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Written submission from Bruce Power

Mémoire de Bruce Power

In the Matter of

À l'égard de

Request for authorization to return Bruce Nuclear Generating Station (NGS) A Unit 3 to service, following its current planned outage

Demande concernant l'autorisation de la remise en service de la tranche 3 de la centrale nucléaire de Bruce-A à la fin de son arrêt prévu actuel

Public Hearing - Hearing in writing based on written submissions

Audience Publique - Audience fondée sur des mémoires

October 2021

Octobre 2021

September 29, 2021

BP-CORR-00531-02090

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

Dear Mr. Leblanc and Dr. Viktorov:

Bruce A and Bruce B: Supplementary Information with Respect to Flaw Probability

The purpose of this letter is to provide an updated probabilistic evaluation related to the existence of dispositionable flaws using the CNSC defined Region of Interest (ROI) for the Unit 3 pressure tubes, requested by CNSC staff in Reference 1, and originally provided in Reference 2.

Bruce Power recognizes that in August 2021, CNSC staff defined a ROI based on the information available at the time as follows:

- Axially – From the burnish mark to 75 mm inboard of the burnish mark; and
- Circumferentially – Full circumference of 360 degrees.

CNSC have indicated a willingness to consider adjustments to the ROI based on additional information, data and analysis. Bruce Power will continue to engage with CNSC staff on this item as further refinement circumferentially is both appropriate and conservative, while recognizing that time is needed for CNSC staff to review material recently provided in Reference 3.

An updated probabilistic evaluation of the existence of dispositionable flaws, using CNSC staff's defined extended region of interest is provided for information in Enclosure 1, as defense in depth. Bruce Power believes this meets the requirements of the Order (Reference 3) and demonstrates both safety and pressure tube integrity in combination with other elements previously provided.

As discussed with CNSC staff, Bruce Power has refined the probabilistic evaluation methodology from that submitted in Reference 4 to establish a more refined quantification. Whereas the analysis provided in Reference 4 estimated the potential number of dispositionable flaws in consideration of the ratio of reportable and dispositionable flaws resulting from inspections; the analysis provided in Enclosure 1 focuses on dispositionable flaws in recognition that there has never been a dispositionable flaw identified within the region of interest. As a result, the analysis estimates that there is less than one (1) dispositionable flaw in Unit 3 within the region of interest defined by the CNSC staff. The results also predict no dispositionable flaws in Unit 3 within the region of interest as defined by Bruce Power.

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Bruce Power notes that this result is consistent with the unitized statistical analysis, previously submitted in Reference 5 using a region of interest limited circumferentially to 60 degrees on either side of 12 o'clock (for a total of 120 degrees), demonstrated very low probability of the existence of a reportable or dispositionable flaw in the region where elevated hydrogen equivalent concentration were measured in Unit 3. This result was based on the inspection data from all units (Bruce 3-8) up to A2131 where there has never been a flaw detected in the region of interest. The inspection results from A2131 also support this observation. The conclusion reached for Unit 3 (and all Bruce Power units) is that the probability for having at least one dispositionable flaw in the region of interest is < 0.5% and as a result, the likelihood of having a significant flaw in the region of interest defined by Bruce Power, which could challenge pressure tube fitness for service is also low.

If you require further information or have any questions regarding this submission, please contact Ms. Lisa Clarke, Director, Regulatory Affairs, at (519) 361-2673 extension 16144, or lisa.clarke@brucepower.com.

Yours truly,

Maury Burton
Chief Regulatory Officer,
Bruce Power
2021.09.29 16:03:54 -04'00'

Maury Burton
Chief Regulatory Officer
Bruce Power

cc: CNSC Bruce Site Office
L. Sigouin – CNSC
R. Jammal – CNSC

Enclosure:

1. B-03644.1-29SEP2021, "Updated Flaw Probability in the Region of Interest in the Uninspected Population of Pressure Tubes in Bruce Units 3-8".

References:

1. Letter, L. Sigouin to M. Burton, "CNSC Review of Bruce A Unit 3: Return to Service Additional Information", September 23, 2021, e-Doc 6646070, BP-CORR-00531-02071.
2. Letter, M. Burton to M. Leblanc and A. Viktorov, "Bruce A Unit 3: Response to CNSC Review of Return to Service Additional Information", September 24, 2021, BP-CORR-00531-02077.
3. Letter, R. Jammal to M. Burton, "Designated Officer Order issued to Bruce Power", July 26, 2021, e-Doc 6612485, BP-CORR-00531-01904.
4. Letter, M. Burton to M. Leblanc and A. Viktorov, "Bruce A Unit 3: Response to CNSC Review of Return to Service Additional Information", September 24, 2021, BP-CORR-00531-02077.
5. Letter, M. Burton to M. Leblanc and A. Viktorov, "Bruce A Unit 3: Return to Service Additional Information", September 17, 2021, BP-CORR-00531-02033.

Enclosure 1

B-03644.1-29SEP2021

Updated Flaw Probability in the Region of Interest in the Uninspected Population of Pressure Tubes in Bruce Units 3-8

FORM-14287 R000*

Supplier Document Acceptance Form

KINECTRICS

UPDATED FLAW PROBABILITY IN THE REGION OF INTEREST IN THE UNINSPECTED POPULATION OF PRESSURE TUBES IN BRUCE UNITS 3-8

B-03644.1-29SEP2021

- [x] Accepted
- [ ] Accepted As Noted – Revision Required
- [ ] Rejected
- [ ] Accepted As Noted – No Revision Required

FOR USE AT BRUCE POWER

ACCEPTED: **LARRY MICUDA** (Print Name) [signature] (Signature)

TITLE: **SENIOR TECHNICAL SPECIALIST** (Print Title)

DATE: **29SEP2021** (DDMMMYYYY)

ACCEPTANCE OF THIS DOCUMENT DOES NOT RELIEVE THE CONTRACTOR OF RESPONSIBILITY FOR ANY ERRORS OR OMISSIONS.

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September 29, 2021

Andrew Glover
Bruce Power
123 Front St., 4th Floor
Toronto, ON, M5J 2M2

Re: Updated Flaw Probability in the Region of Interest in the Uninspected Population of Pressure Tubes in Bruce Units 3-8

Dear Mr. Glover,

Introduction

This work is related to the task of estimating the number of dispositonable pressure tube flaws that exist in the 'region of interest' (defined 4 different ways as given in Table 1) in the uninspected populations of Bruce Units 3-8 pressure tubes. This is a follow-up to the initial work documented in Reference [1].

The purpose of this letter is twofold:

1. To refine the analysis provided in [1] to remove unnecessary conservatisms, and,

2. To address a question asked by the CNSC [2] regarding the possible dependence of the results from [1] on flaw type (e.g. debris fret marks, crevice corrosion, manufacturing flaw, erosion).

The unnecessary conservatism in Reference [1] was the result of the procedure to estimate the number of dispositionable flaws close to the outlet burnish mark (OBM) in uninspected pressure tubes in Bruce Units 3-8. In order to have as many relevant data as possible to describe the distributions of the axial and circumferential locations of flaws, the decision was made to use all reportable flaws (including dispositionable flaws) to estimate these two important distributions. This information was then used to estimate the number of reportable flaws in the uninspected population of pressure tubes and then finally scale this number back to the number of dispositionable flaws according to the ratio of dispositionable flaws to total reportable flaws. It was acknowledged that this assessment was conservative because the ratio of dispositionable flaws to total reportable flaws, while adequate for the whole database, did not hold for flaws close to the OBM. Specifically, given the observation from the flaw database that approximately 1/3 of all reportable flaws are dispositionable [1], one would have expected that 2 out of the 6 reportable flaws found within 75mm of the OBM in B3-B8 would have been dispositionable, when in fact none of them were dispositionable[1]. This discrepancy between prediction and observation strongly suggests that the observation of zero dispositionable flaws in Region 4 should be included in the analysis, which is done in this letter.

This letter compares three estimates of the number of flaws in the regions of interest of the uninspected population of pressure tubes in Bruce units 3-8. The first one, based largely on information from reportable flaws is too conservative for the reasons outlined above, is already reported in Table 5 of Reference [1] and is repeated in Table 2 of this letter for comparison purposes. The second set of estimates uses only dispositionable flaws as inputs, while the third one focuses even further by using only information from dispositionable debris flaws (i.e., the only flaw type in the database within 75 mm of the OMB) as inputs. This last set of estimates is the result of a sensitivity exercise intended to address the CNSC question related to the possible dependence of the results on flaw type.

Methodology

The methodological switch was to use exclusively the incidence and location of dispositionable flaws. This approach would eliminate the assumption that the ratio of dispositionable flaw to reportable flaws is independent of axial location.

For the first refinement analysis it was possible to undertake this approach because there was still a sizeable population of dispositionable flaws (187 flaws) from which to build a reliable distribution for the circumferential location of the flaws. The resulting distribution is still normal but has a slightly larger standard deviation compared with the one based on all flaws and reported in [1].

To estimate the cumulative density function (CDF) for the axial distribution at 75 mm, the interpolation technique described in [1] was used and gives a conditional probability estimate of 0.003535203 given that a flaw was present. The dispositionable flaw incidence has a lambda value of 0.417411 (187 dispositionable flaws / 448 unique inspected channels).

The second refinement only uses information from a further reduced population: dispositionable debris fret marks. The population is now further reduced to 143 flaws and the circumferential location distribution is similar but not identical to the one used for all dispositionable flaws. The flaws removed from the databases were almost exclusively erosion shot flaws and crevice corrosion flaws, none of which are observed in BA units. This refinement ensures a more even flaw incidence representation from each unit.

The CDF for the axial distribution at 75 mm is now 0.004622958 (slightly larger) but the lambda value describing the incidence is slightly lower 0.319196 (143/448).[2]

Results

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[1] Without bearing pads in this region to trap debris against the PT surface, it may well be that any fretting flaws that form there will tend to be less severe.

[2] The product of these two probabilities will be the same for both refinements because the anchor points for the interpolation are the same. Therefore, the results will be identical for the two refinements for Region 4.

Table 3 provides the results of the approach which uses only dispostionable flaw information, while Table 4 provides the results of the approach which uses only dispositionable debris flaw information. The fact that the estimated number of dispositionable flaws in the uninspected populations is larger for the second approach as compared to the first for Regions 1, 2 & 3 is related to the larger standard deviation of the distribution of the circumferential position for the debris flaw population. For all practical purposes these estimated values of flaws in uninspected reactors for Regions 1, 2 & 3 remain zero.

Of particular interest is the change in the estimated number of flaws in Region 4. For the former, very conservative analysis (Table 2) the estimated number of flaws in the uninspected population of each Bruce Power reactor was ~1.9-2.0. The updated, more refined analysis (Table 3 & Table 4) now provides new estimates which indicate a more realistic value of ~0.6 dispositionable flaws in the uninspected populations.

Conclusions

A refinement on the estimation of the number of dispositionable flaws in 4 regions of interest in the uninspected population of Bruce units 3-8 has been developed which does not require the assumption that the ratio of reportable to dispositionable flaws is independent of axial location. Furthermore, an additional sensitivity case has been analyzed to address the potential influence of flaw type on the results.

The following conclusions can be drawn from these improved estimates:

i. It remains highly unlikely to encounter any dispositionable flaws in Regions 1, 2 & 3.

ii. The expected number of flaws in Region 4 is around 0.6 (for all reactors) from which it can be deduced that it is possible but not very likely ($p<0.5$) that one dispositionable flaw will be present in the uninspected population of pressure tubes in Bruce reactors.

iii. The results are not very sensitive to whether all dispositionable flaws are considered, or just dispositionable debris flaws.

The implications of these estimates of the number of flaws are governed by the flaw severity and by the flaw environment with the likelihood of subpopulations of pressure tubes being present with different propensities to be exposed to high Hydrogen equivalent, meaning that associated conservatisms likely still exist in these results.

References

[1] D. Leemans, "Estimation of Encountering Reportable & Dispositionable Pressure Tube Flaws in Various Regions of Interest in Bruce Power Units 3-8", Kinectrics File: B2266/RP/0010 R01, September 24, 2021.

[2] A. Robert, e-mail to A. Glover, "RE: Request for Clarifications Regarding the Statistical Analysis of Flaws Near the Outlet Burnish Mark", Kinectrics File: B2266/RE/0010 R00, September 22, 2021.

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Table 1 – Definition of 4 Regions of Interest in B3-B8 pressure tubes

	Axial Extent	Circumferential Extent Centred at Top of Tube
Region 1	OBM + 75 mm	60° (+/- 30°)
Region 2	OBM + 75 mm	120° (+/- 60°)
Region 3	OBM + 75 mm	180° (+/- 90°)
Region 4	OBM + 75 mm	360° (+/- 180°)

Table 2 – Reference Analysis (from Reference [1]) - Estimates of the Number of Dispositionable Flaws in the Regions of Interest in the Uninspected Population of B3-B8 Pressure Tubes

Unit	# Uninspected Channels	Region 1	Region 2	Region 3	Region 4
3	402	2.52E-04	4.28E-03	4.22E-02	1.94
4	398	2.50E-04	4.24E-03	4.18E-02	1.92
5	403	2.53E-04	4.29E-03	4.23E-02	1.95
6	418	2.62E-04	4.45E-03	4.39E-02	2.02
7	410	2.57E-04	4.37E-03	4.30E-02	1.98
8	401	2.52E-04	4.27E-03	4.21E-02	1.94

Table 3 - Refinement #1 Using Only Dispositionable Flaws - Estimates of the Number of Dispositionable Flaws in the Regions of Interest in the Uninspected Population of B3-B8 Pressure Tubes

Unit	# Uninspected Channels	Region 1	Region 2	Region 3	Region 4
3	402	5.74E-04	4.92E-03	2.83E-02	0.59
4	398	5.69E-04	4.87E-03	2.80E-02	0.59
5	403	5.76E-04	4.94E-03	2.84E-02	0.59
6	418	5.97E-04	5.12E-03	2.94E-02	0.62
7	410	5.86E-04	5.02E-03	2.89E-02	0.60
8	401	5.73E-04	4.91E-03	2.82E-02	0.59

Table 4 - Refinement #2 Using Only Dispositionable Debris Flaws - Estimates of the Number of Dispositionable Flaws in the Regions of Interest in the Uninspected Population of B3-B8 Pressure Tubes

Unit	# Uninspected Channels	Region 1	Region 2	Region 3	Region 4
3	402	9.21E-04	6.73E-03	3.42E-02	0.59
4	398	9.12E-04	6.67E-03	3.38E-02	0.59
5	403	9.24E-04	6.75E-03	3.43E-02	0.59
6	418	9.58E-04	7.00E-03	3.55E-02	0.62
7	410	9.40E-04	6.87E-03	3.48E-02	0.60
8	401	9.19E-04	6.72E-03	3.41E-02	0.59