Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

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Date: 2026-01-22

Written Submission from Bruce Power

Mémoire de Bruce Power

In the matter of the

À l'égard de l'

Status of licensee research and development commitments on elevated hydrogen equivalent concentration in pressure tubes

État des engagements en matière de recherche et développement de titulaires de permis sur les concentrations élevées d'hydrogène équivalent dans les tubes de force

Commission Meeting

Réunion de la Commission

March 2026

Mars 2026

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Canada

Bruce Power
Innovation at work

January 22, 2026

BP-CORR-00531-07172

Ms. Candace Salmon
Commission Registrar
Canadian Nuclear Safety Commission
P.O. Box 1046
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Ms. Salmon:

Bruce A and B: Update on Elevated Hydrogen Equivalent Concentrations
in Inlet and Outlet Rolled Joints in Pressure Tubes

The purpose of this letter is to provide:

1. An update to the Commission regarding Bruce Power's research and development (R&D) activities with respect to elevated hydrogen equivalent concentration ([H_{eq}]) in the inlet and outlet rolled joint (RJ) regions of pressure tubes (PTs), as requested in Reference 1; and,
2. Supplemental information arising from the completion of the R&D activities on elevated [H_{eq}] concentrations in the inlet and outlet RJ regions.

Attachment A provides the background information on the elevated [H_{eq}] concentration observations in inlet and outlet RJs in Bruce PTs and the establishment of the R&D roadmap process. A recent status of the R&D roadmap activities, provided in Attachment B, outlines all completed R&D roadmap activities scheduled for completion up to end of 2025. Key observations and results from the R&D roadmap activities are as follows:

Inlet Region of Interest (IROI)

- PT surveillance has demonstrated observations of elevated [H_{eq}] regions in the IROI to be limited to a "blip", which is on the PT outside diameter (OD).
- Extensive inlet RJ modelling activities have shown that the presence of a blip on the PT OD has minimal impact on a postulated flaw tip hydrided region closer to the PT inner diameter (ID).

This confirms that there is no interaction between a flaw on the PT ID and a blip on the PT OD and demonstrates a low risk of crack initiation in the IROI.

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Outlet Region of Interest (OROI)

- PT surveillance and in-service scrape measurements have demonstrated consistent observations of elevated [H_{eq}] regions in the OROI to be limited to 120 degrees on the upper half of the PT.
- Evidence of the circumferential redistribution of [H_{eq}] from the bottom of the PT to the top of the PT in the outlet RJs was observed due to temperature gradient from top to bottom caused by PT diametral expansion.
- Extensive outlet RJ modelling activities demonstrated the ability to model the [H_{eq}] concentrations in the outlet RJ with the circumferential temperature gradients.

These RJ models and modelling activities continue to demonstrate that the OROI will not expand to regions of PT that contain flaws of significance.

Validation of Existing Crack Initiation Models

- Experiments have been completed on the crack initiation properties with low levels of bulk [H_{eq}] and high levels of bulk [H_{eq}] greater than 200 ppm (up to 240 ppm) in unirradiated/irradiated specimens.
- Based on the results of the experiments, the industry developed approaches for evaluating flaws for crack initiation due to delayed hydride cracking (DHC), hydrided region overloads, and fatigue with bulk [H_{eq}] up to 240 ppm.

Completion of these roadmap activities has provided Bruce Power and industry partners an improved understanding of the mechanisms and influential parameters responsible for the elevated [H_{eq}] concentrations in the inlet and outlet RJ regions. As a result, this improved understanding is being incorporated into the comprehensive [H_{eq}] model, which is on track to be completed by Q2 2026 as scheduled and to be submitted to CNSC staff in the Q3 2026 semi-annual update.

In addition, Bruce Power and industry has provided supplemental information in Attachment C further demonstrating that the PTs currently operating in Bruce Units remain fit-for-service and safe for operation with elevated [H_{eq}] in the inlets and outlet RJs.

In conclusion, Bruce Power's current PT fitness-for-service assessments are not impacted by elevated [H_{eq}] in the Regions of Interest (ROIs) in the RJs. Bruce Power will continue to monitor [H_{eq}] through in-service PTs inspections and ex-service PT surveillance activities in accordance with the actions established since 2021. In Reference 2, CNSC staff concluded that Bruce Power has developed the necessary understanding to complete fitness-for-service evaluations in accordance with Licence Condition 6.1. In support of this conclusion, Bruce Power will apply updated PT flaw evaluation models to regions of elevated [H_{eq}] near the inlet and outlet RJ regions as outlined in Reference 2. Bruce Power will also work with CNSC staff to ensure a seamless transition from the use of the compliance verification criteria (CVC) outlined in Section 6.2 to Section 6.1 of the Licence Conditions Handbook, and to ensure that the LCH is updated with the appropriate wording for Section 6.2.

If you require further information or have any questions regarding this submission, please contact Mr. Maury Burton, Senior Director, Regulatory Affairs, at (519) 386-2394 or maury.burton@brucepower.com.

Yours truly,

Lisa Clarke Digitally signed by Lisa Clarke
Date: 2026.01.22 14:30:50 -05'00'

Maury Burton
Senior Director, Regulatory Affairs
Bruce Power

cc: CNSC Forms / Formulaires
Ms. Anupama Bulkan, CNSC – Ottawa
Dr. Alexander Viktorov, CNSC - Ottawa

Attach.

References:

1. E-mail, A. Tanguay to M. Burton et. al., “Commission Meeting March 2026 – CNSC staff update on the status of licensee R&D commitments for elevated hydrogen equivalent”, December 24, 2025, BP-CORR-00531-07185.
2. Letter, A. Bulkan to M. Burton, “Bruce A and B: CNSC Staff Review of the Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Concentrations, Action Items 2023-07-27173 and 2022 07-26737”, December 5, 2025, e-Doc 7608819, BP-CORR-00531-07093.

Attachment A

Background Information on Elevated Hydrogen Equivalent Concentration Observations in Inlet and Outlet Rolled Joints in Pressure Tubes

Attachment A:
Background Information on Elevated Hydrogen Equivalent Concentration Observations in Inlet and Outlet Rolled Joints in Pressure Tubes

In July 2021, Bruce Power reported elevated hydrogen equivalent concentration ([H_{eq}]) observations in the outlet rolled joint (RJ) regions of surveillance pressure tube (PT) B6S13 and from the 2021 Bruce Unit 3 outage (A2131) RJ scrape campaign. A review of the A2131 scrape measurements identified some PTs with a localized region in the upper half of the PT in the outlet RJ, known as the outlet region of interest (OROI), with a large circumferential variation. In November 2021, elevated [H_{eq}] observations were also reported in the inlet RJ region of PT B6S13—specifically, a localized peak (i.e., blip) of [H_{eq}] on the outside surface of the PT and 10 mm inboard of the burnish mark (BM) known as the inlet ROI (IROI).

Since its discovery, Bruce Power and industry partners established an [H_{eq}] concentration roadmap process to integrate industry efforts related towards a mechanistic understanding and predictive modelling of [H_{eq}] in the inlet and outlet RJs through a number of activities. In July 2022, Bruce Power provided a report to the Commission summarizing the activities to address elevated [H_{eq}] in PT RJs in Reference A1. CNSC staff initiated Action Item 2023-07-27173, in Reference A2, to track the semi-annual progress updates on elevated [H_{eq}] concentration roadmap activities and address CNSC staff comments identified during their review of these updates. The Licence Condition Handbook (LCH) included a new Section 6.2, Fitness for-Service Program for Fuel Channels in Extended Operation which includes limits of applicability for [H_{eq}] in the fitness-for-service assessment models.

Semi-annual updates on these [H_{eq}] roadmap activities were submitted to CNSC staff in References A3 through A7 with the most recent semi-annual update provided in Q3 2025 in Reference A7.

In addition to the semi-annual updates, Bruce Power submissions regarding the finite element diffusion analysis of high [H_{eq}] in a blip in the IROI were provided in separate correspondences (References A8 to A12). CNSC staff comments to these updates were provided in subsequent formal correspondences in References A13 and A14. In January 2025, Bruce Power provided an update to the Commission on the R&D activities to address elevated [H_{eq}] in the inlet PT RJs in Reference A15.

Annual industry workshops and technical meetings were held with CNSC staff since 2022, with the most recent workshop on October 30-31, 2025.

References

A1. Letter, M. Burton to A. Viktorov, “Bruce A and B: Update to the Commission regarding Elevated Hydrogen Equivalent Concentrations – Action item 2022-07-23135”, July 19, 2022, e-Doc 6844485, BP-CORR-00531-02909.
A2. 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, BP-CORR-00531-03929.
A3. Letter, M. Burton to M. Hornof, “Bruce A and B: Update Regarding Detailed Plan to Further Evaluate the Effect of Hydrogen Equivalent Concentration on Pressure Tube Fitness for Service, Action Item 2023-07-27173”, September 27, 2023, e-Doc 7135588, BP-CORR-00531-04393.
A4. Letter, M. Burton to K. Lun, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Equivalent Concentrations, Action Items 2023-07-27173, 2022-07-26737”, March 25, 2024, e-Doc 7249743, BP-CORR-00531-05033.

A5. Letter M. Burton to A. Bulkan, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Equivalent Concentrations, Action Items 2023-07-27173 and 2022-07-26737”, September 26, 2024, BP-CORR-00531-05650.
A6. Letter, M. Burton to A. Bulkan, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Equivalent [H]eq Concentrations, Action Items 2023-07-27173 and 2022-07-26737”, March 20, 2025, BP-CORR-00531-06223.
A7. Letter, M. Burton to A. Bulkan, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Concentrations, Action Items 2023-07-27173 and 2022-07-26737”, September 24, 2025, BP-CORR-00531-06751.
A8. Letter, M. Burton to L. Sigouin, “Bruce A and B: Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region with Postulated Flaw”, June 28, 2022, BP-CORR-00531-02820.
A9. Letter, M. Burton to M. Hornof, “Bruce A and B: Update on Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region”, January 16, 2023, BP-CORR-00531-03588.
A10. A10. Letter, M. Burton to M. Hornof, “Bruce A and B: Update on Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region, Action Item 2023-07-27173”, July 27, 2023, BP-CORR-00531-04245.
A11. A11. Letter, M. Burton to K. Lun, “Bruce A and B: Update on Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region – Action Item 2023-07-27173, April 12, 2024, BP-CORR-00531-05185.
A12. A12. Letter, M. Burton to A. Bulkan, “Bruce A and B: Update on Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region, Action Item 2023-07-27173”, July 11, 2025, BP-CORR-00531-06620.
A13. A13. Letter, M. Hornof to M. Burton, “Bruce NGS A and B: Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region with Postulated Flaw”, December 1, 2022, e-Doc 6926969, BP-CORR-00531-03613.
A14. A14. Letter, M. Hornof to M. Burton, “Bruce NGS A and B: Update on Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region – Action Item 2023-07-27173”, June 23, 2023, E-DOC 7031776, BP-CORR-00531-04290.
A15. A15. Letter, M. Burton to A. Viktorov and C. Salmon, “Bruce A and B: Progress Update on Industry R&D Plan for Elevated Hydrogen Equivalent Concentrations in the Inlet Rolled Joint Region, Action Item 2023-07-27173”, January 24, 2025, BP-CORR-00531-05959.

Attachment B

Status Update on the Industry's Elevated Hydrogen Equivalent Concentration Roadmap Activities

Attachment B:
Status Update on the Industry's Elevated
Hydrogen Equivalent Concentration Roadmap Activities in Inlet and Outlet RJs

Table B-1 provides a status update on the elevated hydrogen equivalent concentration ($[H_{eq}]$) roadmap R&D activities. Key observations and results from the roadmap activities are noted in the cover letter.

Bruce Power and industry partners have completed all R&D roadmap activities scheduled for completion up to the end of 2025. The remaining item from the elevated $[H_{eq}]$ roadmap is the documentation of the comprehensive $[H_{eq}]$ model which remains on track to be completed by Q2 2026 and included in the Q3 2026 semi-annual update.

Table B-1: Status Update on Elevated [H_{eq}] Concentration Roadmap R&D Activities

R&D Activity	TCD (Date of Submission)	Status of R&D Activities
Update finite element software to simulate outlet rolled joint [H_{eq}] evolution	Fall 2023 (Q1 2024)	Complete. Development of the outlet rolled joint (RJ) [H_{eq}] model was documented and submitted in Reference B1.
Develop finite element software to simulate inlet rolled joint [H_{eq}] evolution	Fall 2023 (Q1 2024)	Complete. Development of the finite element software and procedure to simulate the inlet rolled joint [H_{eq}] evolution was completed in 2022 and submitted in Reference B2. Since then, improvements to the finite element analysis model have been incorporated. Documentation of the improved finite element analysis models and simulation procedure were submitted in Reference B3.
Perform evaluation to assess the potential impact of the high levels of [H_{eq}] on flaws at the inside surface of pressure tubes near the inlet region of interest.	Fall 2023 (Q1 2024)	Complete. The evaluation results with the improved finite element analysis model and simulation procedure to assess the potential impact of high [H_{eq}] blip on a postulated flaw at the inside surface of the PT in the inlet RJ were submitted in Reference B3.
Improve characterization of 'blip' and expected evolution of the inlet region of elevated [H_{eq}] with continued operation.	Spring 2024 (Q2 2024)	Complete. Characterization of the elevated [H_{eq}] concentrations in the inlet RJs from surveillance and ex-service PTs from Bruce, Pickering B and Darlington fuel channels were completed. Reports documenting the characterization of the [H_{eq}] blip were provided in References B3, B4 and B5.
Confirm the potential roles of hydrogen isotope ingress and redistribution on the development of the inlet regions of elevated [H_{eq}]	Fall 2023 (Q4 2023)	Complete. The report documenting the hydrogen/deuterium sampling results performed on removed pressure tubes was submitted in Reference B1.
Improve characterization of solubility behaviour of hydrogen isotopes in tubes with elevated [H_{eq}].	Winter 2024 (Q1 2024)	Complete. The report documenting the results of hysteresis and thermal gradient testing was submitted in Reference B4.
Enhance modelling of temperature distributions near the outlet rolled joint region of pressure tubes	Summer 2023 (Q4 2023)	Complete. A report summarizing the enhanced modelling of temperature distributions near the outlet RJ in PTs was provided in Reference B3.
Define input parameters required for interim updates to the [H_{eq}] model	Summer 2023 (Q3 2023)	Complete. Documentation of the input parameters defined for outlet RJ modelling was provided in Reference B1. Documentation of the input parameters defined for inlet RJ modelling was provided in Reference B6.

R&D Activity	TCD (Date of Submission)	Status of R&D Activities
Develop interim [H_{eq}] model	Fall 2024 (Q4 2024)	Complete. A report documenting the interim inlet RJ [H_{eq}] model was submitted in Reference B3. A report documenting the interim outlet RJ [H_{eq}] model was submitted in Reference B3.
Validation activities for the interim [H_{eq}] model to support development of final comprehensive model	Fall 2025	Complete. Activities confirming the continued validity of the interim inlet RJ [H_{eq}] model (i.e., sensitivity cases to various parameters, benchmarking exercises with the outlet RJ [H_{eq}] model, and smaller time steps to achieve better convergence) were documented and submitted in Reference B4 and Reference B7. For the interim outlet RJ [H_{eq}] model, periodic review confirming its continued validity were documented in reports submitted in Reference B4 and Reference B8.
Define input parameters required for the final comprehensive [H_{eq}] model	Summer 2025 (Q3 2025)	Complete. Documentation of the final inputs to the inlet and outlet RJ [H_{eq}] models to account for temperature, stress, ingress, and hydrogen isotope solubility impacts on [H_{eq}] evolution was submitted in Reference B9.
Define the relative importance of variables influential to [H_{eq}] evolution	Fall 2025 (Q3 2025)	Complete. The relative importance of variables influential to [H_{eq}] evolution was determined for both the inlet and outlet rolled joints through a sensitivity study and parametric study performed to the modelling. The results of the sensitivity study were provided in Reference B4 and Reference B8, and the results of the parametric study were provided in Reference B1.
Develop the final comprehensive [H_{eq}] model	Winter 2026 (Q3 2026)	During the industry workshop on elevated [H_{eq}] on October 30-31, 2025, a progress update on the comprehensive outlet RJ [H_{eq}] model was provided to CNSC staff. Development of the final comprehensive [H_{eq}] model is on track for completion by Q1 2026 followed by documentation of the model by Q2 2026. Submission of the comprehensive [H_{eq}] model to the CNSC is planned for Q3 2026.
Complete hydride related cracking experiments for unirradiated material at [H_{eq}] of 220 ppm or higher	Spring 2025 (Q3 2025)	Complete. A report documenting the results from hydride related cracking experiments for unirradiated material at high [H_{eq}] is provided in Reference B9.

R&D Activity	TCD (Date of Submission)	Status of R&D Activities
Complete fatigue crack initiation experiments for unirradiated material at [H_{eq}] of 220 ppm or higher.	Spring 2025 (Q3 2025)	Complete. A report documenting the results of the fatigue crack initiation experiments was provided in Reference B9.
Complete crack initiation experiments for irradiated material with elevated [H_{eq}] without flaws present.	Spring 2025 (Q3 2025)	Complete. A report documenting the results of the crack initiation experiments for irradiated material with elevated [H_{eq}] was provided in Reference B9.
Complete crack initiation and crack growth experiments for irradiated material with elevated [H_{eq}] with flaws present.	Spring 2025 (Q3 2025)	Complete. A report documenting the results of the crack growth experiments was submitted in Reference B9.

References:

B1. Letter, M. Burton to M. Hornof, “Bruce A and B: Update Regarding Detailed Plan to Further Evaluate the Effect of Hydrogen Equivalent Concentration on Pressure Tube Fitness for Service, Action Item 2023-07-27173”, September 27, 2023, e-Doc 7135588, BP-CORR-00531-4393.

B2. Letter, M. Burton to L. Sigouin, “Bruce A and B: Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region with Postulated Flaw”, June 28, 2028, BP-CORR-00531-02820.

B3. E-mail, A. Glover to D. Carriere, “Industry Elevated Heq Status Update – Submissions”, February 27, 2024, BP-CORR-00531-05172, e-Doc 7230931.

B4. Letter, M. Burton to K. Lun, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Equivalent Concentrations, Action Items 2023-07-27173, 2022-07-26737, March 25, 2024, BP-CORR-00531-05033.

B5. Letter, M. Burton to A. Bulkan, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Equivalent Concentrations, Action Items 2023-07-27173 and 2022-07-26737”, September 26, 2024, BP-CORR-00531-05650.

B6. Letter, M. Burton to M. Hornof, “Bruce A and B: Update on Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region, Action Item 2023-07-27173”, July 27, 2023, BP-CORR-00531-04245.

B7. Letter, M. Burton to A. Bulkan, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Equivalent [H]eq Concentrations, Action Items 2023-07-27173 and 2022-07-26737”, March 20, 2025, BP-CORR-00531-06223.

B8. Letter, M. Burton to A. Bulkan, “Bruce A and B: Update on Finite Element Diffusion Analysis of High Hydrogen Level in Rolled Joint Region Action Item 2023-07-27173”, July 11, 2025, BP-CORR-00531-06620.

B9. Letter, M. Burton to A. Bulkan, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Concentrations, Action Items 2023-07-27173 and 2022-07-26737”, September 24, 2025, BP-CORR-00531-06751.

Attachment C

Supplemental Information to Support Pressure Tube Fitness-for-Service Assessments

Attachment C:
Supplemental Information to Support Closure of Action Item 2023-07-27173 and Demonstration of Pressure Tube Fitness-for-Service with Elevated [H_{eq}] in the Inlets and Outlet RJs

Upon completion of the elevated [H_{eq}] roadmap activities (discussed in Attachment B), Bruce Power and industry partners have submitted the following documents in the 2025 Q3 semi-annual update in Reference [C1] to demonstrate that the PTs currently operating in the Bruce units remain fit for service and safe for operation with elevated [H_{eq}] in the inlet and outlet RJs to support closure of Action Item 2023-07-27173:

- Industry position paper on the approach for modelling [H_{eq}] in the inlet and outlet RJs and providing conservative bounding RJ predictions of [H_{eq}] for end-of-life conditions for Bruce B.
- Documentation of the industry's current understanding of delayed hydride cracking (DHC), hydrided region overloads, and fatigue for high levels of bulk [H_{eq}] based on the experiments completed in the elevated [H_{eq}] roadmap process. Recommended approaches for evaluating flaws for crack initiation due to DHC, hydrided region overloads, and fatigue for bulk [H_{eq}] values of between 120 and 240 ppm and for bulk [H_{eq}] values greater than 240 ppm were documented.
- Documentation of the industry's current understanding of DHC, hydrided region overloads, and fatigue for through-wall gradients of high [H_{eq}].

The PT Fitness for Service (FFS) evaluation concluded the following:

1. The inlet ROI is limited to the "blip" on the pressure tube outside diameter.
2. There is low risk of crack initiation in the inlet ROI due to limited impact of the presence of a blip on a postulated flaw tip hydrided region.
3. The outlet ROI is limited to 120 degrees on the upper half of the pressure tube.
4. There is no pressure tube integrity concern due to no flaws in the outlet ROI.

In addition, supplemental information to address feedback from CNSC staff on the recent Q3 2025 semi-annual update on elevated [H_{eq}] (Reference C1) and during the industry workshop, held on October 30-31, was also provided in Reference C2 to further support the above conclusions from the PT FFS evaluation.

For inlet ROI:

- A technical basis report supporting the industry position paper submitted in Reference [C1] for inlet RJ [H_{eq}] bounding predictions for Bruce B (1) with and without a blip and (2) with and without a postulated flaw. Additional details are provided in the technical basis report on the finite element simulation procedure, the evaluation matrix, justification of the selection of input parameters for each of the finite element simulation cases and discussion of the Bruce B and stress, temperature and simulation results.
- A sensitivity study has been performed to demonstrate fracture protection even in an unlikely scenario where a flaw on the pressure tube inside diameter grows through-wall and intersects with a blip on the pressure tube outside diameter. The sensitivity study uses different combination of postulated through-wall flaw lengths and locations of the flaw and the blip to determine that the most realistic postulated through-wall flaw length to be 14 mm from the burnish mark for evaluation.

For outlet ROI:

- A technical basis report supporting the industry position paper submitted in Reference C1 for bounding outlet RJ [H_{eq}] profile for Bruce B PTs at end-of-life conditions. Additional details are

provided in the technical basis report on the ORJ [H_{eq}] prediction methodology using the interim outlet RJ [H_{eq}] model, and justification of the selection of analysis inputs to generate the conservative bounding ORJ [H_{eq}] predicted profile at end of-life conditions for Bruce PTs.

- A report documenting the refinements used to address the over conservatism in the bounding outlet RJ [H_{eq}] profiles for Bruce B provided in the technical basis report and the industry position paper. This refined bounding ORJ [H_{eq}] profile generated for Bruce B provide a more realistic but conservative bounding profile compared to the bounding ORJ [H_{eq}] profile in the industry position paper in Reference C1 which is considered an extreme worst-case scenario to evaluate how the ROI is evolving in time with unrealistically and conservatively high predicted [H_{eq}].

For the outlet ROI, the refined ORJ bounding end of life (EOL) [H_{eq}] predictions remain below 140 ppm inboard of the burnish mark plus 75 mm which which corresponds to the axial extent defined by CNSC staff for the ROI (see Figure C-1). Accordingly, the outlet ROI has demonstrated to not extend beyond the burnish mark plus 75 mm even with the conservative bounding EOL [H_{eq}] predictions (see Figure C-2). Furthermore, no Bruce B dispositionable PT flaws are present within or adjacent to the outlet ROI, as illustrated in Figures C-1 and C-2.

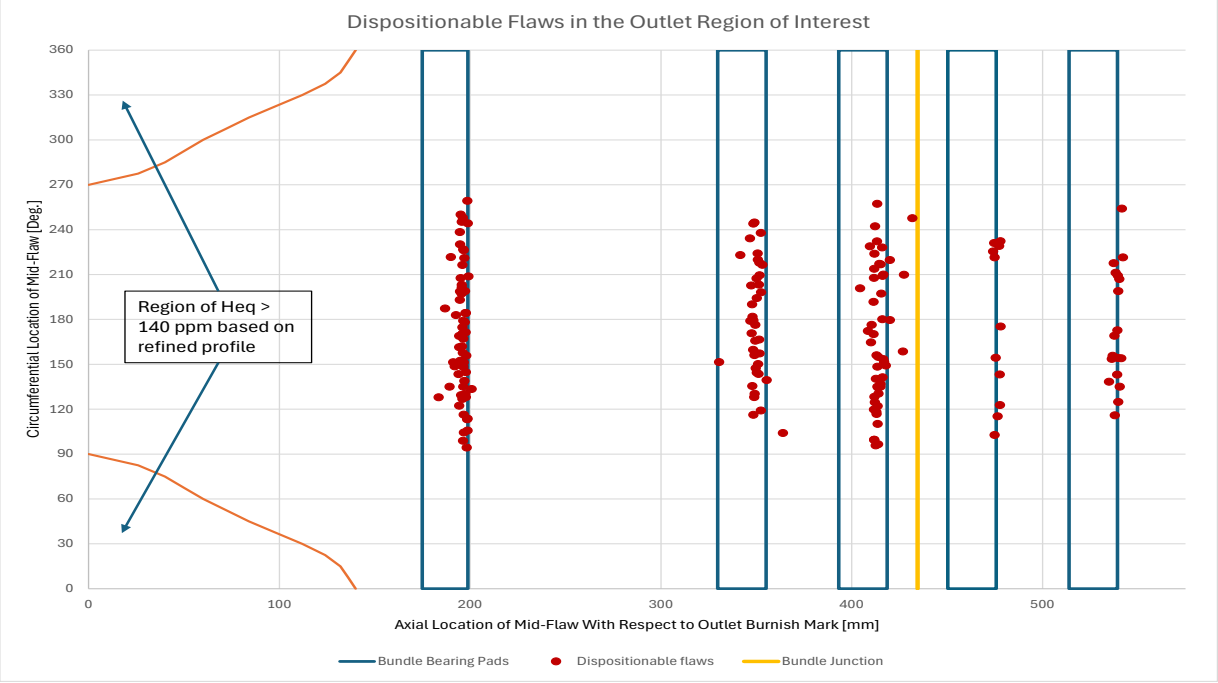

Figure C-1: Location of Bruce B Dispositionable Flaws in the Outlet Region of Interest with respect to the Refined ORJ [H_{eq}] Bounding Profile (Figure 2 of Reference C2)

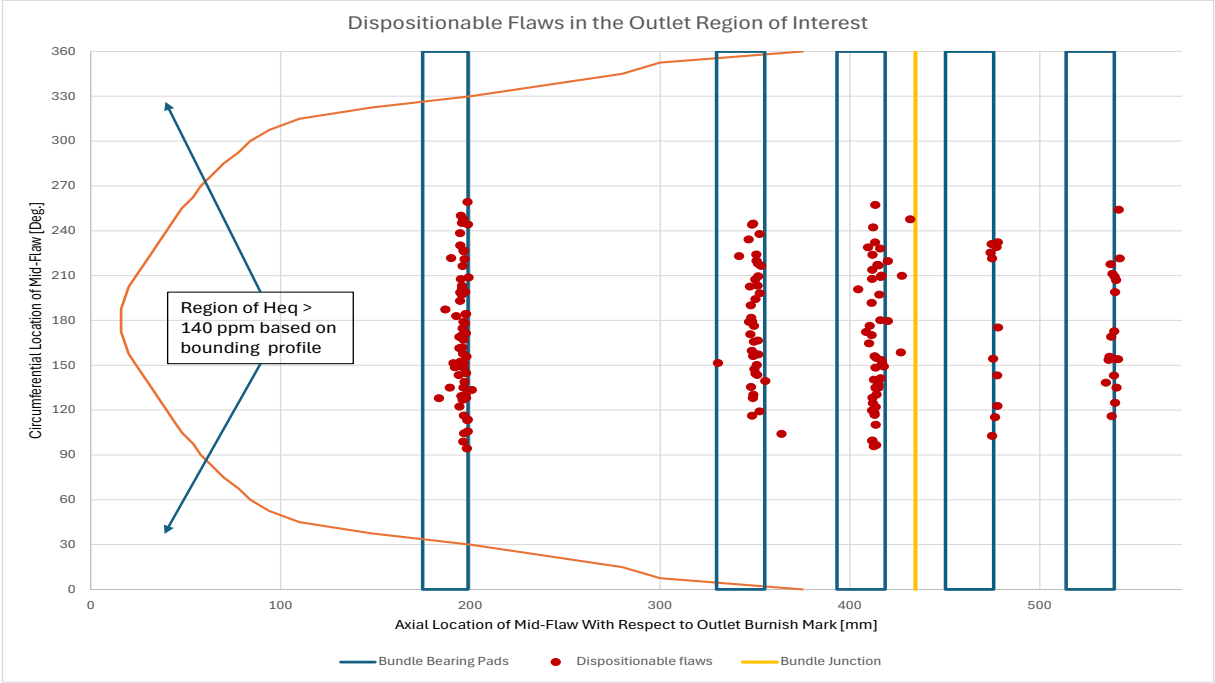

Figure C-2: Location of Bruce B Dispositionable Flaws in the Outlet Region of Interest with respect to the Conservative ORJ [H_{eq}] Bounding Profile (Figure 3 of Reference C2)

Industry approaches for addressing crack initiation at blunt flaws and ensuring fracture protection–applicable to any circumferential position of a blip in the inlet and outlet RJ regions–have also been developed and submitted to CNSC staff in Reference C2.

Considering of the measured [H_{eq}] values of from in-situ scrapes and surveillance pressure tubes, the conservatism of the predicted bounding [H_{eq}] profiles, applicability and validity limits of the engineering models used to evaluate crack initiation and fracture toughness (regardless of the circumferential position of the blip), and the regions of the pressure tube where no dispositionable flaws have been detected, Bruce Power maintains that the structural integrity of the pressure tube at high [H_{eq}] levels at the inlet and outlet ends of Bruce B has been demonstrated.

References:

C1. Letter, M. Burton to A. Bulkan, “Bruce A and B: Semi-Annual Update on Industry R&D Plan on Elevated Hydrogen Concentrations, Action Items 2023-07-27173 and 2022-07-26727”, September 24, 2025, BP-CORR-00531-06751.
C2. E-mail, A. Glover to P. Szymanski, “Supplemental Information to the Q3 2025 Semi-Annual Update on Elevated [H_{eq}]”, December 1, 2025, BP-CORR-00531-07176.