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Presentation from Bruce Power

Présentation de Bruce Power

In the Matter of the

À l'égard de la

Opportunity to be heard on the orders issued by a Designated Officer to Bruce Power and Ontario Power Generation

Possibilité d'être entendu au sujet des ordres délivrés par un fonctionnaire désigné à Bruce Power et Ontario Power Generation

Commission Public Hearing

Audience publique de la Commission

September 10, 2021

10 septembre 2021

Canada

September 10, 2021

Bruce Power Presentation: CNSC Commission Hearing

Designated Officer Order & Bruce Power Proposals

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Introduction

James Scongack
EVP, Operational Services

Bruce Power
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Context

- Bruce Power continues to demonstrate safety and pressure tube integrity in all of its units.
- Bruce Power has carried-out a range of activities to demonstrate compliance with the August, 2021 Order:
  - Additional inspections have provided a larger body of evidence to narrow the region of interest for elevated hydrogen concentration to a limited, localized (<0.5%) volume in the upper portion of the pressure tube, and
  - Additional inspections have further verified a large volume of results confirming there are no flaws in the region of interest.

Bruce Power is requesting the Commission to approve the Return to Service of Unit 3 and the return to service of Units 4,5,7 and 8 from an unplanned outage.

Planned Inspection Outages

	Inspection Date or MCR
Unit 3	Planned inspections complete on Unit 3 after 2021 outage – MCR to start Q1 2023
Unit 4	Next planned outage scheduled in second half of 2022 [Last inspection 2020]
Unit 5	Next planned inspection outage scheduled in first half of 2022 [Last inspection 2019]
Unit 6	Undergoing MCR – All pressure tubes being replaced
Unit 7	Next planned inspection outage scheduled later in 2021 [Last inspection 2019]
Unit 8	Next planned inspection outage scheduled in 2023[Last inspection 2020]

Planned outage campaigns will be used for additional verification and sequenced over the next 18 months. Units remain safe to operate to their planned outage and to return from an unplanned outage.

Request Commission Authorization

Bruce Power seeks Commission authorization to:

1. **Restart Unit 3 upon completion of its Planned Outage**
   - Large body of evidence collected during extensive inspection campaign demonstrates, with high confidence:
     - The conservative prediction of hydrogen concentration outside the region of interest, and
     - Based on extensive inspections, no flaws within the region of interest where elevated concentrations of hydrogen isotopes have been observed.
2. **Return Units 4, 5, 7, 8 to service should an unplanned outage be required before their next planned inspection and maintenance outage**
   - Meets the conditions of the Order and CNSC staff assessment criteria.
   - Inspection results and verified data consistently show, with a high degree of confidence, no flaws in the region of interest defined by CNSC in Units 4, 5, 7 and 8; additional inspections on Unit 3 further bound these units.
   - Bruce Power's strategy provides assurance of safety before returning a unit to service through safety margin enhancements that systematically prevent reactor states to further reduce risk.

Safety & Pressure Tube Integrity

Chris Mudrick
Chief Nuclear Officer

Bruce Power
Innovation at work

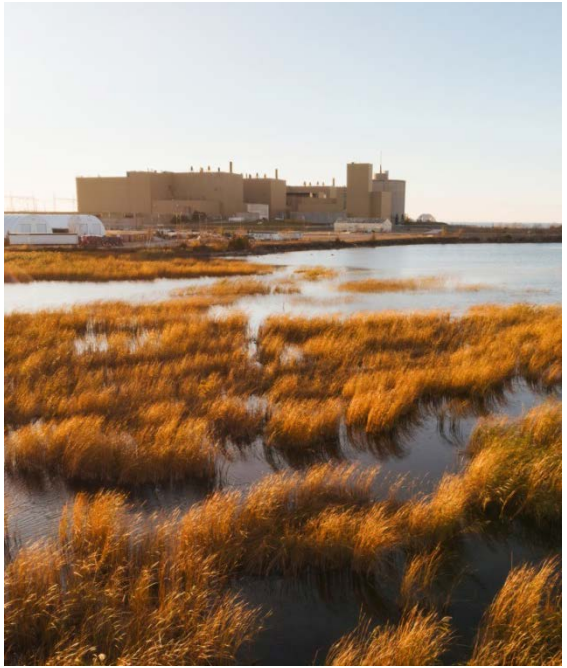
Defense in Depth

High levels of safety, defense in depth and pressure tube integrity at Bruce Power in any mode of operation.

In addition to ensuring pressure tube integrity through inspections and analysis, additional concrete steps have been taken to strengthen safety margin.

- Plant configuration and design enhancements
- Procedural changes and additional operator training

Further improves margins of safety by applying several proactive and post shutdown measures through a defense in depth approach.



Safety Margin and Defense in Depth Remains Strong.

Layers of Safety

- From an operational perspective, the risk is limited to a certain temperature/operational envelope including heat-up and cool down which is limited to <3% of the full range of operating conditions.
  - Strong operational, monitoring and protections are in place providing defense in depth.
- High hydrogen concentrations in isolation will not initiate a challenge to the integrity of a pressure tube.
  - Bruce Power inspects for both Hydrogen Concentrations and Flaws in the pressure tube to maintain pressure tube integrity.

Pressure tube integrity in all units is maintained through inspections to verify flaws are not present and defence in depth.

Inspection Tools

- Circumferential Wet Scrape Tool (CWEST)
  - The CWEST tool takes pressure tube scrape samples determine the hydrogen concentration compared to model predictions.
- Advanced Non-destructive Evaluation Tool (ANDE)
  - The ANDE tool uses ultrasonic testing to measure flaws, pressure tube to calandria tube gap and determine spacer location
- Spacer Location and Relocation (SLAR) and Modal Detection And Relocation(MODAR)
  - The SLAR tool locates spacers and relocates them to optimal positions to ensure that there is adequate gap between the pressure tube and calandria tube.
  - The MODAR tool is used in Unit 8 to perform the same function as SLAR for other units.

Modern inspection tools are utilized during outages to demonstrate fitness for service

Inspections

- Bruce Power applies the evidence we gather from every inspection campaign to continuously improve/focus our inspections, surveillance and maintenance activities.
- Modified tooling and scope selection have and will enable future planned outage inspection campaigns to provide on-going confirmatory results to provide assurance that:
  - Elevated hydrogen concentrations remain consistently within the localized, limited region of interest at the top of the tube and to continue to verify there are no flaws in the region of interest.
- Updates to fracture protection modelling based on new information and verification testing will provided additional certainty.
- Bruce Power will continue to meet Fitness for Service requirements on all Units.

Commission approval of the Unit 3 and unplanned outage proposal will not compromise safety, pressure tube integrity and is consistent with the Order.

Technical Basis for Return to Service

Gary Newman
Chief Nuclear Engineer

Bruce Power
Innovation at work

Pressure Tube Integrity

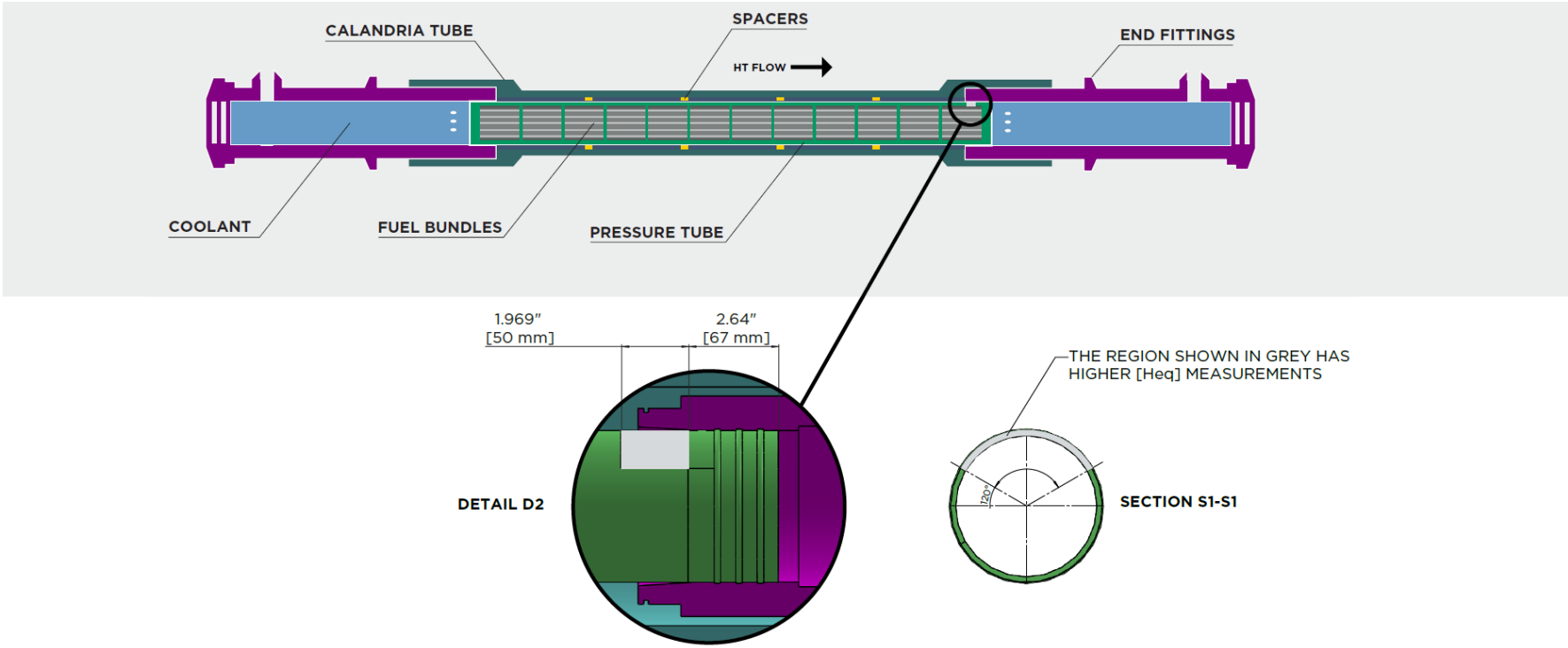
- High hydrogen concentrations in isolation will not initiate a challenge to the integrity of a pressure tube,
  - Based on empirical evidence, it has been demonstrated that **both** high hydrogen concentrations and a flaw with certain characteristics is needed to challenge pressure tube integrity.
- Bruce Power's life cycle program completes surveillance for both Hydrogen Concentrations and Flaws in the pressure tube to demonstrate pressure tube integrity.

The Order is consistent principles of Pressure Tube integrity – Bruce Power complies with this in both proposals submitted to the Commission.

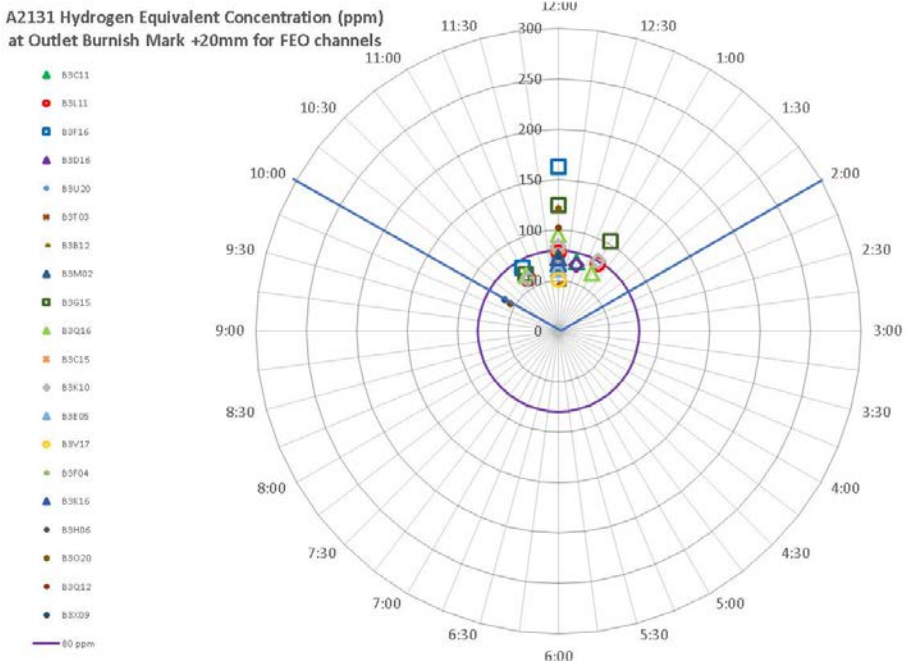
Recent Inspection Results

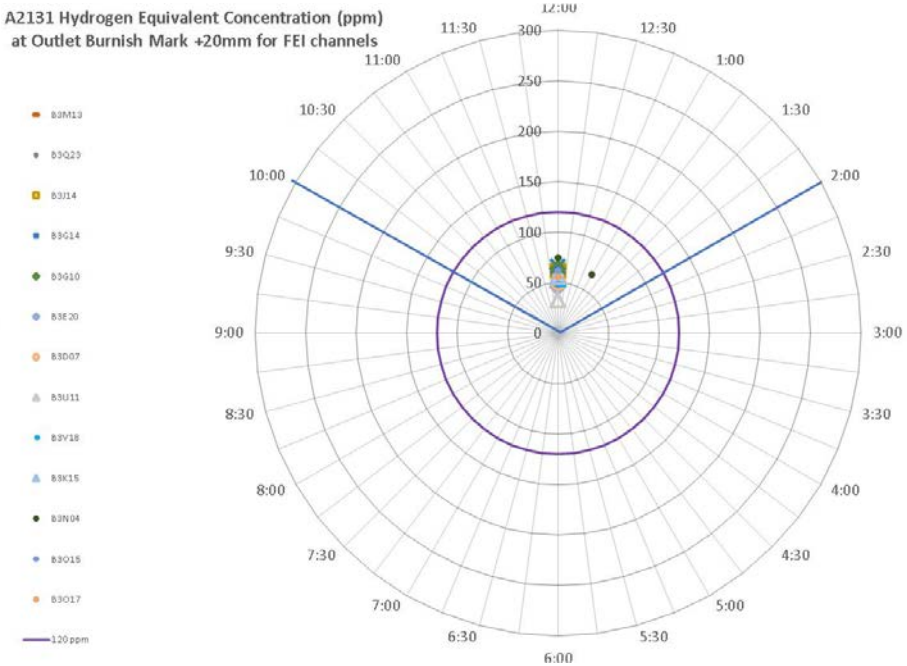
- The original Unit 3 CWEST inspection scope included 8 pressure tubes, three pressure tubes were identified with elevated hydrogen concentration compared to the predicted values in a narrow region of interest.
  - A large population of additional CWEST scrape samples (42) were conducted to confirm the region of interest for concentrations in a narrow region of interest.
  - All of these channels also had ANDE inspections conducted which confirmed no flaws in the region of interest. This approach was also used to further bound the remaining Units and compliment existing evidence.
  - Review of the results of the Unit 3 fuel channel inspection campaign identified in only a subset of tubes a small localized region in the upper half of the tube with a large circumferential variation of hydrogen concentration.
- As a part of the industry surveillance program, pressure tubes removed from Bruce Unit 6 during the MCR outage were selected mainly due to high circumferential variability – results were found to be similar to the narrow region of interest in Unit 3.

Region of Interest

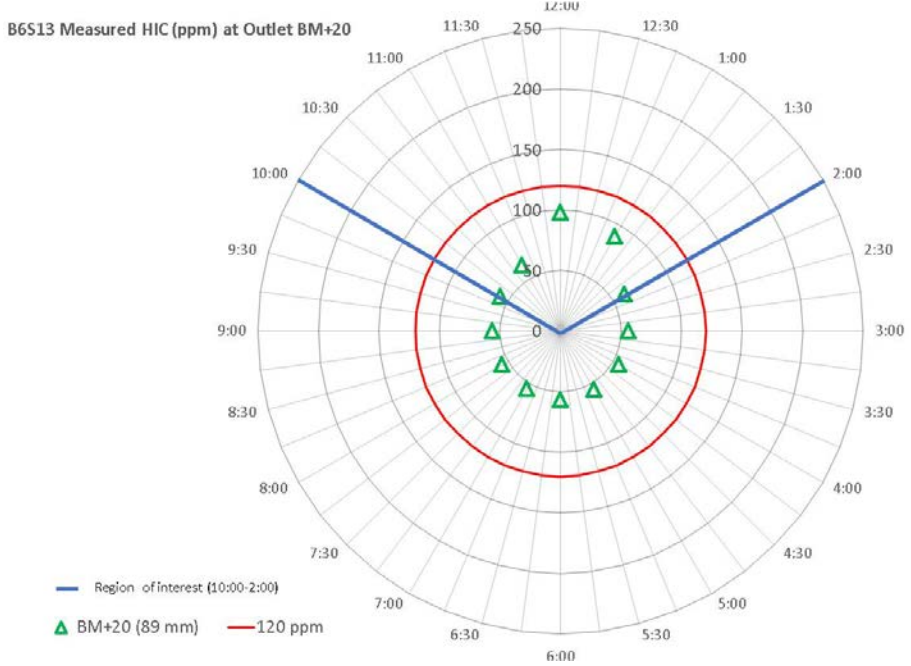


Unit 3 Example





Unit 6 Example

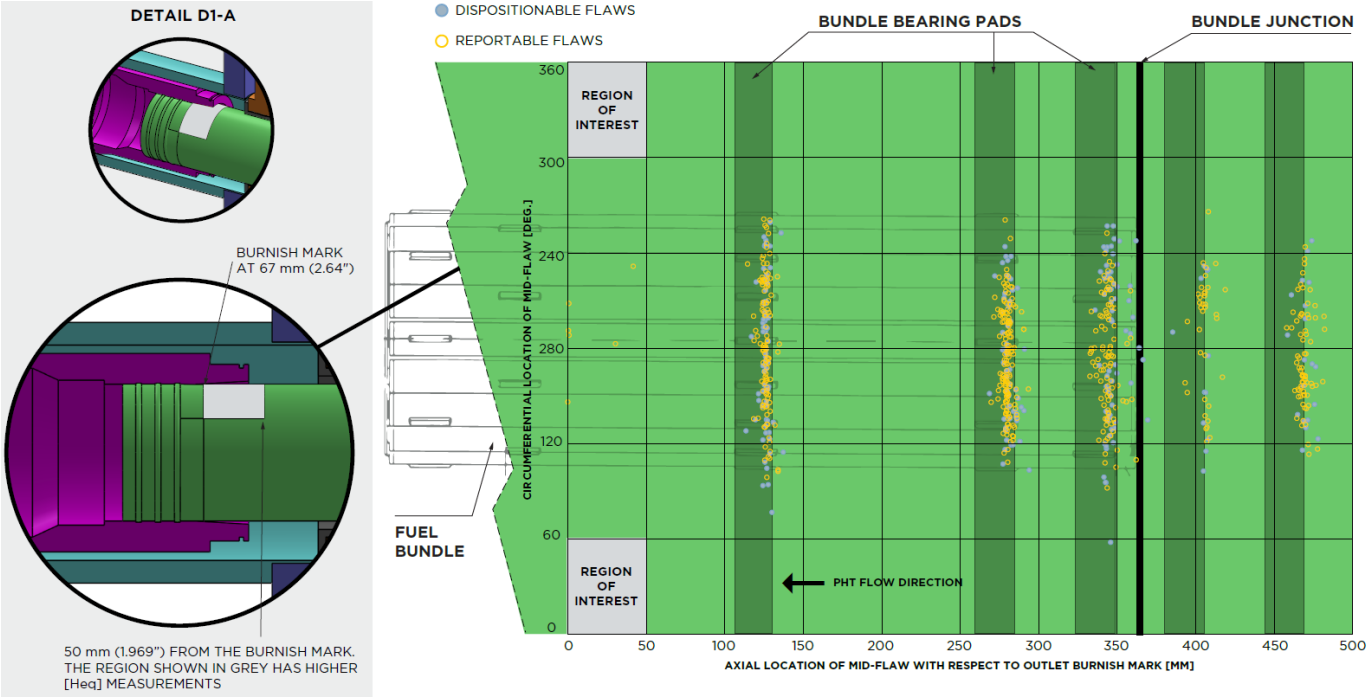


Using results from both Units 3 and 6 the region of interest is well-defined.

Hydrogen concentrations are within predictions outside of the region of interest.

Surveillance Evidence Demonstrates –

No Flaws in Region of Interest



NO FLAWS in the limited region of interest where hydrogen concentration is above model predictions (<0.5% of tube)

+

HIGH CONFIDENCE hydrogen concentrations conservatively below the licensing limit in the balance of the tube (>99.5%)

=

Pressure Tube INTEGRITY

Large Population of Evidence

Bruce Power has performed 448 unique pressure tube inspections (or 728 total inspections including revisits) in Units 3, 4, 5, 6, 7 and 8 – equivalent to nearly one full reactor core (480 channels). This is done on a routine, planned basis as normal practice for planned outages

Based on this evidence and a large population of Bruce channels, **no flaws** have ever been detected in the region of interest at the top of the tube in any Bruce Power unit.

- Bruce Power does not anticipate flaws to ever occur in the region of interest as fuel bundles do not come in contact with this area of the pressure tube based on the design of the bundles and channels.

Statistical analysis has been completed demonstrating very high confidence the large population of channels bounds all Units for flaws in this region of interest.

During upcoming planned outages this will continue to be verified as part of the periodic inspection program.

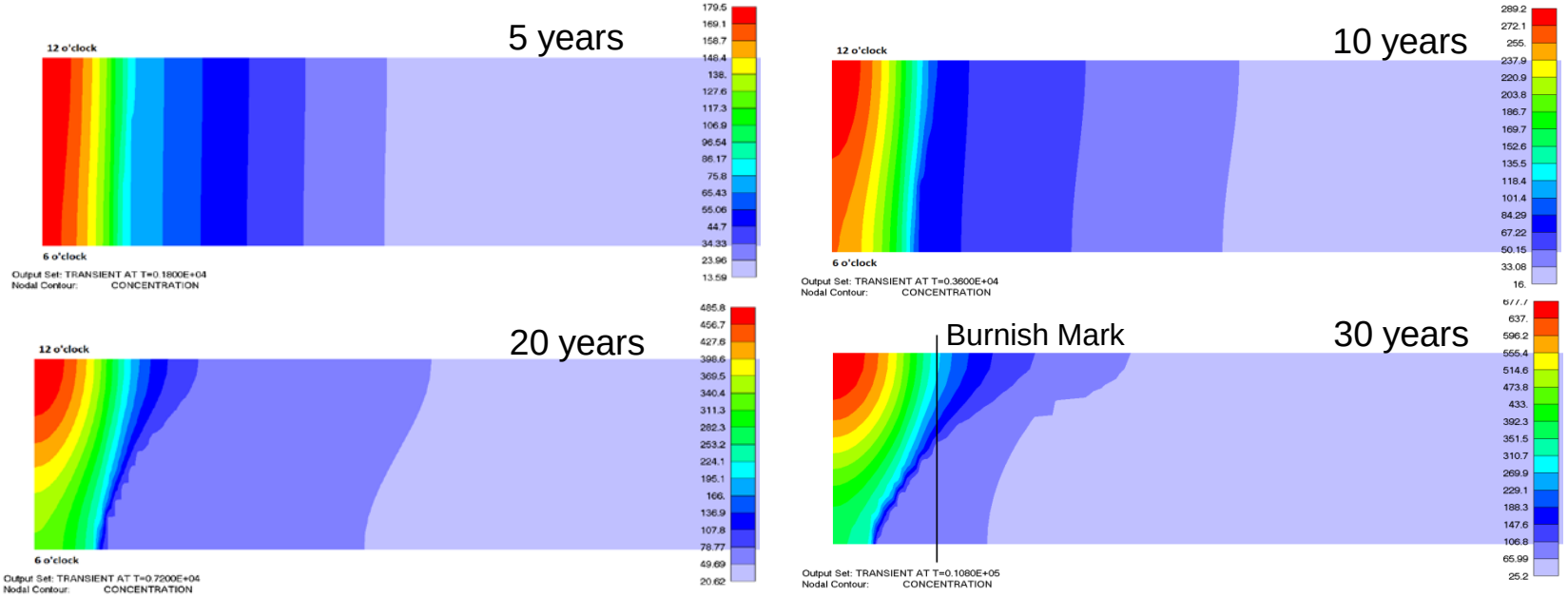
Understanding the Mechanism

- Higher hydrogen concentrations are encountered in some pressure tubes and are consistently found at top of tube in a narrow region of interest.
  - For affected pressure tubes, measurements in areas outside of the region of interest at top of the tube are significantly lower and within traditional model predictions.
- Hydrogen redistribution is occurring due to a temperature gradient at outlet ends.
  - Analysis has been completed based on recent results to understand this mechanism.

Elevated hydrogen concentrations are limited to a small portion of the pressure tube as determined through extensive scrape sampling and surveillance results.

Rolled Joint Ingress

Temperature Gradient



Progression of total concentration distribution from 5 to 30 years

Fitness for Service

- The existing flaw analysis in all Units **remains valid** - *not impacted by elevated hydrogen concentration observed in the region of interest*. Newly inspected Unit 3 channels during A2131 will be addressed following standard fitness-for-service requirements.

- The existing Pressure Tube/Calandria Tube (PT/CT) contact dispositions **remains valid** - *not impacted by elevated hydrogen concentration in the region of interest.*

    - No PT/CT contact in the region of interest is physically possible.

- The existing fuel channel elongation assessments **remains valid** - *not impact by elevated hydrogen concentration in the region of interest.*

Fitness for Service in all of these areas will be maintained for Unit 3 and other Units.

Fracture Protection

- Current fracture protection assessments of record demonstrating compliance with CSA N285.8 are still valid for the rest of the pressure tube outside of the region of interest.
  - Elevated hydrogen concentration in the narrow region of interest will be updated in in analysis to be submitted to CNSC staff in the near future.
- A risk-informed approach is inclusive of operational defense in depth, significant population of evidence from inspections, Pressure Tube integrity factors and conservatism in the fracture toughness model.
  - Modifications to the heat-up and cooldown profile in the operating units are being evaluated in parallel to demonstrate compliance with required safety factors.
  - Margin improvements be implemented to maintain safety factors as required by CSA Standard N285.8 including deterministic fracture protection evaluations.
- Continued low risk of crack initiation will be demonstrated given the overall strength of Pressure Tube integrity.
  - Additional confirmatory testing will also be completed and provided to CNSC Staff.

Bruce Power will continue to demonstrate strong Fracture Protection

Probabilistic Assessments

- The probabilistic core assessment will be updated to reflect the change in prediction of hydrogen concentration in the region of interest.
  - This is expected to be insignificant and not materially impact the conservative safety margin in place.
- The probabilistic fracture protection assessment will also be updated to address channels that have not been inspected.
  - This is expected to be insignificant and not materially impact the conservative safety margin in place.

Conservative safety margin will continue to be demonstrated in both the core and fracture protection probabilistic assessments.

Return to Service Summary

1. Elevated hydrogen concentrations **localized** to limited to the region of interest and inspections have demonstrated no flaws in this area.
2. Methodology applied to Flaw analysis, PT/CT contact and fuel channel elongation assessments remain valid and are **not impacted** and will be submitted to CNSC staff following normal process for Unit 3.
3. **Strong Fracture Protection** will continue to be demonstrated including deterministic analysis.
4. Probabilistic assessments will be updated and will not materially impact the **conservative safety margin in place**.

Safety and Pressure Tube Integrity will continue to be demonstrated in the proposals to return Unit 3 to service and the unplanned outage framework before the Commission for consideration.

Conclusions & Request

Chris Mudrick
Chief Nuclear Officer

Bruce Power
Innovation at work

Conclusions

- Units 4,5,7 and 8 are compliant with the Order to safely return a Unit from an unplanned outage given a large population of inspection evidence both historic and recent.
  - Planned outages scheduled on all Units will provide additional verification through the periodic inspection program.
- Unit 3 meets the conditions of the Order for Commission approval to Restart when its outage is completed in October.
  - Additional submissions will also be provided to the CNSC as outlined in the proposal.
- Margins of safety are being further enhanced through plant configuration, design and procedural changes as well as operator training to assure safety and safety margins before returning a unit to service.

Bruce Power has demonstrated high levels of Safety and Pressure Tube integrity

Request

- Bruce Power is requesting Commission approval of both proposals for Unit 3 and unplanned outages.
  - Safety and Pressure Tube integrity have and will continue to be demonstrated.
  - Compliance with the August, 2021 Order is demonstrated in both proposals before the Commission.
  - Given the planned inspection program and sequential execution of these activities over the next 18-months from a plant, tooling and human resources perspective certainty is required to return Unit 3 to service and to return a Unit from an unplanned outage.
- Bruce Power will be providing CNSC Staff additional submissions as part of the existing fitness for service framework as outlined in the presentation and proposals.
- Given the extensive detail and verification that underpin the demonstration of safety and pressure tube integrity, Bruce Power is requesting a timely decision for both proposals.

Safety and Pressure Tube integrity will not be compromised