Canadian Nuclear Safety Commission	**Commission canadienne de sûreté nucléaire**
Public meeting	**Réunion publique**
September 3rd, 2021	**Le 3 septembre 2021**
Public Hearing Room 14th floor 280 Slater Street Ottawa, Ontario	Salle des audiences publiques 14e étage 280, rue Slater Ottawa (Ontario)
via videoconference	*par vidéoconférence*
Commission Members present	**Commissaires présents**
Ms. Rumina Velshi Dr. Sandor Demeter Dr. Timothy Berube Dr. Marcel Lacroix Dr. Stephen McKinnon Ms. Indra Maharaj Mr. Randall Kahgee	Mme Rumina Velshi Dr Sandor Demeter M. Timothy Berube M. Marcel Lacroix M. Stephen McKinnon Mme Indra Maharaj M. Randall Kahgee
Secretary:	**Secrétaire:**
Mr. Marc Leblanc	Me Marc Leblanc
Senior General Counsel:	**Avocate-générale principale :**
Ms. Lisa Thiele	Me Lisa Thiele

TABLE OF CONTENTS

via videoconference / par videoconference

--- Upon commencing on Friday, September 3, 2021 at 1:00 p.m. / La réunion débute le vendredi 3 septembre 2021 à 13 h 00

Opening Remarks

THE PRESIDENT: Good afternoon and welcome to this virtual meeting of the Canadian Nuclear Safety Commission.

Mon nom est Rumina Velshi. Je suis la présidente de la Commission canadienne de sûreté nucléaire.

I would like to begin by recognizing that our participants today are located in many different parts of the country. I will pause for a few seconds in silence so that each of us can acknowledge the Treaty and/or traditional territory for our locations. Please take this time to provide your gratitude and acknowledgment for the land.

Je vous souhaite la bienvenue and welcome to all those joining us via Zoom or webcast.

I would like to introduce the Members of the Commission that are with us today remotely: Dr. Sandor Demeter; Dr. Stephen McKinnon; Dr. Marcel Lacroix; Dr. Timothy Berube; Ms. Indra Maharaj and Mr. Randall Kahgee.

Ms. Lisa Thiele, Senior General Counsel to the Commission, and Marc Leblanc, Commission Secretary, are also joining us remotely.

The Commission meeting today is an information session to discuss CNSC staff's July 16, 2021 Event Initial Report following Bruce Power's reports that two reactor units showed pressure tube hydrogen equivalent concentrations (or Heq) that exceeded the licence limit of 120 parts per million (or ppm).

After being informed of this discovery, CNSC staff took regulatory action on July 13, 2021, pursuant to subsection 12(2) of the *General Nuclear Safety and Control Regulations*, requiring Bruce Power, Ontario Power Generation and New Brunswick Power to report on their analysis and review of pressure tube fitness for service and any other measures taken in response to this event.

I would also like to take this opportunity to welcome and introduce the Members of the External Advisory Committee on Pressure Tubes who are with us today: Dr. John C. Luxat, Chair of the EAC, Dr. Mark R. Daymond and Dr. Paul Spekkens.

The Commission established the External Advisory Committee on July 30, 2021, under its statutory authority to establish advisory committees, in order to complement the expertise of Commission Members and CNSC specialists, and to provide external perspectives for the benefit of Commission members in their role as decision-makers. The Committee will provide Commission Members with expert information and advice related to pressure tubes, Heq exceedances and predictive modelling.

Over the course of their two-year appointment, the Committee Members will be guided by principles of objectivity, impartiality, fairness, timeliness, responsiveness and transparency.

I encourage you to read their biographies on the CNSC website.

In addition to the review of CNSC staff's Event Initial Report, today's information session will also consider the licensees' reports submitted in response to the CNSC's subsection 12(2) regulatory requirements. The three licensees and CNSC staff will be making presentations, to be followed by a question period where the Commission Members will direct their questions to the licensees, CNSC staff and the CNSC External Advisory Committee on Pressure Tubes.

A separate public Commission hearing will take place on September 10, 2021 so that the Commission can review the CNSC Order issued to Bruce Power for the Bruce Nuclear Generating Stations and the two Orders issued to OPG for the Darlington and Pickering Nuclear Generating

Stations. The Commission is required by law to review these orders and will make a decision to confirm, amend, revoke or replace each of them following the September 10, 2021 hearing. These orders will not be reviewed today.

As always, I would like to begin today's Commission Meeting with a Safety Moment.

It's back to school time. As school doors open, traffic gets a little heavier on our streets. People are back from holidays, school buses and public transit are on regular routes, and more people are walking, cycling or driving to school.

For today's Safety Moment, here are a few basic but important reminders.

One: Observe school zone speeds. Although you should always obey posted speed limits, it is especially important during the school year. Children crossing the road on their way to and from school can easily get distracted and step into harm's way. Slowing down and being vigilant is crucial to keeping kids safe.

Number two: Obey the crossing guard. A crossing guard is there to keep children safe. If you come up to a set of lights and the light turns green but the crossing guard still says stop, follow their direction and not the traffic light. There might be a child still crossing the street that you can't see.

Number three: Watch for darting children. Kids are small and easily distracted, and for drivers this can create dangerous situations on the roads. Be vigilant and alert behind the wheel. You never know when a small child might step out from between parked cars or off a sidewalk. Your fast reflexes might be needed to prevent an accident.

And lastly: Be mindful of school buses. Most mishaps take place outside the bus. When driving your car near a school bus, please note that extra caution is needed. You NEVER pass a school bus when the signal lights are flashing, and drive slowly as a general precaution.

Thank you.

I will now turn the floor to Mr. Leblanc for a few opening remarks.

Marc, over to you.

M. LEBLANC : Merci, Madame la Présidente.

Bonjour, Mesdames et Messieurs. J'aimerais aborder certains aspects touchant le déroulement de la réunion.

For this Commission meeting, we have simultaneous interpretation. Please keep the pace of your speech relatively slow so that the interpreters are able to keep up.

To make the transcripts as complete and

clear as possible, please identify yourself each time before you speak.

The transcripts should be available on the CNSC website within the next two weeks.

I would also like to note that this proceeding is being video webcast live and that archives of these proceedings will be available on our website for a three-month period after the close of the proceedings.

As a courtesy to others, please mute yourself if you are not presenting or answering a question.

As usual, the President will be coordinating the questions. During the question period, if you wish to provide an answer or add a comment, please use the Raise Hand function.

The *Nuclear Safety and Control Act* authorizes the Commission to hold meetings for the conduct of its business.

Please refer to the agenda published on August 26th for the list of items to be presented today.

All the Commission Member Documents (or CMDs) listed on the agenda are available on the CNSC website.

In addition to the written documents reviewed by the Commission for this meeting, CNSC staff and other registered participants will have an opportunity to make verbal comments and Commission Members will have the opportunity to ask questions on the items before us.

Madame Velshi, présidente et première dirigeante de la CCSN, va présider la réunion publique d'aujourd'hui.

President Velshi...?

CMD 21-M31

Adoption of Agenda

THE PRESIDENT: Thank you, Marc.

With this information, I would now like to call for the adoption of the agenda by the Commission Members, as outlined in Commission Member Document 21-M31.

Do we have concurrence?

For the record, the agenda is adopted.

We will now begin with the presentation from CNSC staff and I will turn the floor to Dr. Viktorov.

Dr. Viktorov...?

CMD 21-M39/21-M37/21-M37.A

Oral presentation by CNSC staff

DR. VIKTOROV: Good afternoon, President Velshi and Members of the Commission. My name is Alex

Viktorov and I am the Director General of the Directorate of Power Reactor Regulation.

Today we will be providing an update to the Commission on the discovery at Bruce Nuclear Generating Station Units 3 and 6 of hydrogen equivalent concentration in pressure tubes exceeding the licence limit of 120 parts per million.

We will also summarize the impact that this discovery has had on all Canadian nuclear power plants.

Next slide, please.

This CMD provides details of and an update to the Event Initial Report regarding Bruce A Unit 3 and Bruce B Unit 6 hydrogen equivalent concentration (or Heq) in pressure tube licence limit exceedance.

CNSC staff will also present their assessment of Nuclear Power Reactor licensees' responses to requests pursuant to Subsection 12(2) of the *General Nuclear Safety and Control Regulations* regarding elevated Heq measurements. Licensees' analysis of the impact of this information on the demonstration of pressure tube fitness for service will be summarized as well.

Finally, the CMD provides the proposed next steps following the review by the Commission of the orders issued by the Designated Officer and any actions required related to compliance with the conditions of the orders.

I will begin by providing background information relevant to the Event Initial Report, finalized on July 16th of this year.

On July 5th, 2021, Bruce Power reported that measurements obtained from one Unit 6 pressure tube showed Heq above the predictions and exceeding the limit of 120 parts per million as set in Licence Condition 15.3.

On July 8th, 2021, Bruce Power reported a similar finding for one Unit 3 pressure tube.

CNSC staff immediately requested additional information from Bruce Power.

Within days, I also issued requests for information to all nuclear power plant licensees, pursuant to the *General Nuclear Safety and Control Regulations* subsection 12(2). The details of these information requests will be discussed in subsequent slides. All licensees responded to the 12(2) requests on time, by July 30th this year.

At the end of July, a CNSC Designated Officer also issued orders to Bruce Power and Ontario Power Generation which require Commission authorization prior to the restart of units with pressure tubes in extended operation, following any outage that results in the cooldown of the heat transport system.

The Event Initial Report provided the preliminary findings from in-service scrape samples in Bruce Unit 3 pressure tubes and laboratory examination of a Bruce Unit 6 pressure tube. The findings showed that Heq values were in excess of the 120 parts per million limit established in Licence Condition 15.3 of the Bruce Power operating licence. These findings were not predicted by the current models used for pressure tube fitness for service evaluations.

Bruce Power reported that measurements from a single point at the burnish mark of a pressure tube in Unit 6 showed 211 parts per million Heq, whereas the predicted value of the model was in the range of 100 parts per million. Bruce Power Unit 3 pressure tube inspections are still ongoing. However, preliminary measurements indicate that hydrogen equivalent concentrations in some pressure tubes are in excess of 120 parts per million.

The region of elevated Heq was localized near the outlet end fitting at the top of the pressure tube, as will be shown on the next slide. The root cause of the elevated Heq concentrations at these locations has not yet been determined.

It should be stressed that there were no pressure tube failures. The finding arose during Bruce

Power's activities required to satisfy the fitness for service requirements established in the facility's licensing basis.

Based upon information received to date, the region of elevated Heq observed in the Unit 3 and Unit 6 pressure tubes was located in the top half of the pressure tube within an axial distance of less than 75 millimetres from the area called a burnish mark. The burnish mark is formed by the rolled joint connecting the pressure tube to the end fitting. This region of interest represents less than 1.3 percent of the overall length of the pressure tube between the rolled joints.

Outside of the region of interest, the Heq of the pressure tube material was bounded by the current Unit 3 and Unit 6 Heq models.

This discovery is important because when pressure tubes are at temperatures below the normal operating temperature, high Heq can lead to a reduction in the fracture toughness. Fracture toughness characterizes the pressure tube material's resistance to failure from a crack.

Cracks could initiate from flaws that are formed on the inner diameter surface of a pressure tube due to interactions between the fuel bundles and the pressure tubes or from original fabrication flaws. A description of such flaws was presented by CNSC staff CMD 21-M4 that was presented to the Commission in January this year.

Licensees are required to have a model that accounts for temperature and Heq in order to predict the fracture toughness of pressure tubes during startup and shutdown conditions. The fracture toughness model that is currently accepted by CNSC staff has been validated for Heq up to 120 parts per million.

Currently, industry does not expect that the potential for crack initiation from flaws or the growth rate for cracks will increase at Heq values in excess of 120 ppm, but this expectation has not yet been fully validated.

The findings from the Bruce Unit 3 and Unit 6 pressure tube examinations raise questions regarding the pressure tube fitness for service evaluations performed with the current models.

Please note that in the context of this discussion a flaw is not the same as a crack. Licensees can safely operate pressure tubes with flaws provided they can demonstrate the flaws will not form cracks. Conversely, licensees are not permitted to operate pressure tubes with known cracks.

As mentioned, the degradation process that could be impacted by the findings is the formation and growth of cracks. The process is comprised of the initiation of a crack from a flaw on the inner diameter surface of a pressure tube and the growth of the crack through the wall of a pressure tube.

If the pressure tube fracture toughness at the location of the crack is not adequate, the pressure tube could fail suddenly. On the other hand, if fracture toughness is adequate, the crack would first lead to a leak that could be detected by the reactor leak detection systems and this would permit safe shutdown before the pressure tube failed.

Inspections conducted by licensees under their fitness for service program are used to identify potential flaws of concern for crack initiation. Should any flaws be detected, they are assessed for the potential for crack initiation and growth.

If flaws do exist, then confidence in the models for the crack initiation growth and the fracture toughness of the material is paramount to demonstrate pressure tube fitness for service.

If flaws do not exist, then there would be no driver for crack initiation and elevated Heq is not a concern.

Fitness for service requirements ensure that there are margins between the target operating condition and conditions that would be unsafe for operation. The goal is to maintain sufficient safety margins so that minor degradations do not immediately impact safety.

The elevated Heq measurements from the Bruce Unit 3 and Unit 6 pressure tubes exceeded the limit established in the Licence Condition 15.3, impacting the licensing basis safety margin. However, CNSC staff's assessment of the information indicates that the pressure tubes were not in an unsafe condition. This is because the region of elevated Heq was localized to a part of the pressure tubes where flaws that could lead to a failure of the pressure tubes do not exist.

The discovery also raises questions about the accuracy of the current Heq modelling approach near the outlet rolled joint in pressure tubes, which may impact evaluation of the other units with pressure tubes in extended operation.

The actions taken by CNSC staff in response to the discovery are intended to provide assurance that the safety margins are maintained.

Extended operation of pressure tubes refers to operation beyond 210,000 equivalent full power hours, or EFPH.

In order for a CANDU reactor to be

economically viable, during the design phase it was determined that they should operate for at least 30 years. It was also assumed the reactors would operate for 80 percent of the time on average. The other 20 percent of the time is allocated for maintenance and other outage activities. So in one calendar year, on average, a reactor would operate for about 7,000 equivalent full power hours. Multiplying 7000 by 30 calendar years equates to 210,000 equivalent full power hours.

To achieve this operating objective, pressure tube designers conservatively estimated the rates at which the tube dimensions would change due to irradiation and corrosion to ensure that the dimensions would not exceed allowable limits prior to reaching 210,000 EFPH operational target. As the Canadian reactors began approaching the operational target, licensees were able to demonstrate that the pressure tubes were not coming close to the dimensional or material property design limits.

In other words, pressure tubes can be operated safely as long as the dimensions and the material properties do not exceed limits that ensure the tubes can support design loads. Extending the operation of pressure tubes does not compromise safety as long the limits are not exceeded.

The following slides provide a summary of the information provided by Bruce Power and CNSC staff's assessment following the Event Initial Report.

Licence Condition 15.3 states the following:

"Before hydrogen equivalent concentrations exceed 120 parts per million, the licensee shall demonstrate that pressure tube fracture toughness will be sufficient for safe operation beyond 120 parts per million".

The *Licence Conditions Handbook* also states that licensees:

"...shall obtain approval of the Commission before operating any pressure tube with a measured Heq greater than 120 parts per million..."

The basis for the licence condition limit relates to the fact that the fracture toughness model predictions have only been evaluated up to an Heq level of 120 parts per million.

Bruce A Unit 3 and Bruce B Unit 6 were unknowingly operated outside of the licensing basis for a period of time prior to their shutdown. Both of these units are currently in shutdown.

The Heq modeling predictions underestimated the measured failures in Bruce Units 3 and 6 in a very particular area. Operation outside of the licensing basis does not automatically mean that the units are unsafe. However, Units 3 and 6 were operated in an unanalyzed condition for some pressure tubes at least.

Since the discovery, Bruce Power has performed additional inspections on a number of pressure tubes of Unit 3. Bruce Power reported that no flaws were identified in these pressure tubes in the region of elevated Heq, but the Heq measurement results were not yet submitted to CNSC staff at the time of preparation of this CMD.

A more detailed assessment of inspection results will be provided to CNSC staff in the coming days or weeks.

Unit 6 has been in an extended major component replacement outage since January 2020 and has had all pressure tubes removed for replacement.

Upon discovery of the elevated Heq concentrations, Bruce Power completed technical operability evaluations with the operating units, that is Units 1, 2, 4, 5, 7, and 8. Bruce Power reported that Units 1 and 2 are unconditionally operable, as their pressure tubes have been replaced and the units have not operated long enough to generate elevated Heqs in the pressure tubes.

Bruce Power also asserted that pressure tubes in Units 4, 5, 7, and 8 remain safe to operate.

Since Heq cannot be measured during a

reactor operation, Bruce Power based their conclusion on inspection results performed earlier to date, the lack of flaws observed in the region of interest, the material behaviour at full power operating conditions where Heq is not expected to impact fracture toughness, and the concurrence between predicted and measured Heq values outside the region of interest.

Upon reviewing the submitted information, CNSC staff concluded that safe operation of Units 1 and 2 is not impacted by the findings. And these units are unconditionally operable, at least until the end of the current licensing period. The pressure tubes in these units have been replaced and they have not operated long enough to generate elevated hydrogen concentration.

The elevated Heq observed in the Unit 3 and 6 pressure tubes would not impact safe operation of pressure tubes unless flaws exist in the region of interest that could lead to crack initiation. The likelihood of the existence of such a flaw is considered low in these units. CNSC staff has assured that there is a low risk to safe operation of the remaining Bruce Power units at least until the next outage.

CNSC staff also considered additional short-, medium-, and longer-term actions should be undertaken by the licensees to account for this elevated

Heq discovery event. These actions will be discussed in later slides.

The following slides describe the specific requests made under the *General Nuclear Safety and Control Regulations* subsection 12(2) to all licensees.

Under the overall request pursuant to subsection 12(2), CNSC staff requested Bruce Power to:

First: analyze the impact of this information on the demonstration of pressure tube fitness for service;

2: Conduct necessary tests and analysis to verify that operation of all reactors at Bruce Power remains within their licensing basis; and

3: Inform CNSC of any other measures taken in response to this information.

At the time same, Bruce Power is assessing the Unit 3 outage inspection results, and will submit the results and the impact of these results on pressure tube fitness for service to CNSC staff.

In the longer term, Bruce Power was requested to perform an analysis of the hydrogen uptake model validity.

The Bruce finding of the elevated Heq has raised concerns regarding validity of the Heq model, and this issue affects all Canadian nuclear plant licensees, since they all use similar models. Therefore, CNSC staff made similar requests to other licensees. In addition to confirming the receipt of the information regarding the discovery, the same three short-term actions were requested of Ontario Power Generation and New Brunswick Power.

At this time, I would like to turn the presentation over to Mr. Vali Tavasoli, director of the Operational Engineering Assessment Division, who will discuss the safety application of this discovery.

MR. TAVASOLI: Hello, can you hear me now? Okay, good.

Thank you, Dr. Viktorov, President Velshi, and Members of the Commission. My name is Vali Tavasoli, for the record.

CNSC staff assessed the 12(2) responses from Bruce Power, Ontario Power Generation, and New Brunswick Power with regards to the impact of the Bruce Power discovery event on their particular operation. Next, please.

The units identified in this slide are currently in extended operation and are considered safe to continue operation until at least the next outage, since hydrogen equivalent is not a concern when the pressure tubes are at full-power operating temperature. Next, please.

The Bruce, Darlington, and Point Lepreau units identified on this slide have recently been refurbished and have not operated long enough to generate elevated hydrogen equivalent levels in the region of interest. Thus, these units can be operated unconditionally for the remainder of their current licensing period.

Additionally, OPG does not plan to extend the operation of the Pickering Units 1 and 4 pressure tubes beyond 210,000 effective full-power hours, so elevated hydrogen equivalent is not expected prior to the end of operation. Next, please.

Bruce Unit 3 and Unit 6 and Darlington Unit 3 are currently in planned outages. Bruce Unit 6 and Darlington Unit 3 are in refurbishment outages and will have all of their pressure tubes replaced; therefore, they can be restarted without any concern over elevated hydrogen equivalent or the presence of flaws.

As will be discussed later in this presentation, Bruce Unit 3 will require Commission approval to resume operation from the current outage pursuant to the order issued by the designated officer. Next, please.

Continued operation is considered safe until the next outage of reactors in extended operation based on the following conditions:

- pressure tube material is demonstrated to retain sufficient fracture toughness at full power operating temperatures;

- low population of flaws in the region of interest of inspected pressure tubes based on previous inspection data;

- safety analysis remains valid; and

- finally, defence in depth provisions, which ensure safe shutdown, are maintained.

Next, please.

The following slides discuss the impact of the Bruce discovery event on safe operation. Next, please.

In order to confirm a plant's safety level, CNSC staff assess findings against two nuclear safety concepts, namely, defence in depth and fundamental safety functions. CNSC staff confirm that the levels of defence in depth remain intact for normal full-power operation and that the plant is able to fulfill the fundamental safety functions of control, cool, and contain. Next, please.

Defence in depth is a series of measures aimed at preventing accidents and ensuring appropriate protection in the event of failures. These are broken into five levels, summarized here.

The aim of the first level of defence is to prevent deviation from normal operation and to prevent failures of systems, structures, and components. Level 1 defence in depth is supported by fitness for service assessments of systems, structures, and components, ensuring components such as the pressure tubes do not fail due to high hydrogen equivalent levels. CNSC staff's concern is that this level of defence in depth may have degraded for some scenarios during reactor start-up conditions.

The aim of the second level of defence is to detect and intercept deviations from normal operation in order to prevent events from escalating to accident conditions and to return the plant to a state of normal operation. For a pressure tube crack, level 2 defence in depth is achieved by the annulus gas system whose purpose is to identify small pressure tube leaks before they develop into full rupture. This allows the operator to safely shut down the reactor, averting an accident.

The aim of the third level of defence is to minimize the consequences of accidents by providing inherent safety features, fail-safe design, additional equipment, and mitigating procedures.

To support third-level defence in depth, design basis accidents are analyzed to demonstrate the capabilities of the safety systems to mitigate any resulting radiological consequences.

As this is a design basis accident, level 4 and 5 do not apply in this case. Next, please.

To support level 3 defence in depth, deterministic safety analysis is performed for all design basis accidents. A single pressure tube rupture is a design basis accident. The safety analysis assumes that level 1 and level 2 defence in depth have failed to prevent the event from happening.

To confirm safety system effectiveness, the safety analysis is performed as follows. A bounding initiating event, normally a failure, is assumed to happen. An accident sequence is determined using conservative assumptions for plant conditions. The plant and safety system responses are modeled. The consequences are then calculated and compared to acceptance criteria to confirm that the safety systems are able to mitigate the accident and fulfill the fundamental safety functions of control, cool, and contain. Next, please.

The level 3 defence in depth assessment assumes the most bounding pressure tube failure accident progression as follows. One pressure tube and its corresponding calandria tube are assumed to fail simultaneously. The force of the water exiting the break causes the two ends of the pressure tube to swing away from each other, damaging the neighbouring shutdown system 1 shut-off rod guide tubes. The force of the broken pressure tube impacting adjacent fuel channels is also analyzed and must show that it does not cause additional failures.

The primary heat transport water from the break overfills the calandria and the excess water spills out into containment.

An overlapping and independent set of instrumentation detects the break and triggers either of the two independent shutdown systems. The detection system in containment initiates containment isolation.

Finally, the emergency coolant injection system initiates, providing both short-term and long-term fuel cooling. It is CNSC staff's view that the hydrogen equivalent finding will not impact the bounding sequence of events I just described. Next, please.

In assessing the impact of the hydrogen equivalent finding onto the level 3 deterministic safety analysis, it is CNSC staff's view that the three fundamental safety functions of control, cool, and contain will not be impacted in the event of a pressure tube failure due to the presence of an unexpected crack in a region of elevated hydrogen equivalent. The shutdown systems remain effective, reactor trip effectiveness will not be challenged, and the shutdown systems will be able to shut down the reactor in a timely manner.

Reactors trips are shown to be triggered before the fuel temperature exceeds the prescribed derived acceptance criteria; thus, the control function remains effective.

The pressure tube break results in the release of heavy water coolant at the rate of 225 kilograms per second, whereas the upper end of the small break loss of coolant accident category is 950 kilograms per second. The break size and coolant loss rate are small in comparison to other bounding events and would be mitigated by existing safety systems. Thus, a liquid fuel cooling is demonstrated by the analysis and also significantly bounded by the larger break sizes analyzed.

Also, the ability of the long-term cooling provided by emergency coolant injection system in recovery mode is not negatively impacted. Finally, containment remains effective, keeping radioactive releases very low and well within prescribed limits. Next, please.

To summarize, in terms of level 3 defence in depth and the safety analysis, the elevated hydrogen equivalent findings do not impact the accident sequence; fuel temperature and sub-criticality margins; the plant's ability to fulfill fundamental safety functions of control, cool, and contain; and the calculated consequences of a hypothetical accident. Thus, the findings will not impact the plant's ability to meet its safety objectives.

At this point I would like to pass the presentation back to Dr. Viktorov.

DR. VIKTOROV: Thank you, Mr. Tavasoli.

Alex Viktorov, for the record.

Following the issuance of the request for information on under subsection 12(2) of the *General Nuclear Safety and Control Regulations*, a CNSC-designated officer issued orders to Bruce Power and Ontario Power Generation.

As mentioned previously, the currently licensing basis limits the hydrogen equivalent concentration in pressure tubes to 120 parts per million until licensees can demonstrate that pressure tube fracture toughness will be sufficient for safe operation beyond this value.

While some criteria are included in the *Licence Condition Handbook* to define regulatory expectations, the designated officer established additional conditions to ensure that licensees continue to operate their units within the licensing basis approved by the Commission in the light of the discovery.

Orders were issued by a CNSC designated-officer to Bruce Power and OPG that require authorization from the Commission prior to restart of any units that have not been recently refurbished following any outage that results in the cooldown of the heat transport system.

CNSC staff note that an order was not issue to New Brunswick Power because Point Lepreau Nuclear Generating Station is not in extended operation.

The process for the review of the order by the Commission prescribed by the *Nuclear Safety and Control Act* also provides Bruce Power and OPG with an opportunity to be heard before the Commission. Both licensees have requested an opportunity to be heard, which will take place on September the 10th.

As long as orders are in place, CNSC staff will continue to evaluate licensee performance against the conditions of the order.

The conditions of the order require that prior to seeking Commission authorization for restart, licensees shall either, A, carry out inspections and maintenance activities that demonstrate with a high degree of confidence that pressure tube Heq is within that licensee's licensing basis, as per licence condition G.1, and submit results of such activities to CNSC staff; or B, carry out inspections and maintenance activities that demonstrate with a high degree of confidence that no flaws are present in the region of pressure tubes where the models failed to conservatively predict the elevated Heq and submit results of such activities to CNSC staff.

Option A of the order requires an understanding of the mechanism leading to elevated Heq in pressure tubes to confirm where the other pressure tubes are impacted by the phenomenon.

For Option B of the order, if a licensee can demonstrate that the likelihood of a flaw that could lead to crack initiating in the region of elevated Heq is sufficiently low, then a fitness for service case can be made. The licensee must also demonstrate that potential pressure tube failures under this scenario do not challenge the assumptions of the safety report. Next slide, please.

Assessment criteria being developed by CNSC staff to assess licensee compliance with the conditions of the order. The assessment criteria, which will be further described in the following slides, will be used to assess licensee requests for approval to restart and to provide a recommendation to the Commission.

For both Option A and Option B, criteria for restart will apply to reactors with pressure tubes in extended operation following any outage that results in the cooldown of the pressure heat transport system and to the region of interest defined as the first 75 millimetres inboard of the outlet burnish mark and the full circumference of the pressure tube. This bounds the actual position in the pressure tube where the Heq scrape samples have been traditionally obtained.

CNSC staff note that the assessment criteria for restart will apply to all Bruce Power and OPG units with pressure tubes in extended operation following any outage that results in the cooldown of the heat transport system and the assessment criteria may change as new information becomes available to CNSC staff.

Here I would like to share with the Commission the assessment criteria developed by CNSC staff for both Option A and Option B.

For Option A, the criteria are the licensee shall demonstrate an understanding of the mechanism leading to high hydrogen equivalent concentration in the region of interest and be able to conservatively model Heq concentration in this region to perform fitness for service assessments.

The assessment criteria for Option B are that sufficient inspection data shall be available to justify with a high degree of certainty that no flaws greater than 0.15 millimetres in depth are present in the region of interest and corrective actions shall be implemented for tubes containing flaws greater than the specified depth.

We will now provide the next steps with respect to the activities to demonstrate safe operation of units in extended operation.

CNSC staff request that licensees execute short- and medium-term activities to demonstrate confidence in safe continued operation and safe restart after any forced unplanned outages. Long-term actions are also proposed that pertain to the validity of the Heq model. The likelihood of loss in the region of interest that could initiate cracks is known to be low. It's also known that over-pressurization events are the most likely drivers for a pressure tube failure if undetected flaws exist.

Such over-pressurization events are of low likelihood. Nevertheless, licensees should review operational procedures and implement enhancements to ensure that over-pressurization events are prevented as far as practicable. In addition, licensees should establish plans for enhanced inspection activities to confirm that the likelihood of flaws in the region of interest remains low.

In the medium term, commencing with the next outage, licensees should carry out enhanced inspections to support the fitness for service for reactor restart, for pressure tubes that could have elevated Heq in the region of interest.

To support longer-term operation,

licensees should undertake additional material surveillance and research activities to understand the cause of the elevated Heq in the region of interest and assess the impact on continued operation.

If a licensee is unable to demonstrate an adequate fitness for service safety case relying on the available data and accepted models, then additional corrective actions
should be undertaken.

And the following slide will present CNSC Staff conclusion to date.

Based on available information assessed to date, CNSC Staff conclude that continued operation of reactors currently at power does not pose unreasonable risk.

Conclusion of safety analysis remain valid and indicate minimal radiological consequences in case of a pressure tube rupture.

Conditions specified in the Designated Officer orders will provide additional assurance that pressure tubes remain fit for service for continued operation following planned or unplanned outages.

And response of licensees to the discovery and to regulatory requests have been adequate. CNSC Staff recommend additional risk control measures to support continued operation of units in extended operation, while the cause and potential impact of the discovery is still under investigation.

CNSC Staff will continue to assess information provided by licensees and related the discovery event, as well as verify compliance with the conditions of the Order.

Thank you for your attention. We are now available to answer any questions you may have.

THE PRESIDENT: Thank you, Dr. Viktorov and Mr. Tavasoli.

I'll turn the floor to Bruce Power for their presentation now.

Mr. Scongack, the floor is yours.

CMD 21-M37.1/21-M37.1A

Oral presentation by Bruce Power

MR. SCONGACK: I just want to make sure people can hear and see me.

That's great.

Good afternoon, Members of the Commission, and thank you, Madam President.

For the record, my name is James Scongack and I'm the Chief Development Officer and EVP Operational

Services here at Bruce Power.

Also representing Bruce Power today before the Commission is Chris Mudrick, Executive Vice-President and Chief Nuclear Officer, Gary Newman, Chief Engineer and Senior Vice-President of Engineering, and Maury Burton, Chief Regulatory Officer.

Before we begin today’s presentation, we would like to recognize the Bruce Power Site and where we are all broadcasting from today is located on the Traditional Territories of the Saugeen Ojibway Nation and Traditional Harvesting Territories of the Métis Nation of Ontario and the Saugeen Historic Métis.

Bruce Power appreciates the opportunity to provide additional information on the update before the Commission today.

Next slide.

Actually, we'll go to the next slide.

As noted, Bruce Power carries-out extensive inspection activities on all of its units during planned outages to ensure safety and compliance with the Licensing Basis. Through our inspection and surveillance program, we carry out a number of activities, including measurements for hydrogen concentrations and inspections to check for flaws in the pressure tubes.

Results from these planned activities on

Units 3 and 6 found higher hydrogen concentrations in some tubes specific to a localized area. These same results also found the hydrogen concentration measurements were lower, as expected by our predictions, in the remainder of the areas measured.

The inspections also verified, based on consistency with a large population of existing data, that there are no flaws in the limited region of the pressure tube where higher hydrogen concentrations were measured.

Next slide, please.

In accordance with our *Licence Condition Handbook*, Bruce Power carries out planned inspections of pressure tubes for hydrogen concentration. Units can be returned to service following these inspections if the measured hydrogen concentrations are below the licensing limit and the planned operating period does not go beyond a time when any pressure tube is predicted to exceed the licensing limit. This is outlined in the compliance criteria.

This is also consistent with the requirements in the *Licence Condition Handbook* related to Periodic Inspections and Testing where we are required to select tubes that could be at higher risk of hydrogen concentrations. The justification

for the selection of these tubes is
also submitted to CNSC.

Our inspection program is aligned with these Licensing Conditions and is designed to determine if conditions have changed by targeting pressure tubes that are most likely to have higher hydrogen concentrations. Detecting changing conditions enables Bruce Power to take appropriate action to maintain safety and pressure tube integrity.

Next slide, please.

In response to this discovery condition, Bruce Power maintained transparency by sharing these developments with CNSC Staff and our industry peers. We were also open and transparent with the public using the tools in our Public Information Program.

Consistent with our licensing basis, we carried out an immediate evaluation to ensure safety of operating units using rigorous processes approved within our Management System.

Bruce Power's position and response was proactive, transparent, in full compliance with licensing requirements and has demonstrated safety and pressure tube integrity
throughout.

Next slide, please.

I would now like to take this opportunity to pass the presentation on to Chris Mudrick, Bruce Power's Chief Nuclear Officer, to provide an operational safety overview.

MR. MUDRICK: Thanks, James.

Well, for the record, my name is Chris Mudrick, Chief Nuclear Officer here at Bruce Power.

As a way of introducing our operational safety overview, I would like to share with Members of the Commission a segment from a video we produced for the public that I believe provides a good overview of how we ensure safety and pressure tube integrity through a very comprehensive inspection and defence in depth approach.

Please play the video.

MR. LEBLANC: Give me a second there.

--- Video Presentation / Présentation vidéo

"*Bruce Power operates eight CANDU reactors, and in our operations, safety first is our number one value.*

There are four pillars to nuclear safety, including reactor, industrial, environmental and radiological safety.

CANDU reactors are designed with extensive redundancy and defence in depth. Through our *operation and maintenance programs, we are constantly monitoring the status of our key equipment.*

To better understand the rigorous safety and inspection process, it is helpful to understand the safety measures and important role of the tools and inspection program in relation to the pressure tubes in a CANDU reactor.

Inside each CANDU reactor, there are 480 fuel channels. Each fuel channel consists of a pressure tube, a calandria tube and fittings and spacers.

During operation, pressure tubes are exposed to heat, pressure and radiation. Like parts in a car's engine, these components are tested, maintained and replaced over time. Given the important role they play, reactor tools are used to confirm their fitness for service.

These inspections essentially are focused on three key areas: maintaining separation or a gap between the calandria tube and pressure tube; determining the uptake of hydrogen in pressure tubes which is expected to occur over time, and, more importantly, the location of this, ensuring the tube material is robust by inspecting for flaws.

The combination of these three factors is how we continue to demonstrate pressure tubes *are safe and robust.*

We also remove pressure tubes for laboratory testing to expose them to often more extreme conditions than in a reactor.

Through extensive research, testing and modelling development, CANDU reactor operators have a thorough understanding of the impact of aging on pressure tubes.

Bruce Power and its partners developed a first-of-a-kind tool that has revolutionized how we conduct this testing. The Bruce reactor inspection and maintenance system machine is used to deliver our various inspection tools to the reactor face and deploy them into the fuel channels.

After every reactor inspection campaign, pressure tubes are evaluated against compliance verification criteria to demonstrate the tube will meet the established safety margins until the next planned inspection. This allows Bruce Power to demonstrate a high degree of confidence in the integrity of pressure tubes."

MR. MUDRICK: Thank you.

If we could go back to the presentation.

Okay. And the next slide, please.

As noted, consistent with our licensing basis, we utilized a comprehensive process in our approved Management System to confirm operational safety. This is known as a Technical Operability Evaluation, which we frequently refer to as our TOE process.

This evaluation is structured to review any new information. It includes extensive review of all units, includes results from previous and current inspections.

The process included participation from station operations, engineering and other technical experts. The evaluation included an immediate 48-hour review, followed by a seven-day review. These reviews confirmed that safety was maintained consistent with our defence in depth philosophy.

Next slide.

It is important to recognize that the integrity of pressure tubes is highest during full power operating conditions, and we often refer to this as the region of operation where fracture toughness is greatest or, in simpler terms, the tube integrity is the highest.

Should there be a need for an unplanned outage requiring a unit to be cooled down, we have considered measures we could take to increase safety margin. For unplanned outages, which are often short in duration, we have developed a strategy that maintains healthy margins of safety through plant configuration enhancements, along with procedural changes and through training. This builds on existing well-defined and strong practices.

Despite the very high reliability of our units, we could have an unplanned outage prior to the next planned inspection outage. It's important for us to be able to have confidence that units can operate safely until their next planned outage, even if an unplanned outage is required in the interim. The unplanned outage return to service strategy will be presented in detail during an upcoming Commission hearing.

Finally, our high population of inspections and the verifications for flaws in pressure tubes are also important. And as noted, elevated hydrogen concentrations are limited to a very targeted region of interest, one that is less then 0.5 percent of the total volume of the tube. In this region, based on hundreds of inspections, re-inspections and recently carried-out enhanced inspection activities on Unit 3, we confirm that there are no flaws in this region.

This is what we would expect given the fuel channel and bundle design on the Bruce units.

Next slide, please.

In summary, based on our extensive work, our actions and the results of inspections, Bruce Power units are safe to operate in any mode of operation consistent with our conservative approach to safety and defence in depth. Units 1 and 2 were recently refurbished and, therefore, are not affected by hydrogen concentrations due to low operating hours on the pressure tubes.

Likewise, Unit 6 is unaffected as it will have all its pressure tubes replaced.

The CNSC presentation on safety analysis and accident sequence and the fundamental safety functions of control, cool and contain concluded there is no impact on the plant's ability to meet the safety analysis objectives, and we concur.

Bruce Power has requested an opportunity to present before the Commission our return to service strategy that demonstrates units are safe to return to service until their next planned inspection outage. And this will be the subject of future Commission considerations along with our return to service submission for Unit 3.

I would now like to pass the presentation over to our Chief Engineer, Gary Newman, to outline in more detail how our pressure tube integrity remains strong.

Gary.

MR. NEWMAN: Thank you, Chris.

Next slide, please.

And to the next slide.

For the record, my name is Gary Newman.

To build on previous comments, it's important to note that high hydrogen concentrations in isolation will not initiate a challenge to integrity of pressure tubes. 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 conducts sampling to measure hydrogen concentrations and inspections to identify flaws in the pressure tube to maintain pressure tube integrity as noted using our modern inspection technology shown in the earlier video.

In addition to requiring both a flaw and high hydrogen concentrations, this risk is limited to a certain temperature/operational envelope, including heat-up and cool down. We estimate this to be less than three percent of full operating periods. In other words, greater than 97 percent of the time were spent at high power conditions.

We understand these elements, and this is why we can be confident in our defence in depth approach to maintain pressure tube integrity.

Next slide.

Bruce Power has a large population of inspections for flaws that have been performed in 448 unique pressure tube inspections in Units 3, 4, 5, 6, 7 and 8 equivalent to nearly one full reactor core, which is 480 channels. We also revisit channels, which would increase this number to 728.

This is done on a routine, planned basis as normal practice for planned outages to confirm these conclusions remain bounding.

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 where there are higher hydrogen concentrations in any Bruce Power unit. This provides a high degree of confidence in both safety and pressure tube integrity for all units and will continue to be verified during planned outages.

What's also important to recognize is that Bruce Power does not anticipate flaws to ever occur in the region of interest. This is because fuel bundles do not come in contact with this area of the pressure tube based on the design of the bundles and channels at Bruce Power.

Next slide.

This figure illustrates the evidence of no flaws in the light grey region of interest.

The region of interest was determined based on extensive hydrogen measurements on Unit 3 using enhanced scrape locations both axially and circumferentially as well as punch specimens from Unit 6 at multiple clock positions.

There are no flaws in the region of interest on any Bruce unit based on inspection results for flaws in Unit 3, 4, 5, 6, 7 and 8.
The region of interest is where the high hydrogen concentration is consistently measured. As already noted, this is the upper and lower left grey area of the illustration before you.

With no flaws in this area, even with higher hydrogen concentrations pressure tube integrity is maintained.

Next slide.

I would now like to discuss the targeted region where we have measured higher hydrogen concentrations and why this is occurring based upon our initial analysis.

First I want to underscore the point previously that, based on a large population of historic inspections and recent results, Bruce Power has demonstrated the existing predictive model for hydrogen concentration continues to provide bounding predictions outside this targeted region of interest.

The above two figures shows the newly developed 2D model, which is 12 o’clock to 6 o’clock on the vertical axis, and axial position on the horizontal axis. In addition, this is reflected of two different time intervals, namely, five and 30 years of operation. And you can see how this region of interest develops over this time period.

Higher hydrogen concentrations are limited to this region of interest which is at the top of the tube, near the outlet burnish mark. Our analysis indicates the high concentrations of hydrogen exist at the upper portion of the tube due to a temperature gradient as a result of flows within the channel. We also carried out additional and repeat inspections on Unit 3 to verify this location of higher hydrogen concentrations.

Next slide.

This figure illustrates the region of

interest to put it in perspective. The region of interest was determined based on extensive hydrogen measurements from Unit 3 using enhanced scrape locations both axially and circumferentially as well as punch specimens from Unit 6 at multiple clock positions.

Narrowing down through measurements, this region of interest is important for a number of reasons. It allows us to confirm we do not have elevated hydrogen concentrations in the balance of the tube and also forms a region which we can use a large population of inspections for flaws on the Bruce units and no flaws exist in this area.

It's important to recognize that we have modified our inspection tooling to be able to measure more closely to this targeted region of interest and successfully deployed this enhancement in additional inspections we have completed on Unit 3. This will be used in future planned inspection campaigns at Bruce Power consistent with the inspection program methodology previously referenced from our licensing condition handbook.

Next slide.

In summary, based on evidence from a large population of measured results, no flaws are present in the region of interest. 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 at Bruce Power.

Elevated hydrogen concentrations are localized to a targeted region of interest, and we have carried out additional inspections supported by tooling enhancements to verify this.

Operational measures to build and maintain safety margin are in place during certain conditions such as plant start-up and cool down, and we continue to maintain defence in depth.

I would now like to pass the presentation on to James Scongack to conclude the presentation.

Next slide.

MR. SCONGACK: Thanks, Gary.

James Scongack, for the record.

Next slide, please.

We appreciate the opportunity to present today in this public forum. Bruce Power is committed to continuing to demonstrate high levels of safety and pressure tube integrity. We have demonstrated and maintained our commitment to conservative decision-making around these inspections and how we continue to hold these high standards of excellence.

We will continue with planned inspections using the modern tooling presented in this forum to measure both hydrogen concentrations and confirm no flaws in the region of interest in Units 4, 5, 7 and 8 over the next 18 months as further verification.

Between now and then, high levels of safety are maintained both in operating conditions and returning from an unplanned outage. As noted, that will be the subject of a hearing next week. We also believe Unit 3 meets the requirements set out to safely operate to its MCR. Both of these will be the subject to the meeting noted next week.

Thanks again for the opportunity to present, and Chris, Gary, Maury and myself will be happy to take any questions from Members of the Commission.

THE PRESIDENT: Thank you, Mr. Scongack, Mr. Mudrick and Mr. Newman, for your presentation.

We will now turn the floor to Ontario Power Generation for their presentation and I will ask Dr. Vecchiarelli to make the presentation.

Over to you.

CMD 21-M37.2/21-M37.2A

Oral presentation by Ontario Power Generation

DR. VECCHIARELLI: Good afternoon, Madam Velshi and Members of the Commission.

For the record, my name is Jack Vecchiarelli, I am the Vice President of Nuclear Regulatory Affairs for Ontario Power Generation.

Thank you for this opportunity to share OPG's perspective on issues relating to the measurement of hydrogen concentration in pressure tubes.

I would also like to take a brief moment to acknowledge that all of OPG's facilities across Ontario are located on Treaty and traditional territories of Indigenous people.

Next slide, please.

With me today are several members of the OPG team, including:

Sean Granville, Chief Operations Officer and Chief Nuclear Officer; and

Mark Knutson, Senior Vice-President Enterprise Engineering and Chief Nuclear Engineer.

Also, available for comments are the licence holders for the Pickering and Darlington Nuclear Generating Stations, namely, Senior Vice Presidents Jon

Franke and Steve Gregoris, respectively.

In our presentation today, we will briefly summarize OPG's pressure-tube fitness for service assessment in light of the Bruce Power information and in response to the CNSC request pursuant to subsection 12(2) of the *General Nuclear Safety and Control Regulations*.

Next slide, please.

Before I turn the presentation over to Mr. Knutson, I would like to highlight some key points as it pertains to this matter.

Firstly, as with any emerging industry information, OPG has taken this development very seriously. In fact, we have been proactive all along, engaging closely with both industry and CNSC staff in exercising due diligence to assure, first and foremost to ourselves, that safe operation of our nuclear generating stations is not in question.

OPG's fuel-channel inspection program is robust and comprehensive, meeting or exceeding the applicable standards and supported by a longstanding research and development program.

We have a good understanding of hydrogen behaviour in pressure tubes, including in the region of interest relating to Bruce Power's data.

Our measured values of hydrogen equivalent concentration are within the licence limits, with considerable margins. Moreover, all pressure tubes are demonstrated to be fit for service and they continue to operate in compliance with the licensing basis for both the Pickering and Darlington stations.

In addition to responding to the 12(2) request, OPG has also proactively addressed the aforementioned Designated Officer Orders in advance of any planned or unplanned outage. OPG considers that we have unconditionally met the requirements of the Orders and we look forward to our opportunity to be heard on September 10th when we will outline in more detail our case as to why we are confident that Pickering and Darlington reactor units can be safely restarted following any outage with cooldown of the heat transport system.

Next slide, please. And I will now turn it over to Mark Knutson.

MR. KNUTSON: Thank you, Jack.

Good afternoon, Madam Velshi and Members of the Commission. For the record, my name is Mark Knutson. I am the Senior Vice President of Enterprise Engineering and the Chief Nuclear Engineer for Ontario Power Generation.

I would like to highlight four key points as it pertains to OPG's pressure tube fitness for service.

Number one. OPG has a robust fuel channel lifecycle management plan for Darlington, Pickering 1-4 and Pickering 5-8 that is updated annually and is provided to the CNSC staff. The implementation of this plan allows OPG to continue to meet the licensing basis for our stations as specified in CSA N285.4 and N285.8 and provides the basis and specification for ongoing inspection and maintenance requirements for the fuel channels and the strategy to ensure that fuel channels remain fit for service.

OPG has a long history of executing robust inspections and material surveillance activities, including inspecting the fuel channels during outages, modelling future degradation based on inspection results and laboratory testing of materials removed from the reactor core.

Number two. To monitor hydrogen equivalent concentrations in our pressure tubes, OPG obtains samples via in-reactor scrape during Unit outages and from punch samples taken from removed tubes. The extent of the inspections and testing exceeds the requirements of CSA N285.4. It should be noted that OPG's material surveillance program covers the same pressure tube areas of interest as Bruce Power's pressure tubes in Unit 3 and Unit 6.

Point number three. OPG also performs

ultrasonic inspections on all Pickering and Darlington units to detect and characterize a flaw. OPG has performed 430 unique full-length pressure tube inspections (including the region of interest) in Pickering and Darlington units. The total number of inspected channels are higher if you include repeat channel visits. The number of flaws in the region of interest is very low and have been assessed and demonstrated to be acceptable using methodologies in CSA N285.8.

Point number four. In addition, OPG has assigned considerable resources to fuel channel research and development activities. Improved assessment methodologies, predictive models developed from this extensive R&D testing and analysis are integrated back into the lifecycle management plan.

In the next few slides, I will briefly summarize OPG's pressure-tube fitness for service assessment in response to the CNSC's request.

If we turn to just after the cover page? I think that's good, yes. You can now advance the slide. Thank you.

Even before the issuance of the 12(2) letter, OPG was proactively engaged with Bruce Power to understand the elevated Heq levels seen in Bruce Power's pressure tubes in Unit 3 and Unit 6.

Upon issuance of the 12(2) letter, OPG confirmed to the CNSC receipt of the Bruce Power pressure tube information. Our engineering team began to carefully analyze the Bruce Power pressure tube data as it related to pressure tube fitness for service.

Next slide, please.

OPG's engineering team, along with support from our vendors, completed an engineering assessment to evaluate the impact of elevated Heq OPEX on OPG's pressure tubes. This included review of extensive OPG inspections (in-reactor scrape and removed tube samples) and any flaws in the same region of interest as for Bruce Power.

The assessment, along with sensitivities, concluded that Pickering Units 1, 4, 5, 6, 7, 8 and Darlington Units 1 and 4 pressure tubes remain fit for service in the presence of elevated Heq up to 140 ppm.

Next slide, please.

It should be noted that, in comparison to Bruce Power's pressure tubes in Units 3 and 6, OPG units have lower hot hours of operation, which is a driver for the increasing trend in pressure tube Heq. Hot hours is a measure of time spent with heat transport system 'hot' and influences the deuterium ingress into the pressure tubes.

Pickering Units 1 and 4 will be approximately 70,000 hot hours younger, equivalent to 8 to

9 years, at target end of life when compared to hot hours for Bruce Power Units 3 and 6.

For the record, Pickering Units 1 and 4 are not in extended operation and Heq levels are expected to remain well within licensing limits.

Although at similar hot hours, Pickering 5-8 pressure tubes operate in a lower temperature and pressure range and it is a smaller reactor and have experienced lower deuterium uptake rates than Bruce Power in its years.

The number of hot hours for Darlington 1 and 4 will be approximately 39,000 hours lower, approximately 4 to 5 years less, at target end of life when compared to the hot hours of Bruce Units 3 and 6.

As I mentioned earlier, OPG has performed 430 unique full-length pressure tube inspections, including the region of interest, in Pickering and Darlington units. Based on the extensive number of inspections, the number of flaws in the region of interest is very low.

Based on a review of extensive OPG inspections, both for Heq and flaws, OPG has a high confidence that pressure tubes are fit for service at Pickering and Darlington stations.

Next slide, please.

Based on a review of all past measured Heq data, including in-reactor scrape and Heq samples taken from ex-service material in the region of interest from Pickering and Darlington pressure tubes, OPG reactors are not experiencing similar Heq levels of behaviour as observed in Bruce Power Units 3 and 6.

The Heq values for all units are confirmed to be within licensing limits.

In the unlikely event of a high existing in the region of interest, OPG is confident no pressure tube flaws exist therein or they are dispositioned as safe in accordance with CSA Standards.

Next slide, please.

OPG is proactively planning program enhancements such as pursuing scrape sampling across the 12 o'clock orientation of the pressure tubes during the next planned outages in Pickering 2171, Darlington 2141 and Pickering 2211 -- these are three unit outages -- even though we scrape near the 12 o'clock position and complete punch samples from the 12 o'clock position already, and we have been doing that since 2017 in terms of the punch samples.

OPG will continue to sample ex-service pressure tube material at multiple axial and along all clock positions in the rolled joint regions, including pursuing up to six additional OPG pressure tubes from

Pickering Units 5 and 8 and Darlington Unit 3.

In addition, OPG will pursue 33 additional full-length inspections until shutdown:

- 10 full-length inspections in Pickering Unit 1;

- 22 full-length inspections in Pickering Units 5 to 8; and

- 10 full-length inspections at Darlington.

Heq modelling enhancements to account for Bruce Power Units 3 and 6 observations are being pursued. OPG, in collaboration with industry, intends to submit modelling enhancements for CNSC staff acceptance once fully validated.

Before I turn the presentation over to Mr. Granville, I would like to leave you with the following three points.

Point number one. Operation of all OPG reactors is confirmed to be within their licensing basis. High levels of Heq, on the order of Bruce Power data, have not been observed in any OPG units and we have been looking.

Point number two. OPG has high confidence that pressure tubes are fit for service at Pickering and Darlington stations. In the unlikely event of any high Heq existing in the region of interest, OPG is confident that no pressure tube flaws exist therein or they are dispositioned as safe in accordance with CSA Standards.

Point number three. OPG's future planned outages will be informed by industry Heq OPEX. OPG is engaged with industry partners on work to further understand the mechanism behind the Bruce Power OPEX and on associated Heq modeling enhancements.

Next slide, please, and I will now turn it over to Sean Granville.

MR. GRANVILLE: Thank you, Mark.

Good afternoon, Madam Velshi and Members of the Commission. For the record, my name is Sean Granville. I am the Chief Operations Officer and Chief Nuclear Officer for Ontario Power Generation.

Next slide, please.

My team has laid out how OPG has a robust fitness for service program and extensive defence-in-depth measures in place to ensure safe reactor operation.

Heq values are significantly lower at Pickering and Darlington units and are confirmed to be within the licensing basis. We know because we have looked extensively. We have done hundreds of scrape and punch samples from pressure tubes. OPG's strategy exceeds the requirements of the CSA standard and OPG is confident that our Heq models remain valid for pressure tube fitness for service assessment.

OPG has zero flaws of significance in the region of interest from the Bruce Power OPEX.

In conclusion, we have high confidence in the fitness for service for our pressure tubes and our reactors are operated safely and within the licensing basis.

Thank you and we look forward to your questions.

THE PRESIDENT: Thank you, Mr. Granville, Mr. Knutson and Dr. Vecchiarelli for your presentation.

We will now move over to New Brunswick Power for their presentation and I will turn the floor over to Mr. Nouwens. Over to you.

CMD 21-M37.3/21-M37.3A

Oral presentation by NB Power

MR. NOUWENS: Thank you.

For the record, my name is Jason Nouwens. I am the Director of External Affairs with New Brunswick Power.

I am joined here today by several key members of Point Lepreau, including Jennifer Lennox, our

Engineering Director; Mark Power, our Site Vice President; and Brett Plummer, our Vice President Nuclear and CNO.

I would like to start by saying that we humbly understand that we are coming to this meeting from the land of several Indigenous groups and we are proud to represent that.

Next slide, please.

Just a little bit of background. Similar to the other utilities, on July 13th we did get the original 12(2) letter and provided confirmation on July 19th that we do understand the significance of the request and would confirm with it. And on July 30th we provided an engineering evaluation that really summarized some of the ongoing work that we had already been doing around fuel channel management under our fuel channel program.

Next slide, please.

This summary page is really just a few of the key points I guess that are very important to us. We wanted to express to the Commission that safety is our overriding priority and we worked very hard on this issue with not only Bruce Power but also OPG to really work collaboratively with our industry to understand the significance of the event and the technical aspects of it. We did form an evaluation team to respond to it and kept clear lines of communication open.

The third point which is very important to us is that the analysis to date has continued to confirm that our pressure tube fitness for service is demonstrated for Point Lepreau and that we continue to be compliant with the licensing basis under *Licence Condition Handbook* section 6.1.

Next slide, please.

I don't want to go into too many details, but I do believe that there are a few key technical aspects that are important to speak about when it comes to pressure tube fitness for service.

The first bullet is that we do demonstrate that Point Lepreau remains within its licensing basis.

The conclusions based on a highly localized area of interest and late-life initiation of the mechanisms causing the hydrogen equivalent to be above predicted values.

And the time in service for Point Lepreau pressure tubes is low in comparison to those from Bruce Power.

We do also have a robust fuel channel management plan which ensures the pressure tube and fuel channel health is being continuously monitored. Our pressure tube and flaw assessments will continue to be closely monitored and tracked under this plan.

There are significant conservatisms in our fitness for service assessments and adequate margins per CSA N285.4 and N285.8 standards.

And finally, that the continued safe operation of Point Lepreau will be assured and supported by robust fitness for service assessments that are accepted by the CNSC.

Next slide, please.

As part of our fuel channel management plan, determination inspections, which include the body of the tube and a rolled joint scrape campaign, will be conducted during our scheduled 2022 outage, which will be next spring, and data from this campaign will be used to validate the rolled joint deuterium update models.

In addition to that, volumetric and dimensional inspections will be conducted during the 2024 outage.

Next slide, please.

As part of our continued analysis to support the analysis of the deuterium uptake model validity and as required for compliance with the CSA standards that I previously mentioned, we will be conducting hydrogen equivalent determination inspections during the planned maintenance outage in 2022. These inspections will allow for post-refurbishment rolled joint data with front-end outlet installation configuration to be used to validate the model. NB Power is proposing to incorporate this updated data into the associated report and submit it to the Commission by September of 2022.

Next slide, please.

Thank you for your time. I am going to turn the presentation over to Brett Plummer for some closing verbal comments.

Brett, over to you, please.

MR. PLUMMER: Good afternoon. Brett Plummer, for the record. Thank you for this opportunity to present.

We just want to reaffirm that NB Power is taking this pressure tube concern very seriously. We are committed to maintaining a high level of safety through our robust inspection program for the pressure tubes.

As stated in the CNSC presentation, Point Lepreau is not in an extended period of operation. Therefore, we meet all our regulatory licence basis for the Point Lepreau pressure tubes.

Although our pressure tubes are relatively young, we will continue to work with our industry partners and the CNSC on this pressure tube integrity concern.

Thank you very much.

THE PRESIDENT: Thank you, Mr. Plummer and

Mr. Nouwens.

We will now take a break and resume at 2:50 p.m. Eastern daylight savings time and start with questions from Commission Members.

So we will see you in a bit. Thank you.

--- Upon recessing at 2:33 p.m. /
Suspension à 14 h 33

--- Upon resuming at 2:50 p.m. /
Reprise à 14 h 50

THE PRESIDENT: Welcome back, everyone.

And we'll now resume the meeting with the Commission Members asking questions of licensees, CNSC staff, and the external advisory committee.

And we'll start with Dr. Lacroix.

Dr. Lacroix?

MEMBER LACROIX: Thank you, Madam la Présidente.

Thank you very much to both staff as well as the industry for the presentation as well as for the submissions.

I have a three-part question, so I will try to be as concise as possible.

The first part, according to staff, the

root cause of elevated Heq concentration at these very specific locations in the pressure tube is yet to be determined.

But when I heard the presentation from Bruce Power, it seems that they already have some sort of an explanation to justify the fact that the elevated Heq concentration in this region is due to the -- possibly -- temperature gradients.

But anyhow, I'm not really satisfied with these explanations, and I would like to hear more about you guys concerning is it caused by some sort of thermal hydraulics problem? Is it caused by the neutronics? Is it caused by the materials, the chemistry? Is it caused by the absence of rubbing of the fuel bundle against the pressure tube itself?

And having said that, when you look back at the general design, could there be a design flaw? Could it be related, for instance, to the way the components have been manufactured and assembled? Could it be related to the history of the operating conditions of the reactor?

So there are a number of -- you know, I'm looking for a reason for this phenomenon at this specific location. So that's the first part of my question.

The second part is that when I read the submission from OPG, I was surprised to find out that their reactors do not experience such elevated concentrations. And in spite of the fact that their reactors have been operated for a similar number of hours and also their reactors are roughly the same design. So I'm baffled by this.

And the third part of my question is that I found out in the NB Power submission that the hydrogen uptake is an exponential function of the extended or equivalent full-power hours. So this is concerning in the sense that I wonder if -- you already measured the hydrogen concentration, but do you measure or do you predict with the -- how do you call it? -- the fracture toughness model, do you predict the rate of hydrogen uptake? If you do, that would be quite interesting because once you pass a certain number of hours, a threshold number of hours, say, 200,000 hot hours, this rate may increase very rapidly, and we may have a problem.

So I know this is a loaded question, so this is food for thought, so I would like to have an answer from staff as well as from the industry. Thank you.

THE PRESIDENT: Thank you, Dr. Lacroix.

Let's start with staff and then I'll get the licensees also to respond. So staff first.

DR. VIKTOROV: Alex Viktorov, for the record. I'll start.

Overall, Dr. Lacroix, we are of the same opinion. There are many potential reasons for this phenomenon, and we weren't able to nail down exactly. We may have some hypotheses with regards to the influencing factors, but they need to be tested, proven, and developed to the extent that we have a good model that is able to demonstrate when to expect this kind of behaviour.

So CNSC staff is of the opinion that we have not seen a definitive examination of the root cause for this phenomenon, and we expect licensees to present it for us to form an opinion. As of now, we are in a situation similar to you. We acknowledge there are various factors related to specific conditions, perhaps manufacturing or maybe design conditions that have influenced. It's all still open for us.

With regards to OPG not seeing the same results, again, this may be explainable should we know the root cause. But because we don't, again, we are -- still have doubts whether it's really the fact or it's simply because we don't have data from pressure tubes that may be susceptible to this kind of behaviour.

And finally, with regards to the exponential growth of hydrogen uptake with exposure, again, I will leave our specialist to speak to this in detail, but we do expect licensees to develop models that allow prediction of hydrogen concentration behaviour with the age of pressure tubes. So that's again a factor that we certainly want industry to understand and us to be able to agree with it.

And I'll cede the floor to our specialist, who will be able to provide additional detail. Thank you.

MEMBER LACROIX: Thank you.

MR. CARROLL: For the record, my name is Blaire Carroll. I'm a technical specialist with the Operational Engineering Assessment Division at the CNSC.

Dr. Viktorov has provided a very -- overall a very good answer from the CNSC staff perspective.

We do understand -- or we don't understand the root cause at this point. And with regards to some of the modelling that Bruce Power has provided in that presentation, that has not been formally submitted to CNSC staff yet, so we have not completed a technical review of that.

In theory, it would be the thermal gradients that would move the hydrogen to the top of the pressure tube because that's where the tube is coldest, and the hydrogen tends to migrate to where the -- to the colder temperature locations in the tube. That would explain why the concentration is highest at the top.

But it doesn't explain the magnitude of

the concentration that's been seen, and that's an area where CNSC staff is expecting licensees to develop more -- to do more work to try to determine the cause of the elevated values.

We still have some questions as to whether or not as the hydrogen concentration continues to rise if it will remain constrained to the top of the tube or if it will expand further around the circumference. And because of these questions, you will see in the restart criteria that was proposed by CNSC staff for the time being we've identified a region that -- we've expanded the region of interest to allow for us in time to obtain these questions -- these answers to these types of questions.

So that's the reason why you would see in the CNSC staff's restart criteria our region of interest has expanded to 75 millimetres actually from the burnish mark and the full circumference of the tube to provide those margins in place while the industry has an opportunity to expand further.

And our focus then would be proving that there are no flaws at risk of crack initiation in that region. So that's to compensate for the fact that we don't know at this point in time what the root cause of this factor is.

MEMBER LACROIX: Okay. Okay. That's

good.

THE PRESIDENT: Thank you.

Maybe we'll start with Bruce Power first, then, on what is your current hypothesis to explain the high Heq levels.

MR. NEWMAN: Thank you, Madam Velshi. Gary Newman, for the record.

So as indicated, and we've looked at this now with this two-dimensional finite element model which is also supported by mock-up work that has been done on critical heat flux trials at Stern Labs, which all indicate this cooler region at the top of the pressure tube.

And with this in mind, we then modelled the behaviour of the total hydrogen isotope. And we don't see this as an acceleration of hydrogen isotope pickup, but rather a rooted division to this location in the -- at the top of the tube.

We've measured extensively on Unit 3 up to now 42 in this current outage -- 42 unique pressure tubes. And it all sits within a fairly small angle. We've added a bit of margin to it to a 120 degrees by 50 millimetres, and that -- it's very constrained in that region.

We've also done full volumetric inspection in those regions and demonstrated that there's zero indications. All the flaws tend to be in the lower 180 degrees where the fuel sits, not surprisingly. That's where your bundle pads will interact with the pressure tube and where the debris gets trapped in the fuel from time to time and create debris threats. We've provided some figures in my portion of the slides that show you -- although it's a bit of an eye test, but you can see them at the -- in the plane of where the bearing pads sit on the pressure tube.

We don't believe this is a design flaw. We do think it's influenced by manufacturing at least in Unit (stream lost / diffusion perdue) and also there may be chemistry effects as well from the chemistry. But very early days on those fronts.

We do think there is a manufacturing relationship there because we have what's referred to as front-end outlets in Unit 3 and that's associated with the first portion of the tube that comes out of the extrusion press. And it has a longer period of time where it has a chance to -- for grain growth and so forth, so we think there may be (stream lost / diffusion perdue) relationship there and a propensity to pick up or redistribute, if you like, in this upper region of the fuel channel.

Again, I'd like to stress, though, even though we do see some higher values up there, we see very uniform and consistent hydrogen isotope concentration in the lower portion of the pressure tube where our one-dimensional model still predicts conservatively what the concentration should be down there. In fact, it's probably a little depleted because it's redistributing to the top of the tube.

I hope that answers the question.

MEMBER LACROIX: Yes. And what about the rate of hydrogen uptake? Is it something that you model?

MR. NEWMAN: It is. We're not seeing a change in the rate. What we're seeing is a redistribution. So not an acceleration but a redistribution.

MEMBER LACROIX: I see. Okay. Thank you. Thank you.

THE PRESIDENT: So Mr. Newman, before we move to another licensee on this rate, those two pressure tubes that have shown those high levels, have they been previously inspected in those areas?

MR. NEWMAN: The first pressure tube in Unit 3 is Foxtrot 16, which, you know, part of our program was that the upper bound of some of our prior inspections -- and that's why we specifically went to look at it in this campaign. Whenever we have tubes that have values that are near the upper bound or maybe slightly above, we always go back and revisit them to monitor them as part of our lifecycle management program.

In the case of Unit 6, we specifically chose this pressure tube because it also had some higher values historically. And so we picked it as our surveillance tube. And then it was, you know, cut up and sent to Chalk River, and these tests were done at that location.

THE PRESIDENT: So for that Unit 3, would it have been in that same area of interest that you had seen higher levels? I'm just trying to get an appreciation of the rate of increase of Heq levels there.

MR. NEWMAN: Yeah, again, the pickup rate we're not seeing changing. What's we're seeing is a redistribution to this I'm going to call it 12:00 location. And (stream lost / diffusion perdue) we've got similar behaviour between the channel in Unit 3 and what we saw in the surveillance tube from Unit 6. When this happened to be in situ scrape sampling, the other one is actual destructive analysis at the Chalk River labs.

THE PRESIDENT: Thank you.

Well, let's see if OPG has got anything else to add, and particularly the hypothesis around manufacturing, maybe, the reason and that may explain why you're not seeing it.

I see both Mr. Knutson and Dr. Vecchiarelli have their hands up, so you decide who wants to go first.

DR. VECCHIARELLI: Dr. Vecchiarelli. I'll keep very brief and allow Mr. Knutson to elaborate.

I just wanted to point out that we do work closely with Bruce Power and the rest of the industry at understanding hydrogen behaviour in pressure tubes. We have a good understanding of it, a very extensive inspection campaign. And some of the reasons that Mr. Newman has outlined as the underlying behaviour, we have been discussing those sorts of aspects.

What I would say in relation to Dr. Lacroix's comment about why we're seeing lower hydrogen equivalent concentrations, while reactor designs are similar, operating conditions can be different. And as Mr. Knutson can elaborate and as he said in his presentation, there are other factors such as hot hours and temperature and lower flux that can have an impact on reducing the rate of hydrogen migration.

So I'll turn it over to Mr. Knutson to provide more context. Thank you.

MR. KNUTSON: Thanks, Jack.

So Mark Knutson, for the record.

I'll answer the first question on why we think it's occurring. Like we do see a higher Heq at this location, just not to the extent that Bruce Power has. So we do anticipate a potential lead because of a temperature gradient. And that can be from flow bypass, as the pressure tubes creeps larger diametrically and/or some contact. And we believe that, you know, there is some ridges inside the end fitting that can touch certain locations and cause a localized change in temperature and therefore cause a gradient that, you know, through Brownian motion and other reasons you can move hydrogen in solution around to other locations in the pressure tube. So that's expected, in our view.

However, the extent of that is -- we probably didn't anticipate that at Bruce Power in terms of their tube. But we do model that and we do know that temperature gradient does have an impact. And that's why hot hours -- we consider hot hours important for monitoring as the hydrogen is -- the uptake and the rate of uptake that we monitor also. That would be the why.

Your second part of your question was why is OPG different. Well, I would say, like, for Pickering 1 and 4, in terms of hot hours, we're -- it's about nine years younger. For Darlington, it's about five years younger in terms of hot hours. So I can't tell you at Bruce Unit 3 and 6 age will we not see the same thing. But our end of life for our tubes will end before we reach those ages.

Pickering 5A is of similar hot hour as Units 3 and 6; however, it's a much smaller reactor. It's about a hundred channels less than the other channels, and we see flux differences and temperatures are lower and pressures are lower in those units. So we do see differences.

However, we're aware and monitoring for those changes in Heq. Back in 2017, we began punch samples at the burnish mark and closer to the burnish mark as a result of that thinking that we may have to do more to get that knowledge. And in those punch samples and -- that's when we remove a tube from service -- we got extra knowledge from that. But still not -- we didn't see the extent that was seen on Unit 3 and Unit 6.

Your last question in terms of fracture toughness, we do build an Heq into our fracture toughness model and the rate of pickup is an important for predicting --

THE PRESIDENT: You've just gone on mute.

MR. KNUTSON: I wasn't sure if you cut me off because I was talking too much.

THE PRESIDENT: No! (laughing)

MR. KNUTSON: So it is included in our fracture toughness model, Heq.

THE PRESIDENT: Okay, and let's turn to

New Brunswick Power to see if they have anything they'd like to add.

MR. NOUWENS: Thank you.

Although from an operability point of view we're essentially similar to Bruce Power Units 1 and 2, I will turn over to our Engineering director Jennifer Lennox for a few high-level comments.

Jennifer?

MS. LENNOX: Hi, Jennifer Lennox, for the record.

I would -- as Jason stated, we have nothing additional to add that our peers have already added. However, we'll continue to work with the CNSC and the industry as we understand this issue and determine the root cause. And then going forward, our future inspections that we will do will be informed by this root cause and effect.

THE PRESIDENT: Very good. Thank you.

Dr. Viktorov?

DR. VIKTOROV: Just maybe to put this in a safety context, it's the focus of our longer-term actions to build understanding of this phenomenon and a model that will be able to predict the future behaviour.

So our compensatory actions are conditions that we impose on licensees account for not having a good model in the immediate future. So we put certain expectations for making sure that while we are working to understand the root causes, there are measures in place that will provide confidence and safety of operation.

Thank you.

THE PRESIDENT: Thank you.

Let's then move to Dr. Berube, please.

MEMBER BERUBE: Yes, and good afternoon.

I just want to expand on Dr. Lacroix's question. Actually, you briefly mentioned channel history, and I just wanted to touch on that.

Bruce, if you could just give me an idea of what you actually monitor and track with regard to channel history. I mean, you look at, I would think, past fuel machine issues, failed fuel issues, various things like this. But can you give me a detailed understanding of what you actually track -- manufacturing date, differential material types, this kind of stuff.

And from the data that I'm looking at, at least my impression of it is that we're just looking at a couple tubes here, one in Unit 3 and one in Unit 6 that you've actually looked at. Is this issue that you're seeing a little bit broader than that? Or is it limited specifically to these particular tubes? And how is that investigation going at that point into that?

MR. NEWMAN: For the record, Gary Newman.

So yeah, just as you implied, we actually look at the full -- we have a full history docket on every single pressure tube from, you know, the day it was manufactured, the ingot chemistry, and all of that is taken into account in terms of selecting tubes. And in particular, if we see -- once we've selected a tube and then we sample it both for hydrogen equivalents as well as for potential volumetric flaws, we will then return to that tube and confirm that you -- that the performance continues to be consistent with our, you know, pick-up models and so forth.

And that, in fact, is part of our normal program and consistent with CSA requirements. And in this case, this was a repeat tube that we were looking at.

We've done now expanded inspection which we haven't really shared with the CNSC Staff yet, but it is demonstrating that there are other small numbers of tubes that are exhibit the same behaviour.

They don't seem to have the same amount of redistribution to this 12 o'clock location, but they're showing similar behaviour. And so what we're doing, then, is putting together the pieces of the puzzle to do the root cause as suggested by a number of the folks on this call.

I hope I answered all of your questions

there.

MEMBER BERUBE: Yeah. More or less you've answered that.

So the issue is central to these particular tubes, but it seems to be like other areas are being affected too, so it's not specific to an area in the reactor or anything like this. Okay.

MR. NEWMAN: No. It would be -- it would be specific to -- for the record, Gary Newman.

It would be specific to a tube pedigree, you know, and history, type of thing, but not a specific location other than this region of interest. That seems to be the only common element. It's this very focused region that we've described in some of the earlier slides.

MEMBER BERUBE: I'm going to move on to another topic here, and it's got to do, actually, with the Heq -- the statement that Heq is not a concern at high shell temperatures unless there is a flaw in the actual tube itself. I think that's been stated by both -- by all the operators.

And if you would, please explain to us why Heq is really of not concern at higher operating temperatures in the unit while it's operational. I think the public would need to know this.

MR. NEWMAN: Gary Newman, for the record.

Maybe I'll begin.

This is basically a tube shelf kind of behaviour, so we have a lower shelf and an upper shelf. You spend, as I mentioned in my slides, greater than about 97 percent of your time at high temperature, high power, but you do, from time to time, transition to a cold and depressurized state. And then, on the flip side, you heat up and pressurize the unit to go back to full power.

In this upper shelf region, we have very, very good fracture toughness. We've done extensive testing up there and in concentrations that are well beyond, you know, any of the concentrations or certainly within the concentrations that we're measuring and we see very, very good fracture toughness.

We actually will do an as received burst test when we actually have an ex-service tube. Then we will add hydrogen in an accelerated fashion to whatever concentration we want to test at, so say we want to test at 200 parts per million. We'll add hydrogen to that tube and then what we will do is put it through a burst test program. And from that, we get fracture toughness information.

So good performance, good fracture toughness at the -- in the upper shelf region.

When you look at these transition regions, as you cool the unit down you can have a lower fracture toughness but still -- but still a fracture toughness that gives you safety margins and so forth that are required to safely operate the unit. And it's in this region that our focus has been in the last year or two doing more testing and burst tests as part of our research and development program.

THE PRESIDENT: So maybe I can follow up on what Dr. Berube has asked around the behaviour at high Heq levels and the work -- the research work that's being done.

Can you expand on how confident you are in understanding the behaviour at high Heq levels? And I don't know how you define "high". I think in some of the CMDs I had read 160 but, I mean, more around 200 ppms and above, what's your level of comfort in understanding the pressure tube behaviour and fracture toughness at those levels?

MR. NEWMAN: Yeah. What you'll find at those -- just to explain a little -- that's a great question, but just to explain a little better how this material performs.

At the higher temperatures, you are redissolving hydrogen back into the matrix. It is no longer exists in a solid state as a zirconium hydride and, as a result of that, this hydrogen is free to move around and it does not necessarily create a problem for you unless you have a cold spot, you have a pressure tube calandria contact or if you happen to have a flaw where hydrides are already present. You could have some accumulation there.

But generally, what you'll find is that it's free to move around and it doesn't really degrade the fracture toughness in the same way as it could if you cool the unit down and it now comes -- precipitates out as a zirconium hydride. It's only when it's in that phase form does it create a problem, you know, from a fracture toughness perspective.

THE PRESIDENT: Thank you.

Maybe I'll ask staff and see if they have anything they'd like to comment on or add to, please.

DR. VIKTOROV: I'll ask Blair Carroll to provide additional detail on this subject.

MR. CARROLL: For the record, Blair Carroll.

With regards to the comments in terms of the fracture toughness behaviour for material with elevated Heq, at this point in time -- I'll start, I guess, with talking about the temperature dependence.

Yes, there is an acknowledgement based on test data that once you go above about 250 degrees Celsius in temperature the fracture toughness is generally quite good in the material and doesn't degrade as the Heq value increases, so that's the information that we have available to us today.

And if you maybe refer back to CMD 21-M4 that we presented in January to the Commission which talked about the pressure tube fitness for service issues, we provided a couple of slides that discuss that in more detail with some figures to show how the trend in fracture toughness behaves with temperature.

With regards to President Velshi's question about our confidence in toughness test results or toughness results with elevated Heq, there is some -- there's data to support that material retains good fracture toughness at normal operating temperatures, but there is not sufficient data to show how the -- what the fracture toughness behaviour is at this point at lower temperatures during the shutdown and heat-up phases, and that's one area where CNSC Staff would need to have more information to make -- be able to make a judgment on the applicability of the current models at this time at those temperature ranges.

So again, I'll go back to the path forward that was presented by CNSC Staff in terms of the Order and the restarter criteria associated with that.

We're really focusing at this point on demonstration that there are no flaws in the area of concern that could cause cracks to initiate, and if that can be demonstrated with high confidence, then the fracture toughness isn't immediate concern and industry has time to do more work to better characterize the fracture toughness behaviour.

THE PRESIDENT: Thank you. Thanks very much for that.

Dr. Berube, did you have any follow-up questions to this?

MEMBER BERUBE: No, I'll wait for the next.

THE PRESIDENT: Thank you.

So Mr. Newman, I'll ask you a follow-up. You said you've got additional inspection results that you still haven't shared with staff but that's showing similar behaviour that has brought us here together today.

Have you seen anything greater than 120 ppm on any of the other pressure tubes that you have inspected since?

MR. NEWMAN: Yes, we have. And in fact, I think we reported that this one was about the 120 mark in this one single tube that we did report on, but we found another -- you know, another small group in that same pedigree of tube that was above that value as well.

But again, as I indicated, what we're not seeing are any flaws at this same location and -- which also applies during, you know, full power operation. Of course, there's no flaws in those regions, so it only is impacted if you have defects in the area.

THE PRESIDENT: Thank you. I'm sure we'll hear a lot more about it in the coming weeks and months.

So let's move to Dr. Demeter, then, please.

MEMBER DEMETER: Thank you, and good afternoon.

Thanks for the very technically rich CMDs and presentations.

So Mr. Newman and Mr. Carroll actually segued into the question I have to ask, and it's regarding -- it's predicated on the CMD 21-M4, which is a really good background for this.

And there was a process going on, and this was released on January 21st, 2021, which talked about upper shelf, which we just talked about, and the safety ongoing, you know, sensitive to Heq, is what it said. And I’m more wanting you to focus on the lower shelf transition region, this cohesive zone model.

So our safety case is predicated or

informed by the future fracture toughness model, which is informed significantly by Heq. And the current Revision 1 talked about restricting maximum Heq to 120 ppm and also to 80 ppm in the front end of the pressure tubes. And there was -- and that's under CSA N285.8. And there was work to revise that one to do a CZM Revision 2 to address these to perhaps increase the upper limits of the Heq and to remove the 80 ppm.

Now, with this event, I want to know -- this is happening in the background and this is what's going to inform the safety case in sort of the long run, the CSA standards. Does this have an impact on the process with the CSA standards? Because that's what sort of informs the licence conditions and our safety case.

So what is the interaction between this event and the evolution of the CSA standards? It's called it into question. Is it going to pause for rethink or is it going to -- where is it at, I guess?

I'd ask that to staff and to industry.

DR. VIKTOROV: Alex Viktorov. I'll start.

Certainly any new information that was -- is existing on the standing of pressure tube here calls for another look at our models and standards. I expect that in due time we'll be seeing revision to the standards and models.

Having said that, we acknowledge that the models we have currently in use have been showing good agreement with data in majority of the pressure tube body as well up to a certain level of Heq, so the existing models are not invalidated. It's just the range of applicability may be restricted, in particular as shown as by this discovery issue.

And to be able to predict the fitness for service in future, of course, we'll expect that the models will be improved or allow accounting for the phenomena that resulted in elevated Heqs.

Having said that, I will ask our specialist as well as industry to provide specifics.

MR. CARROLL: Blair Carroll, for the record.

So just to, I guess, focus on the CSA question at this point, with regards to the current standard, the new findings don't really invalidate what's in the standard right now. The model in the standard for fracture toughness is in place for, as you mentioned, Heq estimates up to 120 ppm and 80 ppm in the front end.

So for regions of the pressure tube where it's confident that you can predict the Heq level, the models will stay -- will remain valid for those regions.

And the -- I guess from the general

perspective, the licence condition was put in place because we were not making -- we were applying this to the whole tube, not assuming we know where the flaws would occur. So the restriction in terms of the licence condition of 120 ppm just -- that's what the model was capable of -- was -- of predicting, so we didn't make an assumption at that point in time that we would isolate different parts of the pressure tube in terms of where the flaws would occur.

So that model cannot be applied to regions where the Heq is higher than 120 ppm and that's, again, why we've taken -- at least for the short term, we've taken the focus off the fracture toughness to the flaws in the region where Heq could be elevated because if the flaw isn't present, you won't generate a crack and then fracture toughness is not an issue. The fracture toughness only becomes a concern when you have cracks that potentially occur at that location.

So it would require, I guess, going forward a focus on if we can have confidence in this region that there are no flaws there, then we don't have to worry about being able to model the fracture toughness right away. However, all other regions of the pressure tube, we would have to have confidence that the -- where flaws could occur, we have to have confidence that the fracture toughness model would be applicable for those regions.

It just happens at this point in time the location where the Heq model has not worked in these Bruce pressure tubes, there are no flaws there, so we don't have a concern from a safety perspective with respect to that.

THE PRESIDENT: Anyone in industry?

We'll start with Bruce Power first, if you have anything to add.

MR. NEWMAN: I think Mr. Carroll did a very nice job of explaining it.

I don't think this -- it certainly does not invalidate the existing CSA standard, only the validity, where it can be applied. And we are continuing to apply it in the places where we have flaws. Where we don't have flaws, it's not a requirement there anyways, so.

And as may be implied in the question, we are continually improving the fracture toughness model, including doing a lot more burst testing in this transition region, which -- and that's an important region to focus on, and we've been doing that at continuously increasing hydrogen concentrations to make sure that we continue to expand the validity range for future use.

That has not been accepted yet, so we are not applying that.

THE PRESIDENT: Thank you.

And before we move to OPG, can you -- what levels are you doing your burst testing at and what levels are you planning on doing on that?

MR. NEWMAN: Great question. Thank you, Madam Velshi. Gary Newman, for the record.

We have done testing at a number of different concentrations. Most recently, we did a burst test up to 178 parts per million and got very good agreement with the predictive model.

THE PRESIDENT: Thank you.

OPG, anything you wish to add?

Mr. Knutson.

MR. KNUTSON: Yeah, Mark Knutson, for the record.

Just a brief adding is that obviously we work with industry, with Bruce Power and others, and we are working on the Rev 2. For outlet, that would take us to 140 ppm. And in our submission in July, as a result of this event, we did do a sensitivity study and case and submitted up to 140 ppm.

And obviously, as Gary pointed out, we'll do additional work with additional burst tests, and so we'll continue to be involved in that area along with the CSA Standard.

THE PRESIDENT: Thank you.

Mr. Carroll?

MR. CARROLL: Thank you, President Velshi. Blair Carroll, for the record.

I just wanted to point out to the Commission Members as well that the existing fracture toughness burst test database does have material tested up to 200 parts per million at higher than normal operating temperatures, and that material did exhibit the upper shelf toughness behaviour that we were talking about, so it had very good toughness.

THE PRESIDENT: Okay. Thank you. Thank you for that.

So maybe before I move to the next Commission Member, I'll turn to our External Advisory Committee members and see if they have anything they'd like to add on the topics we have talked about, whether it's root cause, whether it's model or understanding behaviour at higher temperatures or lower temperatures.

So anyone in the EAC want to -- I will come back to you later, but right now, anything you wish to add?

Maybe we'll start -- go ahead, Dr. Luxat.

DR. LUXAT: Yeah, I'll speak on behalf of the committee members. I'm going to talk very generally because, as you know, we've been in place now for just a month, but we've done a lot of reading of great volumes of paper.

But what I would suggest is that we generally agree with what the industry has said regarding operating units, the safe story there. We have a potential hypothesis, but I'm not willing to go down that as a potential rabbit hole until we have some further information that we can use to relate to specific aspects of pressure tube aging. But it does relate to the -- I apologize. I'm breaking up.

But it does relate to the temperature gradient issue, but we haven't yet done any detailed analysis.

THE PRESIDENT: Fair enough. Thank you very much.

Dr. McKinnon, you're next, please.

MEMBER McKINNON: Okay. Thank you.

My question is for CNSC Staff, and it's related to safety margins and factors of safety, and this is in the hydrogen uptake model.

And so factors of safety, they're very widely used in engineering. There's no doubt about that. And they're generally used to account for model uncertainties and probabilities of failure when there's scatter in data. So could you explain in general terms how the various factors of safety or safety margins, as they are used and referred to in all of the documentation -- how those safety margins are selected and how they relate to the failure limits and, specifically, where does the choice of 120 parts per million come into that? Where does that actually come from?

THE PRESIDENT: We'll start with staff on that.

MR. CARROLL: Blair Carroll, for the record.

So the safety margins can be different for different assessments. It depends on the intent of the assessment.

So for instance, if industry was to inspect a pressure tube and identify a flaw, then they would be required to demonstrate that that tube with that flaw would not fail due to cracking. So in order to do that, they would have to demonstrate that that pressure tube could maintain the original safety margins of the design code, so in this case it would be ASME Section 3.

And there are different safety margins associated with that. Typically, for normal operating conditions the tube would have to demonstrate that it could withstand a normal operating pressure -- or sorry, an operating pressure that's three times higher than a normal operating pressure.

For accident conditions, those values come down. So for example, for on a Service Level C or a Service Level D accident condition, the safety factor reduces to, say, around 1.5, but that's because the probability of occurrence of that loading event is higher[*sic*], so the safety margins are associated with the probability of occurrence of a specific loading event.

So that's how it would be captured in terms of design and for the safety margins.

We have other assessments that are done, for instance, some of the probabilistic core assessments that are done for pressure tubes, and those assessments are done to basically say, "I've inspected the sub-population of tubes. I don't -- and how does that information translate if I take that information and say the other tubes are behaving in a similar manner?".

And depending on those types of assessments, we -- some of the acceptance criteria are related back to the safety case requirements.

So for instance, a design basis -- a pressure tube is considered a design basis accident, so in a probabilistic space it would have to be demonstrated that the probability of a failure occurring doesn't invalidate the assumptions of the safety analysis which says I'm not expecting a frequency of pressure tube design basis accidents higher than, say, .01 events per year.

So it really depends on how the assessment is done and what the intent of the assessment is.

With regards to Heq, Heq is used as an input parameter into these different models. For instance, in the deterministic assessment for actually inspected flaws, industry has a model which is based on data that they have collected and they put an upper bound value, I will say the 97.5 percentile, on all the data that they have created -- or that they have gathered and fit their model to. So they try to put conservatism in the assumption of what the Heq would be at that flaw location. And then on top of that you have the design safety margin of three for instance for normal operation. So they try to build in the margins that way.

Now, in this case because we can't analyze Heq for instance specifically to this region, if a flaw existed we wouldn't know what the safety margin is, because it's an unanalyzable state without having the model to be able to predict Heq. So that's why again I go back to reiterating, our focus from a regulatory perspective at this point is demonstrating that there are no flaws there. If there are no flaws there, then it will be not necessary to predict the Heq because there will be no impact on the design pressure that the tube could withstand at that location.

The 120 parts per million value came from the validity limits of the current fracture toughness model. So for the assessments that use the fracture toughness model, that model, the data set that was available to put that model in place was only -- at the time there was only enough data for testing up to 120 parts per million to be able to use it. And we put a limit on that, saying, well, because you don't have data, you don't have the ability to support using that model beyond that. And the intention was for industry to do more testing to further validate that model so that when they got to the point of tubes that could reach 120 parts per million they would have a model in place at that time that would allow them to do assessments beyond 120 parts per million. Unfortunately, this finding with Bruce Power pressure tubes occurred before they predicted it would, so the fracture toughness model hasn't caught up to the level of Heq at these locations.

But again, as I pointed out, if they can demonstrate that there are no flaws associated with that region, then the fracture toughness itself is not an issue at this point in time. We will expect them to do more work to further validate the model to get to -- because the Heq may increase in other parts of the tube going forward, but right now that seems to be bounded by predictions, so we don't have a concern with that at this point. So the focus is this region of interest which the CNSC staff has recommended making a little larger than what industry is using just to provide a buffer to demonstrate that there are no flaws that require the use of the fracture toughness model to evaluate.

MEMBER McKINNON: Yes. I take your point, it's a very good one.

But just to complete the question on this, in the model, which factors -- it's obvious from the discussion there are many factors involved in leading to the uptake of hydrogen and deuterium into the tube. Which factors lead to the greatest uncertainty in the model?

Mr. Carroll...?

MR. CARROLL: Blair Carroll, for the record.

So there are a number of factors leading to Heq, as you pointed out, and they were discussed a little bit earlier in terms of things like operating temperature, flux and corrosion rates associated with those parameters.

With regards to the uncertainties, I'm trying to best --

MEMBER McKINNON: Really, I am trying to frame it in terms of, from a mitigation perspective and design, which ones are the most important to be able to control or where would you put your effort in trying to make sure that you can control the Heq limits.

MR. CARROLL: So I don't think we can actually say that we can control the limits. The idea is to predict the behaviour based on the operational behaviour. In order to control the limits, you would have to -- I mean the limit is based on the temperature, the operating temperature and the radiation and flux and those sorts of parameters. Those are sort of inherent to the operation of the unit. The idea is to be able to take those parameters and reliably predict how that impacts Heq. It's not really possible to control it, the intent is to predict it. I don't know if that --

MEMBER McKINNON: Yes. Yes, I got it.

MR. CARROLL: The issue here is now in this region there are some question marks as to the ability to be able to predict it.

THE PRESIDENT: Mr. Newman...?

MR. NEWMAN: Yes, I agree with everything Mr. Carroll just indicated.

Gary Newman, for the record.

And just to emphasize, what he implied is -- and I mentioned earlier the intent is always to continue to increase the validity range and, as I mentioned earlier, we just recently did a test at 65 degrees C, very much in the transition region, at 178 parts per million. So we continue to evolve the fracture toughness model to take on board higher and higher values of Heq.

And I also agree with his comment about you don't control Heq, what you do is you have lifecycle management programs in accordance with CSA that require you to monitor, to measure, to take surveillance tubes out periodically and then make sure that your material models are reflective of that and still valid within those ranges, very consistent with what pressure boundary materials, the way they are evaluated for fracture and for fitness for service around the world, very consistent.

THE PRESIDENT: Thank you.

MR. NEWMAN: Okay. Thank you.

THE PRESIDENT: Dr. McKinnon, you're good?

MEMBER McKINNON: Yes.

THE PRESIDENT: Mr. Carroll, I had a follow-up. So I know Bruce Power has said that in this region of interest they have not seen any flaws in any of the tubes they have inspected, but I think OPG had said, I think it was Pickering Unit 5 where they had seen some flaws in this area of interest or concern. Are you concerned about that?

MR. CARROLL: Blair Carroll, for the record.

So we are still working on getting information to see the extent of the flaws in those regions.

There are some questions with regards to the potential for crack initiation, because there are also models that use Heq as an input to estimate whether or not a flaw has severe enough geometry to initiate a crack. And what we have discussed with industry in the meantime is if you have some uncertainty as to whether or not there are flaws in these locations, then the next step will be to further validate the models for crack initiation. Fortunately some of that work can be done a lot faster than the burst test models for fracture toughness and I believe, as I understand it, Bruce Power has already started a plan to look at being able to further validate crack initiation models, but we haven't received that information formally yet. But that will be the step in the process that will have to be taken I think. If it comes out that there are flaws in this location which may need to be analyzed, we will have to have further validity of the crack initiation models.

THE PRESIDENT: All right. Thank you.

I see Mr. Knutson had something to add.

Over to you.

MR. KNUTSON: Thanks, Madam Velshi.

Mark Knutson, for the record.

Obviously, Unit 5 does have some flaws. The flaws, though, are from a known cause and that's a fuel bearing pad in terms of the vibration for when the fuel is being discharged in the crossflow for a protracted period of time.

So these are pre-2015. They are very -- there are no sharp corners on these wear points and therefore we have gone through the process of analyzing those and dispositioning those as very low probability, if not zero, for the creation of a crack. And we have analyzed that up to 140 parts per million Heq.

So we are very -- in terms of those flaws, we would treat those as non-flaws in terms of this event.

And also, I want to mention that Darlington does -- that we confirmed at Darlington there is no flaws.

THE PRESIDENT: Okay. Thank you.

Let's then move to Ms. Maharaj.

Oh, I'm sorry. Mr. Newman, to you up next.

MR. NEWMAN: Gary Newman, for the record.

I just wanted to -- I said this in my

presentation but I wanted to emphasize, just like the Darlington design we can't have flaws in this location because of the design. The way that the fuel indexes out of the core, it can't actually produce these kinds of indications at the top of the pressure tube. It can only occur at, you know, in the lower 180 degrees of the pressure tube, but not in this region of concern as we have defined it. I just wanted to emphasize that point.

THE PRESIDENT: And then to Mr. Carroll's point around crack initiation model and either revisiting it or refining it or developing it, can you just give us an update on where you are heading with that?

MR. NEWMAN: Yes. Gary Newman, for the record.

Yes, a good comment. I agree with what he said there.

We have a technical basis that actually has demonstrated that, you know, as you go beyond certain concentrations it does not influence a crack initiation for delayed hydrogen cracking, because there's only so much real estate at the notch, at the root of these volumetric flaws and you just can't put anymore hydrogen in that region.

Having said that, we also -- as a part of a verification effort, we are standing up some additional small specimen tests which will demonstrate this. This will be occurring, you know, before the end of this year.

THE PRESIDENT: Thank you.

Then over to Ms. Maharaj, please.

MEMBER MAHARAJ: Thank you, Madam Velshi.

I have been listening quite carefully about the modelling because, you know, I want to make sure that I'm understanding the assumptions that are going into some of the conclusions that appear to be drawn and perhaps Mr. Carroll can help me, just in little bite-size pieces rather than in one gigantic question, to make sure that I am understanding the assumptions correctly.

So what I think I have understood is that it's not truly the concentration of the hydrogen deposition in isolation that is creating a concern, but it is the pairing of elevated hydrogen equivalent deposition with a potential for a crack that causes the real concern.

Is that a correct statement of that assumption?

MR. CARROLL: Blair Carroll, for the record.

Yes, you have nailed it perfectly. That's the assumption.

MEMBER MAHARAJ: Okay. So if that's the assumption, then the concern is what causes the crack, which is your crack initiation analysis, and that could be a flaw, a metallurgical flaw or a flaw with respect to manufacturing that could create the initiation of a crack, which in the presence of elevated hydrogen equivalence causes the problem.

Is that assumption correct?

MR. CARROLL: Blair Carroll, for the record.

So the flaws that we're referring to are generally flaws that are formed in service because of the fuel bundle contacting with the inside diameter of the pressure tube. So the fuel bundle will vibrate because of the flow of the primary coolant going through the channels and the bearing pads that the fuel bundle rests on between the fuel and the pressure tube material, that can vibrate and it can cause small flaws.

Sometimes if there are small pieces of debris that enter into the fuel channels, then that fuel channel can get -- or that debris can get trapped between the fuel bundle and the pressure tube, and again, as the fuel bundle vibrates that can wear away small -- cause small flaws in the pressure tube.

So what the focus has been on at this point is to demonstrate that at the locations where the Heq is elevated these types of flaws haven't formed during service, because these are the sites where cracks could initiate.

But yes, if there is no flaw, the stresses wouldn't be high enough to cause a crack to initiate during normal operating. It's that flaw that causes a localized increase in stress which can form a crack.

MEMBER MAHARAJ: Okay. And then is it a correct assumption that you are concerned about the region of interest because that's where the hydrogen equivalent deposit occurs, because during hot temperature hour -- or hot full power hour operations the majority of the pressure tube is not subject to the deposition because the heat -- the temperature mitigates against the deposition of hydrogen in that area? So the flaws or potential flaws in the major part of the tube, the major length of the tube, aren't a concern, it's really just this region of interest; is that -- have I got that right?

MR. CARROLL: Blair Carroll, for the record.

So the hydrogen will ingress into the tube during normal operation. The issue is outside of this region of interest. The current Heq -- or hydrogen prediction models are working fine, so industry has confidence in what the hydrogen equivalent concentration is at the locations where they are expecting flaws and they can analyze those flaws and confirm that they meet the required safety margins.

MEMBER MAHARAJ: Okay. So --

MR. CARROLL: So we are looking at a very small region where there are no flaws at this point in time, based on the information we have. There they can't predict Heq, but because there is no flaw to initiate a crack we don't need to be able to predict the fracture toughness at those locations.

MEMBER MAHARAJ: So in the inspection process then -- now that we have gone through all that, here is the question. In the inspection process, is there an accounting or an accountability for examining whether there are any risks of flaws that could potentially create cracks in the balance of the tube or should we really only be focused at that region of interest? Do we need to be concerned about the rest of the tube?

MR. CARROLL: Blair Carroll, for the record.

At this point, based on all the information that we have, no, we would not need to be more concerned than we are right now. We always do -- we always require industry to analyze what's happening in the rest of the tube, it's just the models are in place to be able to do that right now. In this region of interest the models aren't validated to work in that region, so that is why the concern is in place.

And as we pointed out, CNSC staff has -- given the uncertainty with the Heq modelling and how the Heq may progress with further operation, we have recommended at this point expanding that region of interest where we want industry to confirm that they have no flaws, something that is not necessarily constrained to the top of the tube at this point. So we want to consider full circumference and we want to make that region a little bit larger just so if the Heq region of elevated -- sorry, the region of elevated Heq spreads with further operation, while they are investigating what the cause is, we have an additional buffer in place to be able to say we can still maintain the safety margins.

MEMBER MAHARAJ: So then with respect to that region of interest, did I understand correctly that it can't be examined or inspected for flaws which could potentially cause cracks during operation?

MR. CARROLL: Blair Carroll, for the record.

Yes. You can't inspect the tube at all during operation. The tubes can only be inspected when they are shut -- when the reactor is shut down and the fuel is removed. But because the fuel --

MEMBER MAHARAJ: So during ordinary maintenance?

MR. CARROLL: Yes, exactly.

MEMBER MAHARAJ: Okay.

MR. CARROLL: So because the fuel doesn't necessarily -- the fuel bundles don't reside in that location, there is generally not a lot of opportunity for the fuel bundles to cause flaws in that location, because it is such a small distance from the end of the fuel channel. And industry has shown that -- or at least Bruce Power has shown that in their tubes that they have inspected they haven't seen flaws in that region. OPG apparently has some tubes which have some flaws, but further analysis will be done on that. But there has to be a mechanism to cause the flaw, and the mechanism is primarily the interaction between the tool bundle and the pressure tube and that hasn't shown to be a problem specifically at that location where the Heq has been measured to be high. And that is why we want industry to focus on confirming in the short term while they are doing work to investigate if they can understand why the Heq has been elevated there and be able to predict it going forward to support continued operation.

MEMBER MAJARAJ: Okay. So last question. So then just to wind this up, so is it part of the staff's ask of the operators that they differentiate the potential cause of flaws as between the operational causes that you have just described and potential manufacturer or chemistry or metallurgical risk? Has that been asked of the operators as part of your assessment at this point?

MR. CARROLL: So Blair Carroll, for the record.

So the flaws that we are focusing on are primarily mechanically caused in-service. There are potential manufacturing-related flaws that can occur and we have presented the information on that in the past. Those would be detected as well during inspections if they existed. So that's -- part of the assessment would be, yes, we are focusing on the flaws that would be service-induced, these mechanically created flaws, but they also have to consider any original fabrication flaws that might be in the pressure tube and those have not been observed yet either from the information that we have gathered, but it would have to be considered as well as part of the overall safety case going forward. If they could potentially cause a problem, then they would have to be analyzable as well.

MEMBER MAHARAJ: Okay. Thank you, Madam Velshi. Those are my questions on this point.

THE PRESIDENT: Thank you, Ms. Maharaj.

Let's move to Mr. Kahgee then, please.

MEMBER KAHGEE: Thank you, Madam Velshi.

Thank you to the CNSC staff and the licensees for their submissions today.

I initially also had questions that went to the robustness of the Heq models, but I think for the most part my colleagues have covered that off and I got some clarification on there. What I am hearing is that overall CNSC staff and the industry seem to have some degree of confidence in those models going forward, with the caveat that there is still some work to be done. I think, Mr. Carroll, you started expanding on what that work would entail and what that looks like and so I thought that was very helpful.

I'm going to change gears then in light of that. Obviously, when we talk about the overall safety case, part of what we are talking about is ensuring public confidence. My question is to CNSC staff and I also have one to Bruce Power.

The first question is: What is CNSC doing to communicate and ensure confidence in the overall safety case for the public?

DR. VIKTOROV: Alex Viktorov, for the record.

Let me begin trying to answer this

question, but it is a really broad field and many parts of the organization contribute to it, was ensuring we have confidence and communicate it to the public and stakeholders.

To start with, many interactions have been made public. We made public the event initial report, the 12(2) request, the orders, they have been all posted on our website, and we proactively reached out to many interested parties, be it private citizens or elected officials, reporters, media outlets. We put significant effort in trying to quickly respond to any incoming requests for information and again be proactive and as open as we can with the amount of information at our end.

So again, learning from the past experiences and trying to make sure that people understand that in this complex situation, evolving situation, we do our utmost to protect public safety. We put significant effort in this, but maybe my colleagues will provide additional details how it was done and through which channels.

THE PRESIDENT: Let me see, is it someone from the CNSC who is going to talk about what additional stuff CNSC has done or can I move to the licensees?

Mr. Jammal...?

MR. JAMMAL: Thank you, Madam Velshi.

Ramzi Jammal, for the record.

In addition to Dr. Viktorov, I personally reach out to the host communities around Bruce Power, and not just around Bruce Power, to the inter-host community, talking to the mayors to give them assurances with respect to the safety case and the predictability of maintaining the safety.

In addition to the focused outreach, the CNSC itself did update our website that is publicly accessible for anyone to look at where we are with respect to pressure tube, explaining what is pressure tube, explaining the significance of the pressure tube and the safety case itself.

So in conclusion, we did reach out, as Dr. Viktorov, my colleague, mentioned. I personally went on one-on-one discussions with the mayors, elected officials, and the public. And I did reach out for many of the public who wanted to have a discussion with me. Almost everyone accepted, I would say over 98 per cent acceptance. Two were on holidays. Even many of the mayors who were on holidays took the call.

So in conclusion, we reach out. We amended our website and rendered any of this information that is before you publicly available for anyone to review.

THE PRESIDENT: Thanks very much, Mr.

Jammal.

Mr. Scongack?

MR. SCONGACK: Right, thank you, Madam President and Commissioner Kahgee for the further question.

A few elements to add. As Commissioners are aware -- James Scongack, for the record -- as Commissioners are aware, all licensees have a public information program, and that is the case with Bruce Power. And that public information program, from our perspective that -- we engage in that very heavily throughout the course of the summer, transparency was paramount.

We launched a separate website to house videos and all of the documents that are available before the Commission, also the summary materials. We shared that video extensively on social media and to a local emailing list of our newsletter of well over 10,000 subscribers.

Similar to the activities that CNSC undertook, we reached out to Indigenous and non-Indigenous community leaders, providing the opportunity to provide briefings, shared our various materials, and we will certainly continue along these lines.

What I can say is the one area of feedback that I think was most prominent in a number of the discussions is a lot of people really want to understand the multiple factors that contribute to pressure tube integrity. So it was very important for us to continue to reassure people that elevated hydrogen in itself is not the only determinant of pressure tube integrity. So and you'll see some of those elements from the video that Mr. Mudrick shared.

So we're going to continue this. And it's not only important that we demonstrate safety to ourselves and to the Commission, but that public confidence component is absolutely critical.

THE PRESIDENT: Thanks for sharing that, Mr. Scongack.

Can you just maybe at a summary level tell us what's been the public's reaction, level of concern or reassurance that they may have got from you?

MR. SCONGACK: Yeah, James Scongack, for the record.

We have not received one public inquiry in our public information mailbox. Through all of that, we think that the video is an effective way of telling that broader story. I think the feedback has continued to be consistently positive, and we'll certainly keep up with that. But there has been no concerns that have been raised. But obviously, we have to continue to be proactive on that front.

THE PRESIDENT: Thank you.

Mr. Nouwens?

MR. NOUWENS: Thank you.

I just want to add a few comments on this topic. As you know, community engagement and our social licence is of paramount importance to us, and we really strive hard week after week to make sure that we keep those lines of communication open. And one of the primary foundations that we base our social licence on is transparency.

So we did have a meeting with our local community a couple weeks ago. Although we were physically distanced, it was a face-to-face meeting. And we covered the key points, really, of this developing topic in the industry and really just wanted to share in the community that it's important to us. We understand the technical aspects and we're working with our community, but also to ensure and instill them with the confidence that it's a safe station to operate and that we're continuing to reinforce that safety is our number one priority.

Certainly what you just heard from James, we also did not receive any serious -- or sorry, any comments or any concerns around what we're doing in response to this and no concerns around the safety of our operation.

THE PRESIDENT: Thank you. Thank you for sharing that.

Dr. Vecchiarelli?

DR. VECCHIARELLI: Vecchiarelli, for the record.

Just to add, same as for OPG, the social licence is critical for us, and we have a very healthy stakeholder engagement approach.

We have informed our staff, because questions are asked when -- as this event report became more visible. And so we have assured our staff that we have this well in hand, that we're within our licensing basis and the reactors are safe to operate.

Similarly, externally, you know, we've reached out to mayors and news sources where there have been inquiries, and we have not received any sort of particular questions of concern back to OPG.

THE PRESIDENT: Okay, thank you.

Mr. Kahgee, back to you.

MEMBER KAHGEE: Thank you very much for that. I think that's very helpful. And thank you Mr. Scongack for clarifying and expanding, because my follow-up question was going to be did that include engagement with Indigenous communities. You've clarified that.

I'll just come back to a point of clarification with CNSC staff. I heard reference to communications with mayors and host communities. Was there outreach -- did that outreach include specific communication to Indigenous communities in the territory?

THE PRESIDENT: Thank you. I see Mr. Jammal's got his hand up, so over to you, Mr. Jammal.

MR. JAMMAL: Apologies, Commissioner Kahgee. Can you please repeat the question? I got interrupted here from the network. Apologies.

MEMBER KAHGEE: No, no problem. No problem at all.

So I thought the clarification was very helpful. You had talked about CNSC's outreach efforts with respect to host communities and the mayors and local leadership. I was just curious as to whether that outreach included specific communications with or engagement with local Indigenous communities within the territory.

MR. JAMMAL: Thank you for that question. I will pass it on to our communication expert, Ms. Gerrish, with respect to giving you the full picture on the communication. I can -- unfortunately, from my perspective, I did not reach out to the Indigenous communities, that I can confirm.

But definitely the whole campaign from the CNSC did expand to everyone from social media and to specific target technical discussions, more than technical discussions, but I'll ask for our communication expert to provide with details and overall picture with respect to campaign and social media communications and everything else.

And I'd like to remind everyone that this is a public hearing that's being webcasted for everyone, and the engagement of the public will always -- is part of our transparency.

Ms. Gerrish, over to you.

MS. GERRISH: Thank you, Mr. Jammal.

It's Meghan Gerrish, for the record.

Yes, we did have a fulsome communications plan targeting host communities to talk about this issue. We did a number of upgrades to our website. We also -- as Mr. Jammal had mentioned.

We've also been working with members of the media who have expressed interest directly in this topic. So that's something that we are trying to provide technical briefings in order to bring this very technical topic down to a plain language that, you know, most Canadians can understand. And as we can see here today, it is very complex.

So that's something that we'll continue working on. We're working, developing fact sheets and reaching out to communities through webinars and different ways through mail drops in order to really help communities have a direct line to ask their questions to us directly.

THE PRESIDENT: Thanks, Ms. Gerrish, for that.

So coming to Mr. Kahgee's specific question around reaching out to the Indigenous communities and their leaders as we did to the municipal leaders, and Mr. Jammal said he didn't do that himself personally. But did the CMSC's communication plan identify that as a target group as well? And if it doesn't, clearly some changes are needed in that area going forward. So can you comment on that?

MR. JAMMAL: Yeah, for me, Madam Velshi, our Bruce site office, CNSC Bruce site office and in specific Mr. Jeff Stevenson did reach out to the local Indigenous communities as part of our transparency and bilateral discussions.

THE PRESIDENT: Perfect.

MR. JAMMAL: So if the question from Mr. Kahgee was to me personally, the answer, no, I did not. But the CNSC did do it.

THE PRESIDENT: Yeah, right. His question was to the CNSC. Right.

MR. JAMMAL: Okay, but CNSC did, Mr. Kahgee --

THE PRESIDENT: Right.

MR. JAMMAL: -- go out to the Indigenous community via Mr. Jeff Stevenson.

THE PRESIDENT: Okay, thank you.

Mr. Kahgee, did you have any follow-up to your question?

MEMBER KAHGEE: No, Madam Velshi. Those are my questions.

THE PRESIDENT: Thank you.

Well, maybe I will follow up on that because on that whole point around building public trust and it was good to hear from the CNSC as well as the three licensees around transparency and how you have made sure that you've done that.

And this is maybe shifting gears a bit, but I do want to take this opportunity because we have heard concerns around pressure tubes at public hearings before and concerns by some of our intervenors that when they have asked for information around pressure tubes it's not always forthcoming in a timely manner.

And I see that even in the submissions that licensees have made for today's meeting, there are some sections that have been redacted, so not available to members of the public. And I can understand, you know, if it's proprietary information.

But I'm just going to encourage -- maybe more than encourage -- I'm going to beseech industry in particular that when it is a serious issue such as this where we have questions around our ability to predict levels that could result in significant failure, it behooves us to be even more transparent than we normally would have been.

And I just want to make sure I'm getting that commitment from everyone here today that we collectively will make sure that we go out of our way and make information publicly available, and it's only the absolutely proprietary information or highly confidential information that gets redacted. And I would ask CNSC staff to challenge licensees when anything gets redacted or is not made available as to why that is happening.

I know because I personally get letters from members of the public that requests from 2015 are still in the works, and they are not getting the information that they have been asking for. And it's not a place I want to be at. I don't think it's a place you want to be at either.

So maybe I will just ask for a quick affirmation from all three of our licensees. And we'll start with Dr. Vecchiarelli, please.

DR. VECCHIARELLI: Vecchiarelli, for the record.

I wholeheartedly agree with you, President Velshi. We endeavour to be as transparent as possible. You know, we have worked with various groups who have requested information. We've done our best to provide it in a timely manner.

There is a balance sometimes where, as you mentioned, proprietary information of significant value -- we try to strike the right balance between that full transparency and some items that we just perhaps cannot provide.

But the important thing is, I believe, that the context, the relevant information in what we have provided is understandable and the story is there, the information is there. While some broad data may not be included in some cases, I think it all lends itself for members of the public to understand the content of what has been provided. Thank you.

THE PRESIDENT: Thank you for that, Dr. Vecchiarelli.

This is an important issue to me personally, and I will personally get involved in this if I feel that licensees need to be more forthcoming. We've done that with environmental data as well. There are some experts who actually want raw data themselves to be able to do the analysis and if controls need to be put in place to control the further dissemination of that, we may need to look at that.

But I think in order to build public confidence and get as many perspectives from experts outside this room and outside the parties here, I think we all need to go that extra distance in being more transparent.

Mr. Scongack.

MR. SCONGACK: Madam President, James Scongack, for the record.

I think it's a great question. And we share the same importance around this. We have a bias towards transparency.

I think there's only three very brief items I would say in response to your comments. The first is that we encourage all members of the public -- groups, individuals -- they don't need to go to the CNSC for information. They're welcome to request that with us directly. It doesn't all need to be through RFI. Send us an email, give us a call, and let's understand the thing. I think that practical piece is important.

I would note there's only two elements that we have redacted in what we've provided the CNSC. The one was an internal document and it was designed to be an internal document. There was no information that was not made available. And the second was our planned outage dates which are commercially sensitive.

However, what we will note in our upcoming presentation on the 10th of September is, given the public interest on when planned outages are, even though we can't say the exact dates, we have provided more information -- it's available on our website right now -- on when those are. So if folks get a sense that that's not four years away, that it's five months away.

So we have a bias towards transparency and share your passion on that front.

THE PRESIDENT: Thank you very much.

Mr. Nouwens?

MR. NOUWENS: Thank you.

Just to build on the comments you just heard from James and Jack, transparency has always been very, very important to us as an organization and our social licence. And I will reaffirm our commitment to the industry and to the public and to you that we will always be transparent.

Anything we do redact we do not take lightly. We don't like redacting information. Sometimes, as you've heard, it's commercial sensitive or there's other aspects that sometimes it's not our information to share.

But we always, you know, review every piece that we need to redact with a fine-tooth comb. It's never our objective to hold information back from the public or from anyone else.

And I just want to add that there is sometimes other avenues in what we use, and if we do need to redact certain information or tailor the information we provide publicly, we also do offer to any member of the public to meet with us in person. And we have done that routinely where we've brought people in and had them put a concern or even just a special interest in a certain area. We've brought them to our site and we've had face-to-face meetings and provided them with all the information that we can in a face-to-face format.

So we do extend the invitation to anybody to reach out to us and meet with us. And we do everything we can to make sure that the transfer of information is provided.

THE PRESIDENT: Thank you very much for that.

So back to Dr. Lacroix.

MEMBER LACROIX: Thank you very much.

Can I come back to a technical question?

THE PRESIDENT: Of course.

MEMBER LACROIX: Okay, that's great.

This might be a silly question, but how do you define a crack? How do you define a flaw in the sense that who decides when a flaw might be a threat to the pressure tube wall? Is it a function of the size of the crack itself? Is it a function of the population of cracks, of the distribution of cracks, of the orientation of cracks? Is it done by machine? Is it done by an operator? So I would like to have more information on this.

THE PRESIDENT: And do you want staff or do you want licensees to answer that?

MEMBER LACROIX: Licensees first.

THE PRESIDENT: Okay, let's start with Bruce Power, then, please.

MR. NEWMAN: Gary Newman, for the record.

Great question. The way that we distinguish a crack from a volumetric flaw is simply that way, that a volumetric flaw has to have specific geometry. And below a certain rib radius, we just treat it as though it were crack-like. So anything less than a certain minimum radius on that volumetric defect, it's a little bit conservative, but that's the way that we've decided to treat it.

So we don't actually see crack-like features when we do our inspections. We've never come across them. But we do see volumetric flaws. And then we have a cut-off at, you know, at a certain point of geometry that -- and we treat things as crack -- even though they're not a crack, we would treat them as crack-like in that circumstance.

MEMBER LACROIX: And this analysis is performed by a computer?

MR. NEWMAN: No, no. What we do is we do a full-length three-dimensional volumetric inspection that gives all the indication information to licensed NDE technicians. They will take all that ultrasonic information and reduce it down. And it gives them the actual sizes, the dimensions, the length, the width, the depth.

And then, if we need to, if the flaw is large enough, we will actually go in and take a dental mould of the indication and that gives us now even better geometry information.

MEMBER LACROIX: Okay. And you talk about a volumetric crack as opposed to a surface crack. What's the difference?

MR. NEWMAN: All of these indications that we find in the pressure tube, because they result from interaction with the fuel either from fuel bundle bearing pads or from debris-related trapped in the bundle, they're all volumetric by nature because -- you know, because there's a physical size to both the bearing pad and debris that can get into the PHT system. We don't see it very often, but we do see it. Then it has very finite dimensions associated with it.

MEMBER LACROIX: I see, okay. Thank you very much. Thank you.

THE PRESIDENT: Mr. Knutson?

MR. KNUTSON: For the record, thank you for the opportunity.

I guess Commissioner Lacroix, just to add to what Gary -- I agree with everything Gary said.

What I would say is in the CSA standard, you define a flaw at 0.15 millimetres in terms of some distortion of the pressure tube. And obviously, we don't allow anything greater than 0.5 millimetres in terms of through wall.

So typically, the flaws that we have in our units are not cracks. We then analyze those flaws to determine will they grow into a crack. And as Gary pointed out, we do do replications where we put -- we understand the full geometry and in some cases we may do finite element analysis to analyze the stresses being produced. Obviously if there's sharp edges, those are the ones that could lead to a crack.

And in the case of, for example, on Unit 5 for OPG. The tube flaws we have there are from bearing pad wear. So we call them a flaw, but they're very smooth. There are no sharp edges. They've been analyzed. And therefore, in terms of Heq -- and what I mean is hydrogen won't accumulate there because of the sharp edges, because they're flat smooth, hydrogen does not travel there in preference. And therefore, those, what we would call a dispositional flaw, we know it's there, we know why it was caused, and we now better control that that doesn't happen since 2015, since we did operational changes. Those flaws do not occur in that area because of how we limit time in that area.

So I think I -- I'm hoping I helped answer your question there. But that's additional detail.

MEMBER LACROIX: Okay, that's great.

One more question: When you take a -- you scrape a sample from a pressure tube, does it mean that you destroy the pressure tube? Is it -- or can you still use the pressure tube itself?

MR. KNUTSON: Mark Knutson, for the record.

If I can allow myself to answer that question --

MEMBER LACROIX: Sure.

MR. KNUTSON: -- Madam President?

THE PRESIDENT: Yes.

MR. KNUTSON: The scrape is intended to be a smooth cut of the pressure tube to a minimum depth to get an actual sample. So we do -- we do do an oxide scrape to get rid of the oxide layer. And then we do a second scrape to get the sample of targeted area to get the actual hydrogen measurement from that second scrape. And because they're smooth, known geometry, we can disposition those as flaws we've created, essentially, but they're not one where hydrogen will accumulate to nor will they lead to a future crack.

MEMBER LACROIX: Okay, I understand.

MR. KNUTSON: So we are taking material out of the tube, but it's in a safe manner that does not affect its operation.

MEMBER LACROIX: Okay, okay. Thank you very much. Thank you.

THE PRESIDENT: Thank you.

Dr. Demeter? I'm sorry, Dr. Berube.

MEMBER BERUBE: Just a follow-up question on that. I mean, I've been listening very intently throughout this whole discussion. And it seems to me because we're in a situation where we have a region now, a burnish area, where we're uncertain about what's really going on. And we know that fundamentally flaws are now a critical aspect to whether or not we're operating a safe region or not.

I want to investigate or talk about flaw detection and assessment, and in particular I want to look at the tools and the methods and the procedures that are done at all operating stations in terms of what is the technology being used to actually detect these flaws. What is the process by which these flaws are being evaluated. And I want to get right down to are we looking at visual inspection, IR, ultrasound, radar -- what are we doing, here? And are these technologies suitable in the area that we're looking at in the burnish area, because obviously this is of great concern.

And I'd like to start that with the CNSC and maybe the operators can add in later.

MR. CARROLL: Blair Carroll, for the record.

So the primary technology that's used to detect these flaws is based on ultrasound. And it is qualified to detect flaws that could potentially cause issues with the potential for forming cracks. So for instance, the CSA standards has a limit on -- a current limit on flaw depth of 0.15 millimetres and above and beyond that depth the flaw requires further analysis.

So the inspection technologies that are

used have been confirmed through laboratory testing and field exercises to be able to reliably detect flaws of this depth.

Once the flaw is identified, then it's characterized through analysis of the inspection tool data. And dimensions, for instance, the length, the width, and the depth of the flaw are developed. And in addition, the flaw can actually -- the ultrasound signals can actually follow contours through the flaws to look at radii along the radius at certain locations, to look at where the radius may be sharp enough to cause a stress concentration.

And if further analysis is required to be able to -- to be able to further, you know, evaluate the geometry, then as Mr. Newman identified, initially we'll actually go in and actually take a replica of the flaw using a moulding material that's injected into the surface. And then they'll remove that replica, and then they'll be able to physically measure the dimensions from that replica using -- well, oftentimes they use lasers to get really detailed in terms of the geometry if they need to do that level of analysis.

So when they've adequately characterized the size of the flaw, then there are formulae and criteria that are used, and the process is evaluated to determine the stresses associated with that flaw. And then those stresses -- based on those stresses, the potential for hydrogen to accumulate at the flaw and initiate a crack is evaluated. And those procedures are done in accordance with the CSA and N285.8 standard.

And at that point, a decision is made if the flaw is at risk of cracking, the flaw is not acceptable for continued service. And if that's the case, then industry would have to take some sort of an approach to deal with that. And generally the practice would be to actually remove the pressure tube.

If it is not determined to be that severe but it is worth -- it's still worth future monitoring, then that flaw will be added to a list that the industry will continue to reinspect that tube at periodic intervals in the future to make sure nothing changes associated with that flaw.

And that's the process, that's the general process that's used.

Did I capture all of your -- the response to all of your questions?

MEMBER BERUBE: Just need to understand. So basically, it's continuous monitoring using ultrasound technology, laser mitigation for depth analysis, and modelling in that particular case. And then fundamentally, if the tube is deemed to be unsatisfactory, it's replaced.

And I guess during the next maintenance shutdown? How does that progress?

MR. CARROLL: Well, it would depend, but typically it would be replaced during the same maintenance outage. If they determine that the flaw is unacceptable, it would be removed from service before the reactor would be returned from service for that outage.

MEMBER BERUBE: And would industry like to chime in at that point?

THE PRESIDENT: Yeah, Mr. Knutson's got his hand up, so over to you.

MR. KNUTSON: Knutson, for the record.

What I wanted to add there -- everything Blair said is true.

What I would say is we do -- the inspection program is approved and through CSA but also the Canadian Inspection Qualification Board. We train our people and they have to pass the ability to do the inspections.

We also retain all the data going forward so we can actually look at it again. So when you do repeat inspections, we can check to make sure we didn't miss anything on the initial inspection. And so there's a number of checks and balances there that give us very high confidence that those inspections are ...

We also do full pressure tube inspections. And that's full around the whole circumference and all the way through the tube when we do these types of inspections.

Thank you.

THE PRESIDENT: Thank you.

Let's move to Dr. Demeter then, please.

MEMBER DEMETER: Thank you very much. Actually, you know, all of my questions have been addressed. Thank you very much.

THE PRESIDENT: Thank you.

Dr. McKinnon?

MEMBER McKINNON: Yeah, thanks.

I'd like to ask a few questions about the scrape tool testing. In one of the letters for OPG -- so this would be -- sorry, Bruce Power. One of the letters from Bruce Power mentioned that the position of 12:00, very close to the burnish mark, at the outlet roller joint had not been measured as part of prior scrape campaigns due to inherent limitations in the design of the scrape tool.

And that surprised me. I just want to first of all clarify that that is correct. Because that's precisely where this vulnerability of high concentration is now occurring. Is that because that location was not previously well understood in terms of the sample or the data that could be obtained? And could this same condition have been missed in previous inspections due to that limitation? Could you discuss the -- you know, what exactly this limitation is and how it is affecting your sampling and obtaining data?

MR. NEWMAN: Okay, for the record, Gary Newman.

So you are correct. All we did in this case, though, is we were able to sample throughout this region in the -- from the beginning of the pressure tube at the outlet all the way inboard across the entire length to the other end over a six-metre sort of distance. And we do that thoroughly.

All we did in this case, though, is we refined how close we got to the burnish mark. We wanted to move closer. It's not that we had missing information before. But what we were doing is we would normally do a curve fit to where we actually take the measurements. And because we wanted to reduce the uncertainty in that curve fit, we decided to modify the tool so that we could go in and take an actual scrape sample just 10 millimetres outboard of the burnish mark as well as 20 millimetres inboard. And it just required that we had to change slightly the support conditions to make sure that the tool was square to that region of the pressure tube.

So it wasn't like we were -- couldn't see that region. We just wanted to reduce any uncertainty that might exist by taking actual scrape measurements at those locations.

MEMBER McKINNON: Okay. So is this modification, is that tool actually something standard that is bought that other operators would be using exactly the same configuration and they'd be faced with the same limitation?

MR. NEWMAN: Again, they wouldn't be -- there wouldn't be a limitation so much. Their curve fitting routines work fine. So it's not a problem.

In this case, where we were seeing higher concentrations, we wanted to remove any uncertainty at specific locations, so we did a modification to the tool. We had the benders that support us create those modifications. And those -- we made those available to the other utilities as well.

MEMBER McKINNON: Okay, that clarifies. Thanks very much. Because I also noticed, you know, that there was a lot of emphasis placed on the fact that this is only like 0.5 per cent of the volume and very, very tiny and it would be quite easy to miss and, you know, hence your modification.

Okay, thanks for the clarification. Thank you.

THE PRESIDENT: I see there are a few hands up, so let's to go Mr. Carroll first and then Mr. Knutson.

MR. CARROLL: Thank you, President Velshi. Blair Carroll, for the record.

I think there's probably -- I can probably provide a bit more clarity on some of these issues with regards to the measurements as well.

Typically, the in-service scrapes that are taken from the tubes are not taken right at the burnish mark location. They're taken a distance away from that. And I can give you some rough numbers, but may not be exactly the same for every pressure tube. But usually it's 60 to 70 millimetres inboard of the burnish marks. And "inboard" is the direction towards where the fuel is located.

And then they would take another -- other samples outboard of the burnish marks, so on the other side of the burnish mark, inside the end fitting. And from that information, they would fit a curve through the data to try to estimate what the actual measurement is at the burnish mark.

So then again that's one of the reasons why CNSC staff has recommended a region within which there should be no flaws for -- to support the fitness for service case, because you don't actually have the measurements from in-service scrape samples for these tubes right at that burnish mark location. So that provides the buffer to where they first take the initial measurement.

From the surveillance tubes that are removed, so for instance, the Unit 6 tube, that tube is physically removed from the reactor. And from that tube, they take small punch samples that are through thickness. And they can take that at multiple locations, along axial distance and around the circumference. And with those samples, they can measure exactly at the burnish mark location.

So I just wanted to try to distinguish between the two and just point out that, yes, in-service inspection scrape sampling, they cannot actually measure directly at the burnish mark. It's inferred through measurements on either side of the burnish mark.

MEMBER McKINNON: Okay. That helps to clarify.

It's related to another part of the question that I have is that is there a prescribed methodology for those scrape locations? Or is that at the discretion of the operators?

MR. CARROLL: Blair Carroll, for the record.

So the licensees will have procedures that they have in place for doing -- performing these scrape programs. So they try to take it at specific locations according to their procedures. They have submitted those procedures to us in the past for review, and they attempt to follow those procedures as closely at possible.

MEMBER McKINNON: Is that standardized across operators? Or --

MR. CARROLL: It's generally standard, yeah. It is generally standardized across operators. But there may be slight differences. For instance, I said, you know, it may be 60 millimetres, it may be 70 millimetres. It's not, for instance, one takes it at one metre away and the other one takes it a half metre away. We're talking about within millimetres, generally.

MEMBER McKINNON: Okay.

THE PRESIDENT: Thank you.

Mr. Knutson.

MR. KNUTSON: Mark Knutson, for the record.

Just to add to agree with everything the two previous speakers said. The -- obviously, the burnish mark is a high stress area that you typically will not scrape on because it would be tough to analyze and/or you may have to remove the tube, but as you move outward from there, you can do scrapes. So typically, OPG would scrape from 9 o'clock to 12 and from 12 o'clock to 3 o'clock, so the adjustment that Bruce Power has done is to do top dead centre around the 12 o'clock region.

Back in 2017, OPG would have started doing punch samples around every o'clock position on the removed tubes, and that was to verify and check our scrape results to see if we were missing anything.

So that -- the punch samples on a removed tube is intended to check every part of the tube to ensure some -- to help with your modelling and also extra knowledge that -- where the scrape sampling cannot get to.

Hopefully that's helpful.

MEMBER McKINNON: Yes. Thank you very much.

THE PRESIDENT: Thank you.

Ms. Maharaj?

MEMBER MAHARAJ: I just have one short question for staff with respect to the licence condition wording for Licence Condition 15.3.

What the licence condition says in the presentation is that before the hydrogen equivalent concentrations exceed 120 parts per million, the licensee has to demonstrate that the pressure tube fracture toughness will be sufficient for safe operation beyond 120 parts per million.

Is there an outer limit of hydrogen equivalent concentration beyond which it's just not possible to operate the tube safely? Is there a limit?

MR. CARROLL: Blair Carroll, for the record.

We don't know, to put it -- the short answer. The idea behind that 120 limit, as I pointed out earlier, was so we -- because that's where the model was currently validated to.

Industry had always suspected that they would be able to go beyond that, but they didn't have the data to support that at the time the licence conditions were put in place. And they have been working since then to develop a revision to the model to expand beyond that.

They had never intended to operate beyond 160 ppm. That was just based on their predictions. They didn't think they would go beyond that, so the intention was to validate the model up to 160 ppm for the tubes that would be in service the longest.

So this puts into some question now as to what the maximum Heq would be and where they would have to go with finalizing the model to address this, but again, in order to get to that point, I think a better understanding of the root cause is going to be required to see what the potential maximum could be. And at this point, again, I just bring it back to where focusing on the Heq alone is not the failure criteria. It has to be Heq that impacts the fracture toughness with the flaw that can cause a crack. So that's kind of the key point.

But we don't know if there's a certain Heq value beyond which the fracture toughness will never be acceptable. That hasn't been evaluated, and that was never the intent. The intent was always to go with what the value of -- that they were predicting would be at the end of life of the longest tubes that were in service, and that was assumed to be 160. That's what they were intending to validate the model to.

At this point, they probably will have to go beyond that, but we don't know how far beyond they have to go at this point.

MEMBER MAHARAJ: So it's fair to say at this point, in the absence of a flaw or crack or concern about flaw or crack, the 211 ppm that's been detected cannot be determined definitively to be a problem. It's just at this point a data point.

MR. CARROLL: So yes, that's correct. There's no reason to suspect that a tube without a flaw in it would ever have a problem just because the Heq reached 211 ppm.

And as I pointed out earlier, they have done one test on a -- I think the number was 204 parts per million that showed that the tube retained sufficient fracture toughness at normal operating temperatures, but we don't have information yet at the shutdown and heat-up temperatures where we fall into the transition region of the fracture toughness behaviour. That's where the information is lacking.

MEMBER MAHARAJ: Thank you.

That's my question, Madam Velshi.

THE PRESIDENT: Excellent. Thank you.

Mr. Kahgee.

MEMBER KAHGEE: I have no additional questions right now.

THE PRESIDENT: Thank you.

So maybe let's do a quick last round of Commission Members, and maybe you can put your hand up.

Dr. Berube.

Did we lose Dr. Berube?

While we wait for him, maybe -- I have a quick --

MEMBER BERUBE: Sorry about that. I'm here. I hit the wrong button. It's getting late.

Yeah. My last question has to do with mitigation measures during start-up and shutdown because this is the area where we don't have a lot of information on how this is going to respond over time. And I believe that OPG and Bruce had both talked about changing the DCCs in order to change the pressure temperature curves as part of the risk mitigation strategy.

I'm worried about the complexity of that and, actually, the validation of those models and how that would happen.

I think Bruce has also mentioned something about the pressure relief valve, and I'd be -- I'd like to know where they intend to put that in the primary heat transport system to actually mitigate potential issues with over-pressurization during start-up, cooldown and, actually, in the event that we have to dump a reactor.

But let's start off with CNSC and talk about the benefits, maybe, of changing the DCC programming at this point. What's that going to get us in terms of a protection factor by doing this?

I don't know if you've had a chance to evaluate it.

And then it'd be good to hear from the operators as to why they think that's something that is valid at this point.

DR. VIKTOROV: Alex Viktorov, for the record.

This is one of the options that is being actively pursued. CNSC Staff is pretty confident that already existing start-up and shutdown procedures are good and robust in avoiding the areas of risk, but we expect licensees to confirm that any further improvements can or cannot be made.

We haven't received any detailed information with regards to this, so that's something that we'll be expecting and exploring. Nevertheless, again, the safety analysis assumes, as was explained, pretty conservative worse kind of -- worst-case assumptions, so we already know that even in worst-case scenario as a consequence this would mitigate control and the health impact's mitigated.

Nevertheless, when it's practicable, we expect licensees to implement modifications. What they might be, we don't have details yet so we cannot have information yet to comment on the DCC changes. Perhaps the licensee can provide information specific to those changes.

THE PRESIDENT: Any licensee wanting to put your hand up?

Mr. Knutson, please.

MR. KNUTSON: We have -- Mark Knutson, for the record.

OPG has reviewed similar design changes

and, at present, do not deem them viable in terms of shutting off our pressurizing pump and other devices there proactively, so we are -- in 2014, we did design changes that what it allowed us to do, it changed some of our safety system trip set points and other changes in the design to allow us to depressurize sooner as we reduce temperatures in the heat transport system. And that, therefore, minimizes the stresses while -- so minimizing the pressure while at a certain temperature as we cool down. And those were implemented in 2014, which are significantly reducing the level of stress on the tubes when we're shutting down and starting up.

The other aspect of that is the -- you know, we did do a full review of our relief valve system being available during those times. We also have trained operators in the simulator for controlling that episode and, also, if we did -- were to go outside that limit, we would shut down for engineering to review whether a restart would be possible based on reviewing the pressure tube stresses we put on it if there was a pressure event while cold.

So there's a number of controls in place ongoing, and that's why we have confidence in that area.

THE PRESIDENT: Thank you.

Mr. Newman, please, and then Mr. Mudrick.

MR. NEWMAN: For the record, Gary Newman, and Mr. Mudrick will follow with more detail.

And I agree with Mr. Knutson.

We have a step pressure -- have, for -- since the beginning of operating the Bruce units have step pressure profiles. And what this does is it reduces the load that the pressure tube has to carry as the temperature decreases. And we've had that in place for a long period of time.

So it's the same pressure profile on the way down as it is on the way up.

All we really propose to do in this case specifically for Unit 3 is to refine that, so we're just making refinements to that. We follow our engineering change control process in order to make sure that we don't miss any elements of that. And that deals with the normal heat-up and cooldown and pressurization cycle that we would put the unit through at these lower temperatures.

In addition to that, what we -- and they're very rare events, but you can, from time to time -- I think we've had four events over the entire life of the units, all of our units. You can have a loss of pressure control at these lower temperatures, and so the DCC modification simply allows you to take that out of the mix. I just removes that as a potential phenomena -- even though it's low likelihood in terms of the frequency that we've seen, it removes that as a potential pressurization activity.

And what that allows us to do, then, is to be able to show deterministically that we still meet all the safety factors throughout that entire cooldown and heat-up cycle.

I'll turn it over to Chris for some additional comments.

MR. MUDRICK: Yeah. Thanks, Gary.

Yeah, I think Gary put it well. We are just looking at the heat-up and cooldown curves, and to Gary's point, as we step down is there a way we can step down more smoothly to minimize any transients in those conditions. We're running scenarios in the simulator right now using the operators and making sure.

Now, there's other operating conditions, you know, such as our steam drums as Bruce A which can create difficulties, so we have to make sure that we're not putting the operators in a precarious position either based on this risk and causing another risk, so it's important that we go through that very deliberately and make sure that we understand all those different scenarios and, as Gary said, run them through our engineering change process to make sure that we can accomplish, you know, both objectives.

So that's what we're doing.

In the interim, we have issued Just-in-time training. The video that we showed earlier was part of that Just-in-time training, including detailed analysis, detailed understanding to the operators of what it would look like if we got into a cooldown scenario, how they would handle that, and making sure that before we went that route, that we had stopped and made sure that everyone understood exactly what we were trying to achieve with that.

So I think that's been -- and we have an ops memo out right now detailing that.

THE PRESIDENT: Thank you very much for that.

Dr. Berube, did you have any follow-up comments or questions on what we've learned?

MEMBER BERUBE: Yeah, just one question for CNSC Staff.

When we start making changes to the DCC, which has been the main operating program, obviously, for reactors critical to safety and security, how do you actually validate and verify that the new program is actually good to go for safe operation?

DR. VIKTOROV: Alex Viktorov.

I'd like to ask our specialist from System Engineering Division to step in and provide details to this answer -- to this question.

MR. SIGETICH: Good afternoon. I’m Justin Sigetich. I'm the Director of the Systems Engineering Division, for the record.

For changes to the DCCs, there is a CSA standard that we would be evaluating the licensees against. They would be following their processes in accordance with that CSA standard.

It's up to the licensees to be able to follow their engineering change control process and ensuring that they're meeting all of the requirements. We would ensure that they are, in fact, following their processes and they, in fact, have met all of the requirements in their licence and in this CSA standard.

So what we do is we would make sure that they are performing all the actions that they are required to perform and that they have ensured that all of the validations and verification tests have been completed as required.

So we would ensure that they're doing everything in accordance with the standards, and I'll leave it at that.

THE PRESIDENT: Thank you.

I see there are no more questions from any Commission Members. Maybe I'll turn over to the External Advisory Committee for any additional comments you wish to make now before we wrap up for today.

Dr. Luxat?

DR. LUXAT: Well, we -- at this stage, we don't want to have any specific -- make any specific comments. It's probably not appropriate according to our Terms of Reference. We're there to advise the Commission Members and we would do that separately because we're not really here as intervenors or staff. We feel it's -- we'd like to stick with our Terms of Reference, so it would be opportune to have a briefing session between the Commission and the External Advisory Committee.

THE PRESIDENT: Thank you, yes.

And any of that consultation, of course, will be in a public forum in any case, so -- and we'll have lots of opportunities for that, I'm sure.

Well, then this concludes the public meeting of the Commission. I'd like to thank you all for your participation.

The Commission appreciates the information that has been provided to it this afternoon, and we'll now consider and digest that information together with a view to how the Commission will address these issues over the coming months.

Of course, the conclusion of this meeting does not conclude the matter, and the Commission will consider how it proceeds from here in its oversight of this crucial issue. The orders that were issued in relation to the pressure tubes Heq discovery will be reviewed in a hearing scheduled next Friday, and then we'll proceed from there.

So again, thank you all for your participation today. Stay safe, stay well. Au revoir.

--- Whereupon the meeting concluded at 4:53 p.m. /
La réunion s'est terminée à 16 h 53