader considerations in demonstrating pressure tube hydrogen uptake behavior.

An important element to note is the current Unit 3 expanded inspection scope, inclusive of hydrogen scrapes and additional ANDE confirming a high degree of confidence of no flaws, represents one of the most expansive campaigns ever carried-out on a CANDU reactor. The additional activities being undertaken on Unit 3, in particular on channels with a similar configuration to the operating Units, do demonstrate that Hydrogen Concentrations are conservatively predicting below 120 ppm in 99.5% of the channel and the working part of the tube and that a lack of flaws exist within the region of interest.

Summary

The proposed approach in Attachment A is consistent with the licensing basis and continues to ensure high levels of safety for the health, safety or security of Canadians and the environment. Units 4, 5, 7 and 8 remain capable of carrying out their safety-related functions combined with the integrity of key plant components. More importantly, the proposed approach to an unplanned outage is consistent with the requirement outlined in the order and there is significant evidence of these units being able to clearly and conservatively meet that test.

Bruce Power will continue to share operating experience with industry peers regarding: pressure tube hydrogen uptake; other inspection results which have demonstrated strong integrity and the absence of flaws; inspection findings; mitigation strategies; procedures; training materials; design changes. Collectively, this will ensure on-going industry learning and safety improvements.

Bruce Power can confirm, with a high degree of confidence based on a large body of inspection results and verified data that in Units 4,5,7 and 8 there continues to consistently be no flaws in the region of the question and high predictability of hydrogen concentration below 120 ppm in >99.5% of the pressure tube. It is for this reason, combined with the predictability of hydrogen concentrations within the working part of the pressure tubes, that Bruce Power believes this unplanned outage proposal clearly meets the requirements of the order. As a result, Bruce Power requests authorization from the Commission to restart Unit 4, 5, 7, or 8 following any outage that results in the cooldown of the heat transport system, prior to each of their next, respective, planned outages.

Note Bruce Power will request an opportunity to provide the Commission with an oral presentation, in response to Reference 3, under separate cover.

If you require further information or have any questions regarding this submission, please contact Mr. Maury Burton, Chief Regulatory Officer, Corporate Affairs & Operational Services, at (519) 361-2673 extension 15291, or maury.burton@brucepower.com.

Yours truly,

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cc: CNSC Bruce Site Office
L. Sigouin, CNSC - Ottawa
A. Viktorov, CNSC - Ottawa
R. Jammal, CNSC - Ottawa

Attach. Note: Attachment B contains CONFIDENTIAL information and has not been included in this document.

References:

1. Letter, M. Burton to L. Sigouin, “Action Item 2021-07-23406: Bruce A and B: Pressure Tube Surveillance Hydrogen Equivalent Concentration Measurements”, July 25, 2021, BP-CORR-00531-01883.
2. Letter, R. Jammal to M. Burton, “Designated Officer Order Issued to Bruce Power”, July 26, 2021, e-Doc 6612485. BP-CORR-00531-01904.
3. Letter, M. Leblanc to M. Burton, “Opportunity to be Heard on Designated Officer Order”, July 28, 2021, e-Doc 6614735, BP-PROC-01913.

Attachment A

Shutdown and Return-to-Service of Units 4, 5, 7 and 8

Attachment A: Shutdown and Return-to-Service of Units 4, 5, 7 and 8

This attachment outlines the approach that Bruce Power intends to follow should there be a desire or need to cool down a unit in advance of its planned maintenance outage. This strategy applies to Forced Outages where the Unit is required to cool down. For any Forced Outage where the Reactor remains at Zero Power Hot (ZPH), the current approach remains valid and applicable. This strategy applies to Forced Outages in Units 4, 5, 7, and 8. Units 1 & 2 have recently been refurbished.

As described in the Technical Operability Evaluation, provided as Enclosure 1 to Reference A1, there is low risk of pressure tube rupture under cold overpressure transient (COPT) conditions, as there would need to be a through-wall flaw in a pressure tube which remained undetected by the persistent monitoring of the Annulus Gas system. Notwithstanding the low risk, cold overpressure transients, form a design basis challenge to pressure tube integrity which is appropriate to evaluate as Bruce Power has done through its process given additional information.

A cold over pressure transient (COPT) is when there is a loss of HT pressure control causing the HTS to pressurize at a cold PHT temperature. For example, a failure of pressure controllers in solid mode with the heat transport system full and cold could cause a COPT. While these are low probability as part of Bruce Power's rigorous process to continue to secure safety margin this was reviewed.

Reactor states which present an opportunity for a COPT to occur include any time that:

1. the unit is in a high level drained state and Unit-33320-RV16 not in place.
2. the unit is full, cold (<~140C) and Unit-33320-RV16 is not in place.
3. the unit is not in normal mode when the pressurizer remains connected providing a steam cushion.

Bruce Power has developed a strategy to mitigate the risk of this (rare/unlikely) event through the implementation of a proposed strategy that encompasses several proactive and post shutdown measures.

Proactive measures underway to build safety margin include:

1. Outage Planning and execution improvements
2. Revision of the Pressure/Temperature profile for heat-ups and cooldown
3. Permanent design changes and an enhancement to mitigate the magnitude and frequency of the COPT
4. Future inspections

The post shutdown measures are to review and evaluate the outage specific cooldown profile and confirmation if the Unit experienced an unplanned transient and in particular a Cold Over Pressure Transient.

Proactive Measures Underway:

1. **Outage Planning and execution improvements to lower risk of COPT**
   These activities are intended to minimize the time at risk or completely mitigate COPT likelihood during outages. Some activities that Bruce is considering have been broken down into three main categories. The first category is the Heat Transport System operating states (e.g. maximizing time with boilers open and reducing the time at risk by cooling down and heating up the PHT with the Feed and Bleed system in Normal Mode). The second is limiting time at risk configurations (e.g. reviewing lead out SSTs to reduce exposure time to COPTs). Finally,

ensuring the Operational documentation is updated and the crew receives additional training to decrease the response time for operator intervention should the pressure increase.

2. **Revise the Pressure/Temperature profile for heatups and cooldowns**
Bruce Power is evaluating the feasibility of adjusting the Temperature and Pressure profile for heatups and cooldowns to provide additional margin for fracture protection. The changes will be performed in accordance with the Engineering Change Control Process (ECC) at both Bruce A and Bruce B. The target completion is approximately two months.

3. **Design Changes in relation to COPT**
Bruce Power is evaluating two actions to recover available margin in the fracture protection assessments. These changes are to be completed through the Engineering Change Control Process (ECC) to ensure the appropriate level of rigor is applied with respect to the change and to confirm its applicability.

   The first action being investigated is a DCC software update which will provide automatic Heat Transport Feed Pump trip by the DCC on rapid increase of Heat Transport pressure. This update is currently underway and the target completion is approximately two months in order to complete the ECC process.

   The second action is a design change to install an alternate conditioned Liquid Relief Valve (LRV) setpoint to enhance overpressure protection to mitigate the consequence of a COPT. The design is in progress with a target completion of no later than Q1 2022 as this change will require system registration with the TSSA for all affected Units.

   Given that the cold over pressure transient is an already rare event, Bruce Power is taking these actions to further reduce the risk of a COPT.

4. **Future Inspections**
To further understand the pressure tube hydrogen uptake behavior, Bruce Power has undertaken modifications to the circumferential wet scrape tool (CWEST) to facilitate the acquisition of scrape measurements closer to the burnish mark region and at some other positions around the pressure tube circumference (e.g. 12 o'clock and 7-9 o'clock positions). The modified tool is to be used during forthcoming outages starting with the Unit 3 planned outage which is currently underway. The next outage is scheduled in the fall of 2021 in unit 7. Bruce Power is currently evaluating the quantity of CWEST inspections in the next planned outage in Unit 7.

Post Shutdown Measures:

Review and Evaluate the outage specific cooldown Profile
Bruce Power has comprehensive operating manual procedures that apply operating pressure tube constraints for cooldown and heatup transients. These procedures are intended to maintain the Primary Heat Transport System (PHTS) within temperature, pressure, and duration profiles during the transient. The profiles minimize the risk of crack initiation from service-induced flaws in pressure tubes.

In general, the pressure tube operating procedures during heat-up and cool-down transients are developed to achieve the following objectives.

1. Heat-up and cool-down cycles in compliance with the operating procedures can minimize the risk of crack initiation from flaws in the pressure tubes due to Delayed Hydride Cracking (DHC), overload or fatigue.

2. Heat-up and cool-down cycles in compliance with the operating procedures will result in precipitating bulk hydrides which are less deleterious to fracture toughness.

The pressure, temperature, and duration steps in the operating procedures are generally governed by the operating envelope that is based on fracture protection, consideration of the pressure tubes using the fracture toughness versus temperature curve, or the flaw stability lines, in accordance with the CSA Standard N285.8. The time durations at various temperature ranges are generally established based on the consideration of DHC initiation avoidance.

Following any unit transient, the exact PHTS conditions during the transient are reviewed to assess whether the assumed operating conditions used in the assessments of pressure tube flaws remain bounding and therefore the acceptability of further operation. Bruce Power will specifically confirm and document that the preventative measures have been effective at avoiding a cold over pressure transient should a unit be removed from service requiring transition to a cold / depressurized state.

Attachment B

Current Planned Outage Schedule for Units 4, 5, 7 and 8

Attachment C

Hydrogen Concentrations

Attachment C – Hydrogen Concentrations

The deterministic generic hydrogen equivalent [Heq] predictions are based on bounding operating conditions in each Bruce Power Unit. The upper bound (97.5% percentile) of the corresponding body of tube model is used for waterside corrosion contribution coupled with the upper bound of the corresponding Rolled Joint (RJ) model. The existing deuterium pickup model continues to provide bounding predictions for the “working portion of all Bruce Power pressure tubes” which includes the lower hemisphere of the pressure tube that support the fuel bundles and could be subject to the introduction of flaw in the pressure tubes due to debris or fuel bundle bearing pad fretting.

There is a region of interest at the outlet end in a subset of pressure tubes that has had the recent discovery of [Heq] measurements above 120ppm. The current theory is that diffusion of hydrogen isotopes to this region is driven by a temperature gradient from the top to the bottom of the pressure tube; this is being investigated further via finite element modeling. In order for there to be a fitness-for-service concern, an in-service flaw combined with higher hydrogen isotope and a reactor pressure transient condition would need to all combine to challenge pressure tube integrity. On the observed subset of pressure tubes from Unit 3 and the surveillance tube from Unit 6, the volume of the region of interest is approximately <0.5 % of the total pressure tube volume.

Bruce Power has initiated a number of corrective actions in response to the newly observed hydrogen uptake behaviour. Bruce Power expects, by the end of the year, to:

1) Use the measurement results from the current Unit 3 outage (A2131) and the Unit 6 surveillance pressure tube to evaluate and determine the hydrogen equivalent concentrations appropriate to evaluate fracture protection (FP) and probabilistic core assessments (PCA);
2) Complete fracture toughness burst tests at 160 ppm hydrogen concentration. Confirm results are within acceptable range to confirm model behaviour;
3) Complete fracture protection (FP) assessment for the bounding units to confirm results are within acceptance criteria, and
4) Complete probabilistic core assessment (PCA) for the bounding unit and confirm results are within acceptance criteria.

With this in mind, in the coming months Bruce Power, in partnership with industry, will pursue additional activities further detailed in Reference C1.

<u>Reference:</u>

1. Letter, M. Burton to M. Leblanc and A. Viktorov, “Bruce A and B: Response to Subsection 12(2) of the General Nuclear Safety and Control Regulations: Measurement of Hydrogen Equivalent Concentration in Pressure Tubes”, July 30, 2021, BP-CORR-00531-01884.

Attachment D

Flaw Inspections

Attachment D – Flaw Inspections

Bruce Power has performed ~728 pressure tube inspections (the region of interest) for the life of Bruce Units 4, 5, 6, 7 and 8. This is a very large population of channels and, to place this into context, would be the equivalent of a full unit of tubes on the Bruce Power Site. No flaws have ever been detected in the region of interest and there have been no dispositionable flaws detected for all axial and circumferential positions in this portion of the pressure tubes.

The following information demonstrates 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] in Units 3, 4, 5, 7 and 8 (See Figure D1).

This satisfies the condition of the Order that a sufficient number of inspections have demonstrated that there are no flaws in the region of interest.

Table D1: Detected Flaws in B3-8

Unit	Number of Unique Channels Inspected Full Length	Total Full Length Channel Inspections (including revisits)	Total Number of Flaws within the first 100mm from the OBM Reportable (Dispositionable)	Total Number of Flaws within the first 100mm from the OBM in the Upper Region
3	78	126	1 (0)	0
4	82	119	0 (0)	0
5	77	129	4 (0)	0
6	62	103	0 (0)	0
7	70	114	1 (0)	0
8	79	137	0 (0)	0

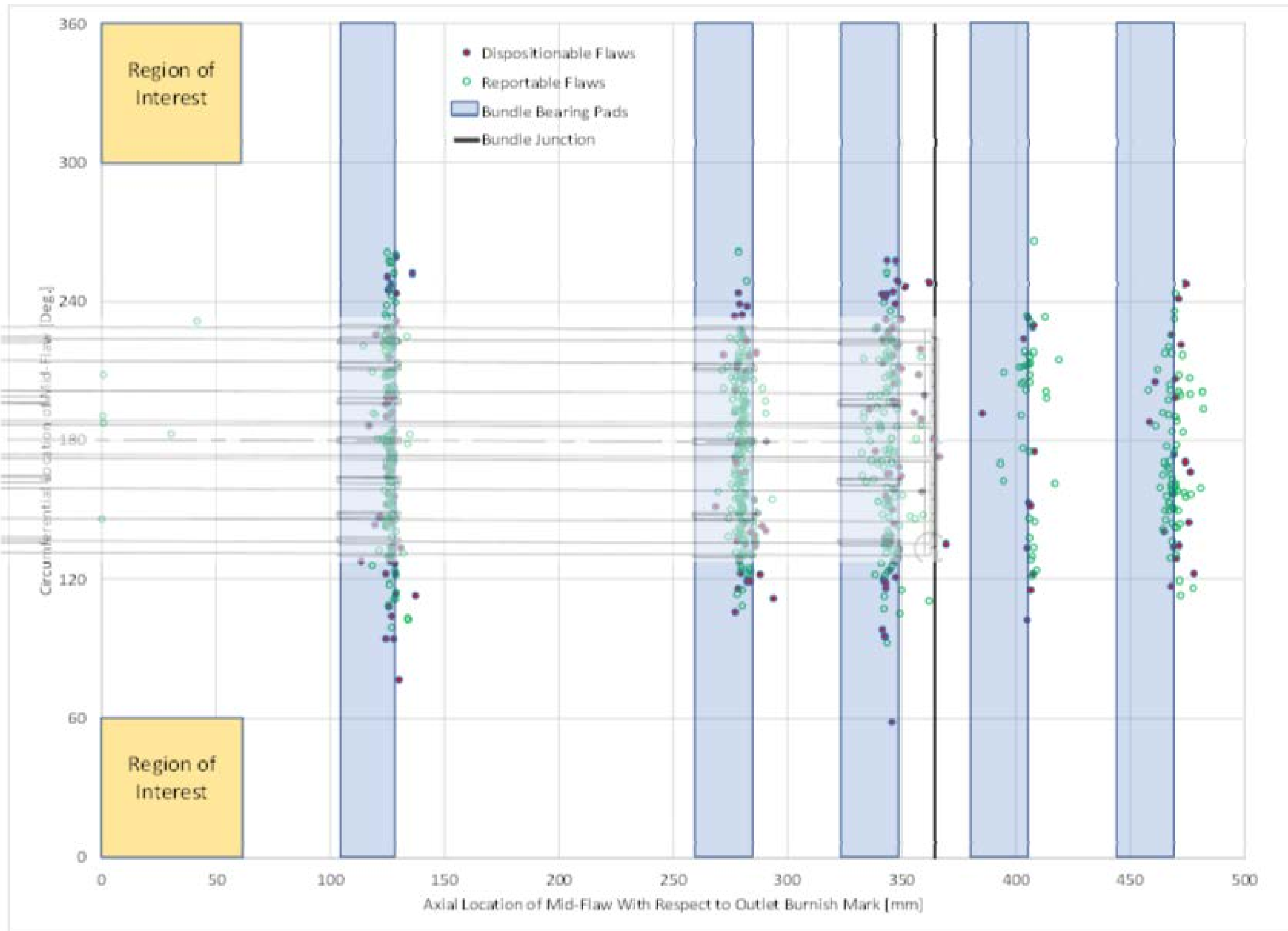
Notes:

1. This table does not account for the A2131 volumetric inspection.
2. This table accounts for all unique reportable and dispositionable flaws in B3-B8 for flaw types that have the potential for crack initiation. These include debris flaws, bearing pad flaws, crevice corrosion, PT/CT contact, erosion, linear indications, mechanical damage & manufacturing flaws, and exclude deposits, corrosion, roughness & proud indications, fueling scratches, OD scratches & scrapes.

The Advanced Non-Destructive Examination (ANDE) system has been designed and field implemented as a high speed data acquisition system to meet the requirements of the CSA N285.4. It was built from the solid foundation of CIGAR experience and uses cutting edge hardware and software to attain high speed data collection enabling relatively quick inspection of a large number of fuel channels. The capabilities of the ANDE inspection system include: surface and volumetric inspection of pressure tube by ultrasonics; flaw characterization by ultrasonics; pressure tube diameter measurements; pressure tube thickness measurements; garter spring location by eddy current; garter spring location by ultrasonics; and pressure tube sag measurement.

In addition to the above, selected flaws/areas of a pressure tube can be replicated using a two plate ANDE replica tool. At the heart of the inspection system is a set of twelve ultrasonic probes positioned in such a way that the inspected areas are examined from various angles and directions and by various ultrasonic wave modes (shear and longitudinal). High frequency ultrasound used for the examinations allows for reliable detection of small flaws. Separate sensors have been installed on the inspection head for Garter Spring location and sag measurements.

Figure D1: Detected Flaws in Units 3-8 in the first 500mm outlet portion of the PT



Notes:

1. This figure includes all unique reportable and dispositionable flaws in B3-B8 for flaw types that have the potential for crack initiation. These include debris flaws, bearing pad flaws, crevice corrosion, PT/CT contact, erosion, linear indications, mechanical damage & manufacturing flaws, and exclude deposits, corrosion, roughness & proud indications, fueling scratches, OD scratches & scrapes.
2. This figure does not account for the A2131 volumetric inspection The 4 flaws almost coincident with the burnish mark (at 0mm) actually straddle the burnish mark and extend inboard by no more than 2.1mm. Such flaws carry a significantly reduced risk of crack initiation due to the net compressive stress that exists outboard of the burnish mark.
3. ‘Mid-flaw’ is the middle point of the flaw in terms of axial and circumferential location.

Bruce Power
Innovation at work

August 5, 2021

BP-CORR-00531-01920

Mr. M. Leblanc
Commission Secretary
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Dear Mr. Leblanc:

Bruce A and B: Designated Officer Order to Bruce Power – Opportunity to be Heard

The purpose of this letter is to respond to Reference 1 and request an opportunity to be heard by the Commission with respect to the order which Commission authorization be obtained, prior to the return to service of Units 3, 4, 5, 7, or 8, following any outage that results in the cooldown of the heat transport system.

Further to the information provided in References 2 through 8, Bruce Power would welcome an opportunity to be heard by making a supplementary oral representation before the Commission at the earliest opportunity. The opportunity would also allow Bruce Power to answer Commission members' questions, should any be raised.

Bruce Power notes that it may also be appropriate to discuss the recently submitted limited request for authorization (Reference 9), related to the return to service of Units 4, 5, 7, or 8, following any outage that results in the cooldown of the heat transport system, prior to each of their next, respective, planned outages.

Prior to, and in anticipation of, the opportunity to be heard, Bruce Power also plans to submit a request for authorization from the Commission related to the process for the return to service of Unit 3. While this submission will follow shorty under separate cover, Bruce Power notes that it may also be appropriate to discuss this forthcoming submission as part of the appearance before Commission members.

If you require further information or have any questions regarding this submission, please contact Mr. Maury Burton, Chief Regulatory Officer, Corporate Affairs and Operational Services, at (519) 361-2673 extension 15291, or maury.burton@brucepower.com.

Yours truly,

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cc: CNSC Bruce Site Office
L. Sigouin, CNSC - Ottawa

References:

1. Letter, M. Leblanc to M. Burton, “Opportunity to be Heard on Designated Officer Order”, July 28, 2021, e-Doc 6614735, BP-CORR-00531-01913.
2. REGDOC-3.1.1 Unscheduled Report, “A2131 Outage Scrape Campaign Hydrogen Equivalent Concentration Measurements”, June 29, 2021, B-2021-93819 DR.
3. REGDOC-3.1.1 Unscheduled Report, “Pressure Tube Surveillance Hydrogen Equivalent Concentration Measurements on Unit Shutdown for Major Component Replacement”, July 5, 2021, B-2021-98077 DR.
4. Letter, M. Burton to L. Sigouin, “Action Item 2021-07-23406: CNSC Review REGDOC-3.1.1 Event Report B-2021-98077 DR”, July 15, 2021, BP-CORR-00531-01853.
5. Letter, M. Burton to L. Sigouin, “Action Item 2021-07-23424: CNSC Review of REGDOC-3.1.1 Event Report B-2021-93819”, July 16, 2021, BP-CORR-00531-01863.
6. Letter, M. Burton to M. Leblanc and A. Viktorov, “Bruce A and B: Response to Subsection 12(2) of the General Nuclear Safety and Control Regulations: Measurement of Hydrogen Equivalent Concentration in Pressure Tubes”, July 19, 2021, BP-CORR-00531-01875.
7. Letter, M. Burton to L. Sigouin, “Action Item 2021-07-23406: Bruce A and B: Pressure Tube Surveillance Hydrogen Equivalent Concentration Measurements”, July 25, 2021, BP-CORR-00531-01883.
8. Letter, M. Burton to M. Leblanc and A. Viktorov, “Bruce A and B: Response to Subsection 12(2) of the General Nuclear Safety and Control Regulations: Measurement of Hydrogen Equivalent Concentration in Pressure Tubes”, July 30, 2021, BP-CORR-00531-01884.
9. Letter, M. Burton to M. Leblanc, “Designated Officer Order to Bruce Power – Unplanned Outage Restart Request”, August 4, 2021, BP-CORR-00531-01908.

August 13, 2021

BP-CORR-00531-01935

Mr. M. Leblanc
Secretary
Canadian Nuclear Safety Commission
P.O. Box 1046
280 Slater Street
Ottawa, Ontario
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Dear Mr. Leblanc:

Designated Officer Order to Bruce Power - Unit 3 Planned Outage Restart Authorization

The purpose of this letter is to request authorization from the Commission to restart Unit 3, upon completion of its planned outage in early October, based upon fulfillment of the requirements of the Order issued in Reference 1, and consistent with the criteria and clarification provided by CNSC staff in Reference 2.

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.

Unit 3 Planned Outage

Unit 3 entered a planned outage in March 2021. The scope of the outage was to conduct the Extended West Shift Plus program, Asset Management activities, preparatory work for the Major Component Replacement (MCR), and reactor inspections including Spacer Location and Repositioning (SLAR), Advanced Non-Destructive Examination (ANDE) and Circumferential Wet Scrape Tool (CWEST) activities.

The pressure tubes selected for inspection by ANDE, CWEST and SLAR are determined using conservative criteria that ensure the pressure tubes selected for inspections are representative and bounding of unit conditions. The ANDE tool examines the pressure tube for flaws, CWEST obtains samples for hydrogen concentration evaluation, and SLAR assesses the space between the pressure tube and calandria tube, and can make adjustments where necessary.

Upon discovery of elevated hydrogen concentration levels, in a localized area, at the top of certain Unit 3 pressure tubes, Bruce Power further expanded the inspection scope to examine a larger population of pressure tubes. The additional scope was to examine hydrogen isotope concentration and verify there is no evidence of flaws within the region of interest of the pressure tubes near the outlet end burnish mark.

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Through this extensive campaign and the large body of evidence collected, Bruce Power has demonstrated, with high confidence, both:

(i) the conservative prediction of hydrogen concentration outside the region of interest; and,

(ii) there is no inspection evidence of flaws within the region of interest where elevated concentrations of hydrogen isotopes have been observed.

This expanded scope represents one of the most significant CWEST campaigns completed on a CANDU Unit. This campaign included a sample of both Back End Outlet (there are 240 in Unit 3) and Front End Outlet (there are 240 in Unit 3) pressure tubes within Unit 3 (i.e. there is a total of 480 pressure tube outlets within Unit 3).

With these expanded inspections underway, in parallel with the remaining outage scope, the Unit 3 outage is expected to be completed and in a position to return to service in early October 2021. For clarity, the additional scope, currently underway, is not needed to meet the requirements of the Order but is confirmatory and, as noted, will have broader benefits. The completion of this planned outage will allow Bruce Power to move into the Unit 7 planned outage, which also includes pressure tube inspections, scheduled to commence in November.

Once Unit 3 is returned to service it will have a short final operating interval as its planned Major Component Replacement (MCR) is set to commence in the first quarter of 2023. Notably, Unit 3 must also be removed from service for a month, in the second quarter of 2022, in support of the Bruce A Vacuum Building and Station Containment outage (VBO/SCO). Bruce Power is seeking Commission authorization to restart Unit 3 from the current Unit 3 outage, and future planned and unplanned outages, consistent with the requirements of the Order related to pressure tube integrity, and consistent with the criteria and clarifications provided by CNSC staff in Reference 2.

Unit 3 Pressure Tube Integrity

In isolation, elevated levels of equivalent hydrogen concentration do not challenge pressure tube fitness for service. For fitness for service to be challenged, a pressure tube would also need a flaw of significant dimensions introduced to an area with adequate hydrogen concentration and be exposed to high pressure and low temperature.

Measured Hydrogen Concentrations

Within the current Unit 3 outage, results have consistently confirmed that, in the few cases where elevated hydrogen equivalent concentrations were beyond predicted levels, they are limited to a defined area which comprises <0.5% of the total pressure tube volume, at the top of the pressure tube near the outlet burnish mark. In fact, Bruce Power has found that only a small number of the tubes sampled reflect elevated hydrogen equivalent concentrations within this region of interest.

Note that Bruce Power has greater specificity with respect to the extent of the region interest in comparison to that of CNSC staff as described in Reference 2. Of inherent relevance to the Order is the importance of both the ability to accurately predict hydrogen equivalent concentration and the presence of flaws. Whereas CNSC staff have conservatively defined the region of interest to be the first 75 mm, inboard of the outlet burnish mark, over the full circumference of the pressure tube, Bruce Power's extensive inspections have demonstrated the model is accurately predicting hydrogen equivalent concentrations in all areas of the pressure tube, save for the limited region at the top, near the outlet burnish mark. In fact, the results from Unit 3 confirm the model is fully and accurately predicting in >99.5% of the pressure tube.

Results indicate the lower portion of the tube can be excluded from the region of interest and Bruce Power will share additional information with CNSC on this matter. However, this is a not a consideration that would impact compliance with the Order in the case of Unit 3 but is a broader consideration and the region of interest is very specific. Bruce Power will seek to reconcile the definition of the region of interest with CNSC staff in the short term, under separate cover.

No Flaws are Present in the Region of Interest

As supported by full length volumetric inspections used to detect pressure tube flaws using ANDE, and Channel Inspection and Gauging Apparatus for Reactors (CIGAR) inspections, Bruce Power has a high degree of confidence that there are no flaws in the region of interest within Unit 3, or any other Bruce Power unit.

For clarity, this applies to both Bruce Power's specific definition of region of interest outlined, and the broader definition put forward by CNSC staff in Reference 2.

In fact, 448 unique pressure tube inspections (or 728 total inspections including revisits) have been carried out prior to the current outage in Units 3, 4, 5, 6, 7, and 8. In 100% of the inspections, the total number of flaws within the first 100mm from the outlet burnish mark, in the upper region, has been zero. To put this in perspective, this would be essentially enough pressure tubes to reflect a full reactor (i.e. 480 pressure tubes) and is a large body of results within the Bruce Power fleet.

The area of greatest probability for flaws to occur is the lower hemisphere of the tube because this is the region where fuel bundles are in contact with the pressure tube. When fuel bundles are in a pressure tube during operation, and added or removed during fueling, the bundle pads come in contact with the bottom of the tube and not the top. Therefore, as evidence has demonstrated, flaws have not developed at the top of pressure tubes, within the region of interest.

This is the same reason that, at the top of the pressure tubes where hydrogen concentrations are elevated, there is a high degree of confidence that no flaws exist within the region of interest as the pressure tube contact with fuel is negligible. This has been demonstrated historically and confirmed through both a large population of historical inspections and, more recently, in all operating units through the inspection program.

Attachment A provides a summary of the inspection data confirmed up to the A2131 outage in all Units and supports the requirements of the Order. Inspection results from the current unit 3 outage (A2131) continue to support this assertion.

Defense in Depth

As noted in Bruce Power's unplanned outage request for Commission Approval (Reference 3), measures are being put in place in all Bruce Power units to further enhance safety margins. While this is not specific to compliance with the Order, in the case of an unplanned outage, or for this Unit 3 request, Bruce Power continues to focus on Safety First and Defense in Depth.

Summary

Consistent with the requirements of the Order, Bruce Power requests Commission authorization for the return to service of Unit 3, following the completion of its planned maintenance outage and in consideration of the criteria provided by CNSC staff in Reference 2. Bruce Power will further confirm the operational readiness of the pressure tubes to satisfy regulatory requirements, prior to Unit 3's return to service, through the established fitness for service assessments required in accordance with the licensing basis as described in Attachment B. This is consistent with the requirements of the Order; wherein, the Commission may provide authorization based upon either, hydrogen equivalent concentrations, or a high degree of confidence that no flaws are present within the region of interest.

Bruce Power has confirmed, through one of the most extensive inspection campaigns carried-out on a CANDU Unit, with a high degree of confidence and based on a large body of inspection results and verified data, that there continues to consistently be no flaws present in the region of interest and high predictability of hydrogen concentration in >99.5% of the pressure tube.

For this reason, combined with the predictability of hydrogen equivalent concentrations within the lower part of the pressure tubes, Bruce Power has concluded the return to service of Unit 3 may be authorized by the Commission, and requests that the Commission acknowledge that the requirements of the Order do not apply to future outages, beyond the return to service of Unit 3 from its current planned outage.

Therefore, given the Unit 3 outage is scheduled to be completed in early October, Bruce Power respectfully requests the Commission consider this request in a timely manner. Bruce Power believes this return to service request meets the requirements of the Order as outlined. In support, Bruce Power has requested an opportunity to present to the Commission in Reference 4 and is willing to provide any background to CNSC staff, or to brief the recently established External Advisory Committee, to achieve timely resolution of any outstanding questions, including any related to the satisfaction of the criteria used to confirm the operational readiness of pressure tubes.

If you require further information or have any questions regarding this submission, please contact Mr. Maury Burton, Chief Regulatory Officer, Corporate Affairs and Operational Services, at (519) 361-2673 extension 15291, or maury.burton@brucepower.com.

Yours truly,

Lisa Clarke
Digitally signed by Lisa Clarke
Date: 2021.08.13 13:11:33 -04'00'

Maury Burton
Chief Regulatory Officer
Bruce Power

cc: Mr. Luc Sigouin, CNSC Ottawa
CNSC Bruce Site Office

Attach.

References:

1. Letter, R. Jammal to M. Burton, “Designated Officer Order issued to Bruce Power”, July 26, 2021, e-Doc 6612485, BP-CORR-00531-01904.
2. Letter, A. Viktorov to M. Burton, “Bruce A and B: CNSC Staff Assessment Criteria for Restart Requirements”, August 12, 2021, e-Doc 6621711, BP-CORR-00531-01946.
3. Letter, M. Burton to M. Leblanc, “Designated Officer Order to Bruce Power – Unplanned Outage Restart Request”, August 4, 2021, BP-CORR-00531-01908.
4. Letter, M. Burton to M. Leblanc, Bruce A and B: Designated Officer Order to Bruce Power – Opportunity to be Heard”, August 5, 2021, BP-CORR-00531-01920.

Attachment A

Flaw Inspections

Attachment A:
Flaw Inspections

Bruce Power has performed ~728 pressure tube inspections (including the region of interest) for the life of Bruce Units 3, 4, 5, 6, 7 and 8. This is a significant population of pressure tubes. No flaws have ever been detected in the region of interest and there have been no dispositionable flaws detected for all axial and circumferential positions in the broader region of interest defined by CNSC in Reference A1..

The following information demonstrates with a high degree of confidence that no flaws are present in the region of interest Units 3, 4, 5, 7 and 8 (See Figure A1).

This satisfies the condition of the Order that a sufficient number of inspections have demonstrated that there are no flaws in the region of interest, and the requirements of CNSC staff provided in Reference A1.

Table A1: Detected Flaws in Units 3, 4, 5, 6, 7, and 8

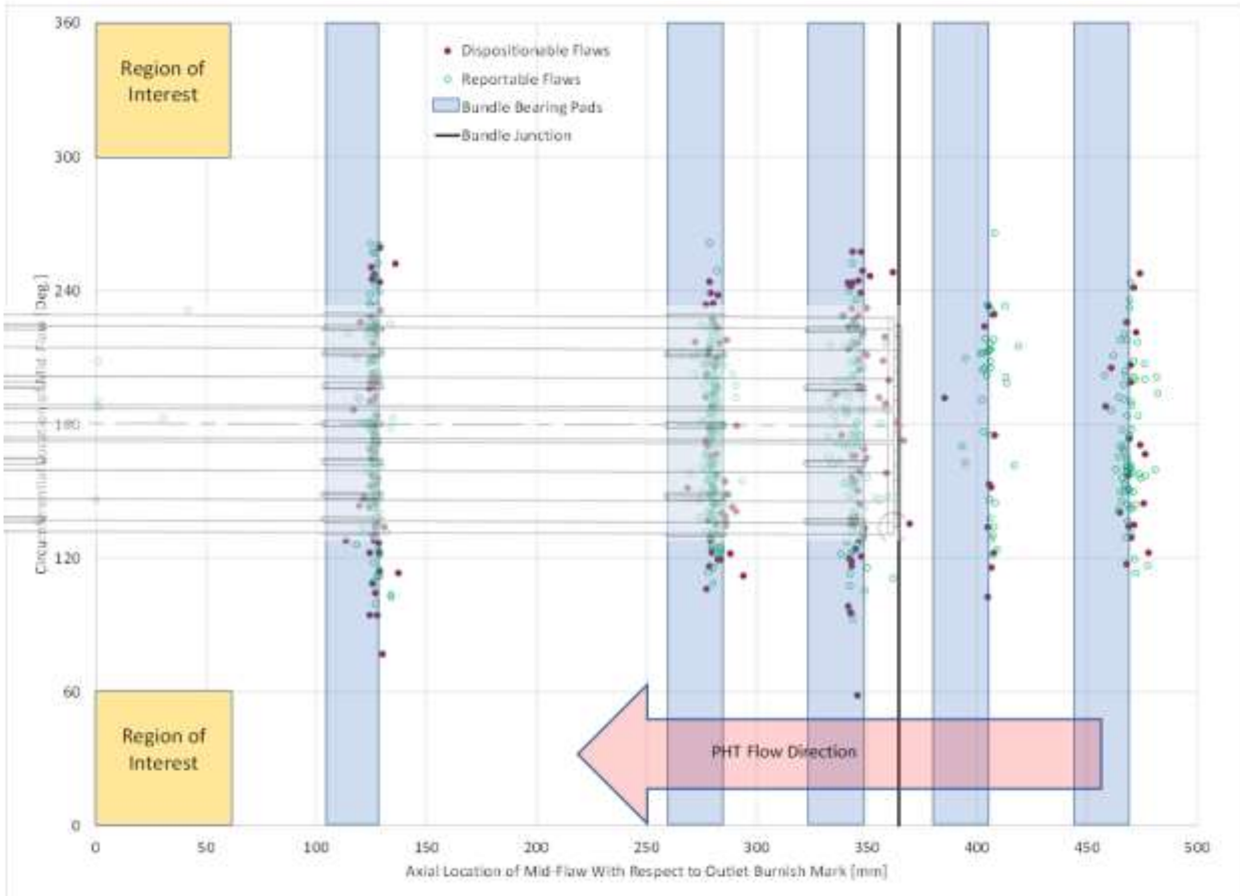
Unit	Number of Unique Channels Inspected Full Length	Total Full Length Channel Inspections (including revisits)	Total Number of Flaws within the first 100mm from the OBM Reportable (Dispositionable)	Total Number of Flaws within the first 100mm from the OBM in the Upper Region
3	78	126	1 (0)	0
4	82	119	0 (0)	0
5	77	129	4 (0)	0
6	62	103	0 (0)	0
7	70	114	1 (0)	0
8	79	137	0 (0)	0

Notes:

1. This table does not account for the A2131 volumetric inspection.

2. This table accounts for all unique reportable and dispositionable flaws in B3-B8 for flaw types that have the potential for crack initiation. These include debris flaws, bearing pad flaws, crevice corrosion, PT/CT contact, erosion, linear indications, mechanical damage & manufacturing flaws, and exclude deposits, corrosion, roughness & proud indications, fueling scratches, OD scratches & scrapes.

Figure A1: Detected Flaws in Units 3-8 in the first 500mm outlet portion of the PT



Notes:

1. This figure includes all unique reportable and dispositionable flaws in B3-B8 for flaw types that have the potential for crack initiation. These include debris flaws, bearing pad flaws, crevice corrosion, PT/CT contact, erosion, linear indications, mechanical damage & manufacturing flaws, and exclude deposits, corrosion, roughness & proud indications, fueling scratches, OD scratches & scrapes.

2. This figure does not account for the A2131 volumetric inspection The 4 flaws almost coincident with the burnish mark (at 0mm) actually straddle the burnish mark and extend inboard by no more than 2.1mm. Such flaws carry a significantly reduced risk of crack initiation due to the net compressive stress that exists outboard of the burnish mark.

3. Within this Figure, the direction of PHT coolant flow is from right to left.

4. 'Mid-flaw' is the middle point of the flaw in terms of axial and circumferential location.

Reference:

A1. Letter, A. Viktorov to M. Burton, "Bruce A and B: CNSC Staff Assessment Criteria for Restart Requirements", August 12, 2021, e-Doc 6621711, BP-CORR-00531-01946.

Attachment B

Proposed Return to Service Criteria

Attachment B:
Proposed Return to Service Criteria

As described in the covering letter, and consistent with the proposed resolution of the Order, Bruce Power requests Commission authorization for the return to service of Unit 3 following the completion of the current planned maintenance outage.

Unit 3

In order to address the specific inspection results for A2131, Bruce Power maintains the following serve as appropriate safety verification criteria to confirm operational readiness of pressure tubes to satisfy regulatory requirements prior to restart:

#	Safety Verification Criteria
1	Completion of Burst Testing on Front End Material
2	Submit Pressure Tube Flaw Assessment
3	Submit PT/CT Contact Assessment
4	Submit Fracture Protection Assessment

With respect to the selection of these criteria, a rationale is provided below:

#1 – Completion of Burst Testing on Front End Material

A burst test specimen is being prepared for testing the front end section of B6N07. A test temperature will be selected where the margin between the allowable pressure profile and the heat-up and cooldown transient is limiting in fracture protection evaluations.

#2 - Submit Pressure Tube Flaw Assessment

As per established process, an updated flaw disposition would be submitted to CNSC for acceptance prior to the return to service from a planned maintenance outage and would account for inspection findings, as required.

#3 - Submit Pressure Tube to Calandria Tube (PT/CT) Contact Assessment

Updated PT/CT contact assessments, based on completed inspection and maintenance scope, would be submitted to CNSC for acceptance prior to restart from a planned maintenance outage, and would account for inspection findings, as required.

#4 - Submit Fracture Protection Assessment

While existing probabilistic fracture protection (PFP) assessment remain valid for portions of pressure tubes outside the region of interest, for the region of interest, demonstration of fracture protection for elevated hydrogen equivalent concentrations would be evaluated for all Service Levels.

For heat-up and cooldown transients a fracture protection evaluation could be performed, potentially with a modified transient, with the objective of meeting the acceptance criteria as required by CSA N285.8. Any modifications to the heat-up and cooldown profile in the operating units would be evaluated via the Engineering Change Control (ECC) process.

Similarly, for Level C transients, fracture protection evaluations could be performed to meet the acceptance criteria, as required by CSA Standard N285.8, by potentially crediting logic changes and plant operation to prevent pressure excursions in the Heat Transport System via the ECC process.

August 20, 2021

BP-CORR-00531-01966

Mr. L. Sigouin
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Dear Mr. Sigouin:

<u>Bruce A and B: CNSC Staff Assessment Criteria for Restart Requirements</u>

The purpose of this letter is to initiate regulatory interactions to provide more information in order to further inform considerations related to the definition of the region of interest as established by the Designated Officer Order issued to Bruce Power (Reference 1), and later defined by CNSC staff in Reference 2, as communicated in Bruce Power's recent request for Commission authorization (Reference 3).

The Designated Officer Order issued to Bruce Power required that, prior to seeking an authorization to restart any of Units 3, 4, 5, 7, or 8, following any outage that results in the cooldown of the heat transport system, sufficient inspection and maintenance activities be carried out to 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]".*

As a result of the extensive inspections carried out, both within the current Unit 3 outage and as measured within the surveillance tube taken from Unit 6, Bruce Power has been able to repeatedly and consistently confirm that hydrogen equivalent concentrations are bounded by predictions for greater than 99.5% of the pressure tube. Only within a limited region at the top of the pressure tube, near the outlet burnish mark, have there been indications of elevated hydrogen equivalent concentrations.

Bruce Power is in a position to offer additional surveillance evidence based upon the most recent inspection results and analysis that demonstrates the elevated hydrogen equivalent concentrations is consistently bounded by the following region:

- Axially – From the burnish mark to 50 mm inboard of the burnish mark, and

- Circumferentially – 60 degrees on either side of 12 o'clock for a total of 120 degrees.

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While Bruce Power believes any definition of the region of interest must relate to the hydrogen equivalent concentrations, as established within the Order itself, Bruce Power acknowledges that the distinction is not a consideration that would impact Bruce Power's compliance with the Order in the case of Unit 3, or the ability of the Commission to authorize the return to service of Unit 3, given the lack of dispostionable flaws within the region of interest.

Bruce Power looks forward to reviewing results of the inspection and maintenance activities and additional information with CNSC staff in the coming months, in anticipation of the forthcoming interactions with the Commission, to assist in refinement of the definition of the region of interest.

If you require further information or have any questions regarding this submission, please contact Ms. Lisa Clarke, Director, Regulatory Affairs, at (519) 386-1370 extension, or lisa.clarke@brucepower.com.

Yours truly,

On behalf of
Maury Burton
Chief Regulatory Affairs
Bruce Power

cc: CNSC Bruce Site Office

References:

1. Letter, R. Jammal to M. Burton, "Designated Officer Order issued to Bruce Power", July 26, 2021, e-Doc 6612485, BP-CORR-00531-01904.
2. Letter, L. Sigouin to M.Burton, "Bruce A and B: CNSC Staff Assessment Criteria for Restart Requirements", August 12, 2021, e-Doc 6621711, BP-CORR-00531-01946.
3. Letter, M. Burton to M. Leblanc, "Designated Officer Order to Bruce Power – Unit 3 Planned Outage Restart Authorization", August 13, 2021, BP-CORR-00531-01935.