



CMD 23-M20

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Event Initial Report

Rapport initial d'événement

Bruce Power

Bruce A Unit 4 Heat Transport
Purification System Heavy Water
Leak

Bruce Power

Fuite d'eau lourde provenant du
système d'épuration du circuit
caloporteur de la tranche 4 de la
centrale nucléaire de Bruce-A

Commission Meeting

Réunion de la Commission

June 28, 2023

Le 28 juin 2023

EVENT INITIAL REPORT (EIR)

e-Doc 7059019

EIR: Bruce A Unit 4 Heat Transport Purification System Heavy Water Leak	
Prepared by: Directorate of Power Reactor Regulation (DPRR) and Bruce Regulatory Program Division (BRPD)	
Licensee: Bruce Power Inc.	Location: Bruce Nuclear Generating Station (NGS) A Unit 4
Date Event was Discovered: 2023-04-25	Have Regulatory Reporting Requirements been met? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Proactive Disclosure: Licensee: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> CNSC: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Overview	
Reporting Criteria: 15) Issues, events, occurrences that the Directors-General (DGs) or their designates judge to have potential for repercussions outside the CNSC and for which the DGs or their designates believe the Commission should be informed.	
Description: On April 25, 2023 at 14:07, Bruce Power control room operators received indications of elevated leakage of reactor heavy water from the Heat Transport System (HTS) of the Bruce NGS A Unit 4. Efforts to locate and isolate the source of the leak were unsuccessful, due to failure of the moisture detecting beetle (essentially an energized spark plug) located in the leak location. Consequently, with a leak rate estimated around 600 – 700 kg/h at 16:43, Bruce Power entered an 8-hour clock for unit shutdown and cooldown, per normal procedures. Given that the leak rate continued to increase, unit shut down preparation activities began at 17:30, with unit shutdown starting at approximately 19:30. During unit shutdown, the leak rate increased significantly leading to the transfer of water from the heavy water storage tank and other units at Bruce A to make up the loss in the HTS. At approximately 1:00 on April 26, 2023, the source of the leak was identified to be in the HTS purification system, inside a room outside containment containing filters and ion exchange columns for the system. Water was visually identified outside the room, where it had leaked through the room door after accumulating on the room floor. The purification system equipment in the room was immediately isolated and the leakage stopped at 1:20. Clean up of the leaked heavy water commenced at 1:10, April 26, 2023 As the HTS water accumulated in the purification system room, associated tritium vapour had migrated into areas accessible to plant personnel outside of the room where the leak occurred. Bruce Power announced a plant radiological incident at 1:10 and the response procedure for abnormal radiological conditions was initiated. Bruce Power partially stood up its off-site Emergency Management Centre (EMC). Bruce A Operations and Radiation Protection staff responded with the following immediate actions: <ul style="list-style-type: none"> • staff not involved in the incident being removed from the incident area • prevention of entry into the areas with elevated tritium • establishing boundaries for contamination control areas Response measures were also deployed to prevent the water from entering any inactive drains, which drain directly to the plant outfall entering the adjacent Lake Huron. Emergency response measures continued to be deployed as needed until plant tritium levels reduced significantly by approximately midnight on April 27, 2023. On April 26, 2023 Bruce Power posted information about this event to their external website. Spill cleanup recovery efforts continued in the following days. Bruce Power estimated that the total amount of heavy water that leaked from the Unit 4 HTS during the event was 135 Mg. Cause: The leak source was later identified as a failed flexible hose located on the inlet of a Unit 4 purification system filter. The purification system includes Bank A and Bank B hoses, and the failed hose was a Bank A hose. The failure mechanism of the hose is currently being assessed by Bruce Power. The hoses may have been in place for approximately 20 years since Unit 4 was restarted in 2003 and, as such, advanced aging may have been a contributing cause for the leak. Leak	

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detection using a beetle monitor in the room where the leak occurred also failed to alert the operators, which would have resulted in earlier identification of the leak location.

Impact of the Event

On People:

How many workers have been (or may be) affected? Twenty four workers involved in the initial event response, as well as the 153 workers involved in the clean-up and mitigation efforts that followed after the initial event response (see below).

How many members of the public have been (or may be) affected by the event?

None

How were they affected?

All workers involved in event response were nuclear energy workers (NEW). Workers were exposed to elevated tritium levels and the estimated combined dose for initial event response, mitigation and clean-up measures, as well as for other NEWs in the area, is less than 21.96 mSv.

The combined dose impact to workers involved in the initial event response was approximately 14.48 mSv. The total dose impact to the remaining 153 workers involved with spill clean up and mitigation measures was approximately 7.26 mSv.

The highest individual dose received by any worker was 2.36 mSv.

The annual dose limit for NEWs per the *Radiation Protection Regulations* is 50 mSv per year and 100 mSv over five years.

On the Environment: Airborne radiological emissions from Bruce A measured in contaminated and non-contaminated stacks for plant ventilation systems confirmed that plant tritium emissions were minimally impacted by the event and were well below Environmental Action Levels.

For aqueous emissions, post-incident investigations revealed that a small amount (approximately 20 L) of HTS water passed through a spill containment berm set up for event response and entered an inactive drain which enters the plant outfall that flows to Lake Huron. The total tritium loading from this potential release was conservatively estimated to be equivalent to 9.26×10^{11} Bq, which was assessed by Bruce Power as not resulting in any adverse environmental impact or risk to the public. CNSC staff have reviewed and are satisfied with this assessment.

Other Implications: None

Licensee Actions

Taken or in Progress:

Corrective actions implemented by Bruce Power following the initial event response, as described above, included replacing both Bank A and B hoses on Unit 4 prior to returning the unit to service. The extent of condition for similar hoses on other operating Bruce A Units 1 and 2 was also assessed and determined that the hoses were safe for operations on the short term. However, since these hoses have also been in operation for an extended period, Bruce Power initiated their replacement and this will be done as soon as replacement parts (hose and couplings) become available. Bruce Power estimated a technical completion date for this work of June 2023 for Unit 1 and July 2023 for Unit 2. Bruce A Unit 3 is currently shut down for major component replace (MCR) and the hoses for that unit will be replaced within the MCR schedule prior to the unit returning to service. Bruce B hoses were also assessed, and no issues were found, but will also be replaced as part of the corrective actions. In addition to repairing the Unit 4 PHT purification system leak detection system an extent of condition was also conducted for similar beetle leak detection systems in other parts of Bruce A and B, and remedial repairs taken as necessary, to ensure reliable operation.

Unit 4 was returned to service on May 1, 2023.

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On May 3, 2023, Bruce Power submitted a Preliminary Event Report as per REGDOC-3.1.1, Reporting Requirements for Nuclear Power Plants, and the Detailed Event Report is due to be submitted on July 1, 2023.

For the determination of longer-term corrective actions, a Root Cause Analysis is being conducted. To date, Bruce Power has identified hose failure as the primary cause of the event, with leak detection and identification a secondary root cause. Bruce Power's preventive maintenance program did not identify the importance of the replacement of the purification hoses, with corrective actions being taken in this regard. Enhancements to spills response measures are also being assessed. Regarding leak detection, Bruce Power has determined that the moisture detector (beetle) design is not robust. Bruce Power is working on increasing redundancy using other means to detect moisture to provide back up in case of beetle moisture detection failures. In addition, actions are being taken to ensure preventive maintenance inspections are better documented to identify as-found conditions for equipment that fails testing.

Bruce Power has informed other Canadian NPP licensees of this event as part of CANDU Owners' Group OPEX sharing activities. Bruce Power is working with Canadian NPP operators on the periodic review of response to abnormal operational events as an improvement to current OPEX sharing activities.

CNSC Actions

Taken or in Progress: Upon verbal notification of the event at approximately 7:20 on April 26, 2023, a CNSC site inspector was dispatched to Bruce Power's Emergency Management Centre to monitor Bruce Power's event response. CNSC staff also monitored remotely via Bruce Power's online emergency management system, which provides updates online regarding emergency actions implemented. CNSC staff continued to monitor Bruce Power's response actions over the course of the day.

Although Bruce Power notified the Bruce Regulatory Program Division of the event verbally at approximately 7:20 on April 26, 2023, a formal Duty Officer notification was not made until 11:04. On April 26, 2023, DPRR staff liaised with the CNSC's Corporate and Regulatory Communications staff to prepare information in case of media interest. Information on this event was posted to the CNSC external website. Indigenous Nations and communities in the vicinity of the Bruce NGS were notified of this event by CNSC staff.

In the days following the initial event response, CNSC staff continued to monitor the spill recovery efforts and short-term actions conducted by Bruce Power to address the cause of the leak.

CNSC staff attended Bruce Power's Event Review Board meeting on May 2, 2023, and subsequently met with Bruce Power staff multiple times to obtain additional information on the event.

CNSC staff reviewed the REGDOC-3.1.1 Preliminary Event Report submitted on May 3, 2023 and continue to monitor licensee follow-up corrective actions through review of station records, discussions with licensee staff, and on-site field inspections.

In response to the inactive drain that was not plugged and led to heavy water leaking into the environment, CNSC staff have conducted a reactive environmental protection inspection to verify that Bruce Power has correctly characterized inactive drains that are identified as plugged. Results of this inspection are pending review.

To verify the adequacy of Bruce Power's emergency response procedures, CNSC staff are initiating an action item on Bruce Power with a request to review and, if necessary, update their procedures.

Based on the information provided to date, CNSC staff are, overall, satisfied with Bruce Powers actions taken in response to the event. CNSC are conducting, or will conduct, additional compliance activities in the areas identified above and in the planned activities noted below where CNSC staff has identified that additional information is needed.

Planned:

1. CNSC staff will increase the scope of a planned preventive maintenance inspection to examine the preventive maintenance factors that lead to the hose failure that occurred during the event.

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- Based on the results of this inspection, CNSC staff will consider further activities regarding the preventive maintenance of all non-metallic hoses at the Bruce Power NGS, and whether this should be assessed across the Canadian CANDU fleet.
- 2. CNSC staff will conduct a reactive inspection to verify the radiation protection response actions taken during the event and subsequent clean-up activities for minimizing environmental/worker impacts.
- 3. CNSC staff will review and assess the REGDOC-3.1.1 Detailed Event Report and Root Cause Analysis once complete and submitted by Bruce Power. Based on the information submitted, CNSC staff will consider additional compliance verification and follow-up activities including:
 - Performance and reliability issues with beetles including redundancy, preventive maintenance, and other means by which heavy water leaks may be detected.
 - Noting that the leak occurred in an area of the station that is not frequently accessed and difficult to access, verification of how Bruce Power ensures that such areas of the stations are inspected for any issues .
 - Reviewing how licensee safety culture may have impacted response to this event.

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Additional reporting to the Commission Members anticipated:

Yes

No

Name and Title	Signature
<p>Alexandre Viktorov</p> <p>Directorate of Power Reactor Regulation</p>	 <div style="font-size: small; margin-top: 5px;"> Digitally signed by Viktorov, Alexandre DN: C=CA, O=GC, OU=CNSC-CCSN, CN="Viktorov, Alexandre" Reason: I am approving this document Location: Date: 2023.06.19 08:43:40-04'00' Foxit PDF Editor Version: 12.1.2 </div>
	<p>Director General</p> <p style="font-size: large; font-weight: bold;">19 June 2023</p>