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Written submission from Bruce Power

Mémoire de Bruce Power

Follow up from June 28, 2023
Commission Meeting

Suivi découlant de la réunion de la
Commission du 28 juin 2023

**Bruce Power: Update on the Unit 4
Primary Heat Transport
Purification System Leak at the
Bruce Nuclear Generating Station A**

**Bruce Power : Mise à jour sur la
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

December 13-14, 2023

13 et 14 décembre 2023

Attachment A

**Bruce A: Update to the CNSC Commission on the
Unit 4 Heat Transport Purification System Heavy Water Leak**

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Unit 4 Heat Transport Purification System Heavy Water Leak**

Summary of Event:

On April 25, 2023, the Bruce A Unit 4 Heat Transport System (HTS) experienced a leak outside of containment losing HTS inventory that challenged the normal method for inventory makeup, exposed station personnel to a radiation hazard, and resulted in an unplanned shutdown and depressurization. Despite these challenges, adequate heat sink and inventory for the purpose of fuel cooling were maintained throughout the event.

The elevated leak rate was detected by control room staff through routine monitoring. Unit 4 was safely removed from service utilizing normal operational procedures.

Due to this event, staff received 22mSv (2.2 Rem) of dose in total, including initial D2O spill response, Unit 4 containment vault entry, decontamination, maintenance and, supporting work activities in R4-102. The highest individual dose uptake was 2.36 mSv and no radiological action levels were exceeded. The airborne radiological emissions from Bruce A remained well below the Environmental Action Levels.

The leak was from a hose in the HT purification circuit, which was difficult to diagnose, as a key indicator pointing to the location of the leak also failed.

Unit 4 was shut down for five days to allow for cleanup and hose replacements.

Extent of Condition:

Heat transport purification hoses and beetles, with similar design and construction, exist at both Bruce A and B and are inspected, repaired and/or replaced at a pre-defined frequency under Bruce Power's Preventative Maintenance (PM) program.

Following the event, inspections of HT hoses and beetles were completed. As a result of these inspections, five beetles were repaired, redundant detection mechanisms were added to critical locations and 32 HT hoses were replaced.

Additionally, an Extent of Cause on other station component hoses was completed to confirm their relation to the Pressure Boundary (PB) Program and that their PM strategies were as expected. Work orders for hose replacements scheduled in 2023 and 2024 were reviewed and verified.

Root Cause Investigation:

As a result of this event, Bruce Power conducted a Root Cause Investigation (RCI). As a result of the RCI, the following was identified:

- Two Direct Causes:
 - HT Purification Filter Return Hose ruptured; and,
 - The ruptured HT Purification Hose was not isolated until after Unit 4 was shut down and depressurized.

- Two Root Causes:
 - A gap between the PB Program and the Preventative Maintenance (PM) Program with respect to hose replacements; and,
 - The absence of a program to manage and improve response to abnormal operation events.

In addition to the purification hose failure, the local leak detection beetle failed to alarm, which challenged diagnosis and isolation of the leak. This is considered to be a contributing factor to the duration of the event.

Corrective Action:

As a result of this event, Bruce Power has developed a comprehensive response plan that addresses gaps and sustainably improves performance in four areas:

1. Radiological and Environmental Safety
2. Operational Response
3. Maintenance Practices
4. Organizational Effectiveness

This plan, and the status of the actions, are reviewed on a regular basis at the Chief Executive Officer Direct Report Meeting to ensure effective implementation of the plan.

Radiological and Environmental Safety

A learning team was brought together to assess the spill response evolution and make recommendations to improve future responses. These recommendations included:

- pre-staging additional spill response material, spill response equipment and personal protective equipment (PPE) at designated locations throughout the station and establishing regular routines to check and replace material and equipment, as required,
- updating spill response procedures to ensure effective worker coordination,
- developing a method to remotely trigger sump pumps, and
- to evaluate the use of engineered barriers to block inactive drains in the vicinity of heavy water systems.

These actions are scheduled to be complete by May 2024.

A project to determine the feasibility of replacing HT purification hoses with hard piping has been completed. Options to support ease of filter replacement/maintenance with the hard piping configuration is currently being evaluated.

Operational Response

- The operational procedures used to direct HT leak response have been updated to include additional guidance to improve leak detection, search and mitigation actions based on this event, external OPEX and industry best practices.
- The operational procedures used to direct alternate checks have been updated and reissued to include additional guidance on secondary indications that should be used when beetles are known to be out of service.
- Focused training based on operating experience and lessons learned from this event was developed and delivered to control room staff. This covered a range of training items around HT leakage and leak rates.
- The creation of a HT storage tank rate of change alarm, and the automation of a leak rate calculation to provide active trending and formal output on the digital control computer, is being evaluated. Feasibility is expected to be determined by December 2023.
- This event and the updated HT leak response procedures have been incorporated into training and modeled in Bruce Power's simulator. The updated procedures and abnormal incident manual have been incorporated into simulator training as a focus area in 2024.

Maintenance Practices

- The PM frequency for beetle inspections was adjusted from 30 months to six months for beetles that can be inspected while a unit is in operation. Beetles that are only accessible during a unit outage will continue to be inspected during an outage.
- To address the gap between the PB and PM Programs with respect to hose replacements, a mandatory PM for PHT purification hoses was created, and PHT purification hoses have been added to the Performance Monitoring Equipment List.
- An enhanced beetle design has been developed to improve the reliability, redundancy, and dependability of leak detection systems; this design will provide indication to the main control room when a beetle is in a failed state (i.e., disconnected). Beetle addition and replacement will occur online and during scheduled outages between 2024 and 2029.
- To improve the accuracy, quality, and timeliness of collecting feedback from maintenance on field conditions (e.g., "as found" / "as left"), a software system that integrates with Bruce Power's work management systems will be rolled out beginning in December 2023. Maintenance training has been updated to reflect this change.

Organizational Effectiveness

- An A3 problem solving investigation was completed on a declining trend of PM health. A Health Index has been implemented and the Preventative Maintenance Oversight Group (PMOG) Terms of Reference, Meeting Agenda and Key Performance Indicator Dashboard have been updated to address identified weakness in PM health.
- An external industry advisor/subject matter expert has been retained to evaluate and align Bruce Power's Abnormal Incident Manual and Abnormal Incident Program with industry best practice. Terms of Reference for an industry working group have been established with the group to convene in Q1 2024.
- A pulse safety culture survey was conducted to obtain employee feedback based on the Institute of Nuclear Power Operations (INPO) traits of a health nuclear safety culture. Details of this survey are outlined below.

Safety Culture:

As a learning organization, Bruce Power actively engaged workers at all levels of the organization to gather insights on safety culture, based on their experience in relation to the Unit 4 leak event, through a pulse safety culture survey. One hundred and eighty-eight (188) survey participants provided feedback based on the INPO traits of a health nuclear safety culture.

A cross-functional leadership reflection session was held to identify beliefs the workforce holds, and the experiences that are shaping those beliefs. Bruce Power also developed a future state to define “the workforce beliefs we want in our culture” and the experiences workers would need to create these beliefs.

An action plan has been developed and is being implemented to create these experiences to drive the culture shift to workforce beliefs that:

- Duty crew staff understand their authority to place the plant in a safe condition when the situation warrants; and,
- Leaders ensure priorities are aligned to reflect nuclear safety as the overriding priority and messaging is consistent.

Bruce Power routinely uses various tools within our safety culture monitoring program to gather insights from staff at all levels to understand how safety culture may influence behaviors and decisions. We will continue to use these tools to monitor the progress of this action plan.

Emergency Response:

Bruce Power has also taken corrective actions with respect to the emergency response plan and procedures.

Adequacy of emergency response plan

BP-PLAN-00001, *Bruce Power Nuclear Emergency Response Plan*, BP-ERP-00001, *Shift Emergency Controller – SEC*, and interfacing procedures will be reviewed. If necessary, these documents will be updated with a focus on ensuring the criteria for declaring a station emergency are clear and implementable; specifically:

- The adequacy of categorization in BP-ERP-00001 will be reviewed,
- BP-RPP-00047, *Station Response to an Abnormal Radiological Condition*, will be reviewed to ensure it directs personnel to BP-ERP-00001,
- BP-PLAN-00001 will be reviewed to ensure it aligns with any changes made to BP-ERP-00001.

Personnel will be briefed on any changes through tabletop exercises and/or other communications. The target completion date for the above review is December 2023.

To ensure that staff assembly and accounting in the event of an emergency can be done without the potential for additional risks to workers, BP-PROC-00405, *Bruce Site Assembly, Accounting and Evacuation*, was revised and reissued. This included revision to:

- Station assembly area supervisor job aid,
- Evacuation area supervisor job aid,
- Station assembly and accounting What Excellence Looks Like (WELL) sheet; and,
- Building evacuation WELL sheet.