Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

CMD 22-M16

Date: 2022-03-11
File / dossier : 6.02.04
Edocs pdf : 6754276

Event Initial Report

Bruce Power

Elevated Hydrogen equivalent concentration (Heq) in the inlet rolled joint of a Bruce pressure tube removed from service

Commission Meeting

March 24, 2022

Rapport initial d'événement

Bruce Power

Concentration élevée d'hydrogène équivalent (Heq) dans le joint dudgeonné du point d'entrée d'un tube de force retiré du service à Bruce

Réunion de la Commission

Le 24 mars 2022

Canada

EVENT INITIAL REPORT (EIR)

E-DOCS-# 6744152

EIR: Elevated Hydrogen equivalent concentration (Heq) in the inlet rolled joint (IRJ) of a Bruce pressure tube (PT) removed from service

RIE: Concentration élevée d'hydrogène équivalent (Heq) dans le joint dudgeonné du point d'entrée d'un tube de force retiré du service à Bruce

Prepared by: Agnes Robert, BRPD, DPRR

Licensee: Bruce Power	**Location: Bruce B Unit 6**
Date Event was Discovered: 2021-12-10	**Have Regulatory Reporting Requirements been met?** Yes ☒ No ☐ **Proactive Disclosure:** Licensee: Yes ☒ No ☐ CNSC: Yes ☒ No ☐

Overview

Reporting Criteria: REGDOC-3.1.1 Table A1 – 14(b)

Bruce Power reported discovery of elevated hydrogen equivalent concentration (Heq) at the inlet rolled joint of a pressure tube removed from Bruce Unit 6.

Description: Following the July 2021 discovery of elevated Heq near the outlet rolled joint, Bruce Power performed additional surveillance testing on the removed PT B6S13 and discovered that elevated Heq also exists near the inlet end of the PT. The reported Heq level from a through-wall punch sample was 126 ppm at approximately 10 mm inboard of the burnish mark. The testing was performed as part of the Fitness for Service Program, which includes an on-going requirement for periodic destructive examination of pressure tubes. This is referred to as surveillance monitoring.

Cause(s): Bruce Power has postulated the potential causes of this discovery. However, Bruce Power's presented theories need to be proven with evidence before CNSC staff can perform an assessment of the root cause.

Impact of the Event

On People:

How many workers have been (or may be) affected? None

How many members of the public have been (or may be) affected by the event? None

How were they affected?

There was no impact on workers or people since there has been no radiological exposure.

On the Environment: None

Other Implications: The requirements of Canadian Standards Association (CSA) N285.4 and CSA N285.8 to confirm fuel channel fitness for service for the inlet region of pressure tubes cannot be met until the root cause and impact of the finding is evaluated.

CNSC staff assessment of this finding is as follows:

1. The Heq measurement exceeds the limits of the fracture toughness model for front end material.
    a. The Rev. 1 fracture toughness (FT) model, currently in use, has a hydrogen concentration limit of 120 ppm overall, and a limit of 80 ppm for front-end material.
    b. The proposed revised version, Rev. 2 FT model, will increase range of applicability of the model to 140 ppm, while for the front-end the limit will increase to 100 ppm. This model is currently under review by CNSC staff with a target completion date of April 2022.
2. Bruce Power does not have a mechanistic understanding of the phenomenon nor validated models as a result of this finding. In other words, their Heq model is invalid because the outputs of the Heq models do not align with the B6S13 measurement of 126 ppm at the inlet end of the PT. These Heq outputs are used as inputs into Fitness for Service Assessments such as leak-before-break (LBB) and fracture protection (FP) assessments. The uncertainty of the Heq inputs impact the LBB and FP aseessments. CNSC staff are of the opinion that Bruce Power cannot confidently perform these assessments until the Heq phenomenon is understood and modelled.
3. The observation at Bruce Unit 6 extends to other non-refurbished units in the CANDU fleet. CNSC staff are assessing the impact of this finding on those units.

CNSC staff are of the opinion that there is no concern about the ability of safety systems to effectively perform their safety functions of control, cool and contain in order to ensure continued safe operation. In addition, Bruce Power has shared

E-DOCS-# 6744152

EIR: Elevated Hydrogen equivalent concentration (Heq) in the inlet rolled joint (IRJ) of a Bruce pressure tube (PT) removed from service

RIE: Concentration élevée d'hydrogène équivalent (Heq) dans le joint dudgeonné du point d'entrée d'un tube de force retiré du service à Bruce

information that indicates a negligible increase in the CDF (Core Damage Frequency) and LRF (Large Release Frequency) due to this inlet end of PT finding. Bruce Power's latest Probabilistic Safety Analysis (PSA) results show that both Bruce A and Bruce B plant risk (severe core damage risk) is below both the safety goal (1E-04 occ./year) and the administrative safety objectives (1E-05 occ./year). In summary, CNSC staff find Bruce Power's latest PSA evaluation acceptable.

Licensee Actions

Taken or in Progress: On December 10, 2021, Bruce Power reported the discovery event via the REGDOC-3.1.1 reporting process (REGDOC-3.1.1 B-2021-135624, e-Doc 6701533). Following CNSC staff letter of December 14, 2021 and subsequent emails requesting additional information, Bruce Power provided further information related to the Heq measurement and a fracture protection evaluation (Reference eDocs# 6716619, 6735622 and 6745124). Bruce Power concluded that all Bruce A and B operating units are fit for continued service based on their engineering evaluation and deterministic fracture protection assessment which indicates that all safety factors are still met in light of this new finding. Probabilistic Safety Analysis was re-evaluated by Bruce Power taking this finding into consideration and concluded that there is a negligible increase in the CDF and LRF frequencies due to this inlet end of PT finding.

Planned: Bruce Power will provide additional information at the Heq Industry Workshop at the end of March 2022. In the longer term, Bruce Power has committed to determining the root causes for this IRJ (and the ORJ) phenomena and updating the Heq models accordingly.

CNSC Actions

Taken or in Progress: CNSC Letter sent on December 14, 2021 opened Action Item 2021-07-24426 to request additional information on this discovery. This information was provided in January 2022. Bruce Power responded to CNSC staff requests for further information in January and February. CNSC assessed the information provided by Bruce Power to date, including the impact of this discovery on the safety of operating reactors.

CNSC staff have concluded that:

1. Assuming the phenomenon observed in the surveillance PT removed from Unit 6 also exists in other units, the previously accepted methods can no longer be used to evaluate PT Fitness for Service, specifically in the locations close to the inlet rolled joint.

2. The discovery puts into question the full efficiency of level 1 defence in depth, i.e., reliability of the process systems and components. However, there is no concern with respect to the ability of safety systems to effectively perform their safety functions of control, cool and contain,

3. CNSC staff find Bruce Power's PSA evaluation acceptable.

While investigation into the root cause and extent of the observed phenomenon continues, the incremental risk of continued operation is judged to be acceptable based on the probabilistic safety analysis results.

Planned: Work is ongoing, both by the licensee and CNSC staff, to better understand the safety implications of the finding. Based on the information currently available, CNSC staff concurs with the licensee's conclusion that the incremental risk is small to continue operation while Bruce Power determines the root cause of the elevated Heq. Bruce Power is required to update their Heq models. On the request of CNSC staff, Bruce Power will provide, in the Spring of 2022, a plan to investigate the root cause and extent of the phenomenon. Once Bruce Power provides a plan to address the elevated Heq inlet finding, CNSC staff will inform the Commission of their assessment of the plan.

CNSC staff are assessing the impact of this finding on other non-refurbished units in the CANDU fleet.

To further characterize the risk, CNSC staff will undertake a systematic assessment for the risk based on a risk-informed decision making (RIDM) assessment, using CSA 290.19 and benchmark it against the process used by the US NRC.

CNSC staff will also explore the possibility of involving international experts to assist in these endeavors.

Additional reporting to the Commission Members anticipated:

☒ Yes

☐ No

E-DOCS-# 6744152

EIR: Elevated Hydrogen equivalent concentration (Heq) in the inlet rolled joint (IRJ) of a Bruce pressure tube (PT) removed from service RIE: Concentration élevée d'hydrogène équivalent (Heq) dans le joint dudgeonné du point d'entrée d'un tube de force retiré du service à Bruce	
If Yes, provide method of reporting: CMD	
Name and Title	Signature
Alex Viktorov, DG DPRR Directorate of Power Reactor Regulation	Digitally signed by Viktorov, Alexandre DN: C=CA, O=GC, OU=CNSC-CCSN, CN="Viktorov, Alexandre" Reason: I am approving this document Location: your signing location here Date: 2022-03-11 08:39:11 Foxit PhantomPDF Version: 9.7.1 Director General Date