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Supplementary Information

Oral Presentation

Presentation from Anna Tilman

Renseignements supplémentaires

Exposé oral

Présentation de Anna Tilman

In the Matter of

Ontario Power Generation Inc., Pickering Nuclear Generating Station

Request for a ten-year renewal of its Nuclear Power Reactor Operating Licence for the Pickering Nuclear Generating Station

Commission Public Hearing – Part 2

June 2018

À l'égard de

Ontario Power Generation Inc., centrale nucléaire de Pickering

Demande de renouvellement, pour une période de dix ans, de son permis d'exploitation d'un réacteur nucléaire de puissance à la centrale nucléaire de Pickering

Audience publique de la Commission – Partie 2

Juin 2018

Canada

Presentation to the Canadian Nuclear Safety Commission (CNSC)

OPG's Application re:

Renewal of its Operating Licence for the Pickering Nuclear Generating Station for a 10-year Period

June 26 2018

Anna Tilman

Assisted by

Dr. R. Gordon Albright

Introductory Comments

- **OPG's Licence Request: 2018-2028**
  - **Continue to operate Units 1 and 4 and 5-8 until end of 2024 - extend EFPH to 295,000**
  - **Stabilization stage – 3-4 years**
  - **Safe–storage stage – commencing 2028**
- **In contrast to**
  - **Shutdown by 2020 as stated in its current licence**

Pickering's Legacy – Safety Issues

- **Safety issues early on – Unit 2 – pressure tube rupture in 1983**
  - **All 4 Pickering A units were shut down in 1997, only Units 1 & 4 were returned to service after re-tubing**
- **All reactors share the same safety and support systems, and containment and emergency cooling systems.**
- **At least 2 units of Pickering B must be operating to support safe operation of Units 1 and 4.**

OPG's Plan for Pickering - 2013

- **Pickering Units 5-8 would enter the continued operations phase between 2014 and 2016, and continue operating until the end of 2020 or the limit of 247,000 EFPH was reached.**
- **Since the pressure tubes of Units 1 and 4 were replaced in the 1980's, they would not reach the EFPH limit by 2020, but are to be shut down at the end of 2020.**
- **After the last shutdown, Pickering would apply a deferred decommissioning strategy with a 30-year safe storage period.**

Current License 2013-2018 End-of-Life Projections

- **Pickering B**

Unit	Projected EOL Dates based on 210k EPFH	Shutdown Date based on 247k EPFH
5	Q1 2015	Q1 2020
6	Q2 2014	Q2 2019
7	Q2 2015	Q3 2021
8	Q2 2016	Q3 2021

- **Pickering A**

Unit	Projected Shutdown Date	K EFPH for PTs
1	Q3 2020	162
4	Q3 2020	134

Note: EFPH limit was increased from 210 k to 247 k for the current licence period.

OPG's Licence Request 2018-2028

- **OPG is now requesting that the EFPH limit for Units 5-8 be increased from 247,000 to 295,000 to allow these Units to operate until 2024.**
- **A caveat - there is even a possibility of a further delay in closure beyond 2024. In fact, CNSC stated that:**

  "OPG must notify the CNSC no later than December 31, 2022, in case it intends to operate any reactor unit beyond December 31, 2024".[1]

[1] Part 1 of the public hearing, CNSC staff presentation April 4, 2018 CMD 18-H6.A p. 21

Operating Times - EFPH

EFPH values (Pickering B) –2017

Unit	EFPH
5	229,124
6	236,883
7	228,008
8	215,905

- **Current EFPH limit - 247,000**
- **Unit 6: Expected to surpass limit by 2020. Six more years of operation at about 80-85% power, EFPH would be ≈ 290,000.**
- **Units 5,7 and 8 would also surpass current limit**
- **Therefore OPG is requesting an EFPH limit of 295,000 to operate until 2024.**

Operational, Aging Issues

- Current age of Units 5-8 (> 30 years)
- OPG is proposing to extend the end-of-life of fuel channel components from the current limit of 247,000 Equivalent Full Power Hours (EFPH) to 295,000 EFPH.
- As they deteriorate with age, failure becomes more likely for Pressure Tubes, Calandria Tubes, Feeder Pipes, Annulus Gas System, and Spacers.
- There is no reliable way to predict when a critical fuel channel component will fail.

Aging Issues – Fuel Channels

The deterioration of fuel channel components is the single greatest cause of declining performance in CANDU reactors. The degradation of pressure tubes (PTs) limits reactor performance the most.

Problems include leakages at rolled joints, neutron-induced creep, embrittlement and blister formation due to excessive hydrogen pickup, material wear and fretting, and corrosion.

Pressure Tubes – Fracture Toughness

- **As reactors age, there is an increased risk for cracks to develop. If not detected or repaired (if that is even possible), this could lead to a Loss of Coolant Accident (LOCA) in the Heat Transport System (HTS).**
- **The concentration of hydrogen increases the longer the reactor operates. This accumulation of hydrogen results in the formation of blisters and cracks, and is the dominant contributor to the reduction in pressure tube fracture toughness.**

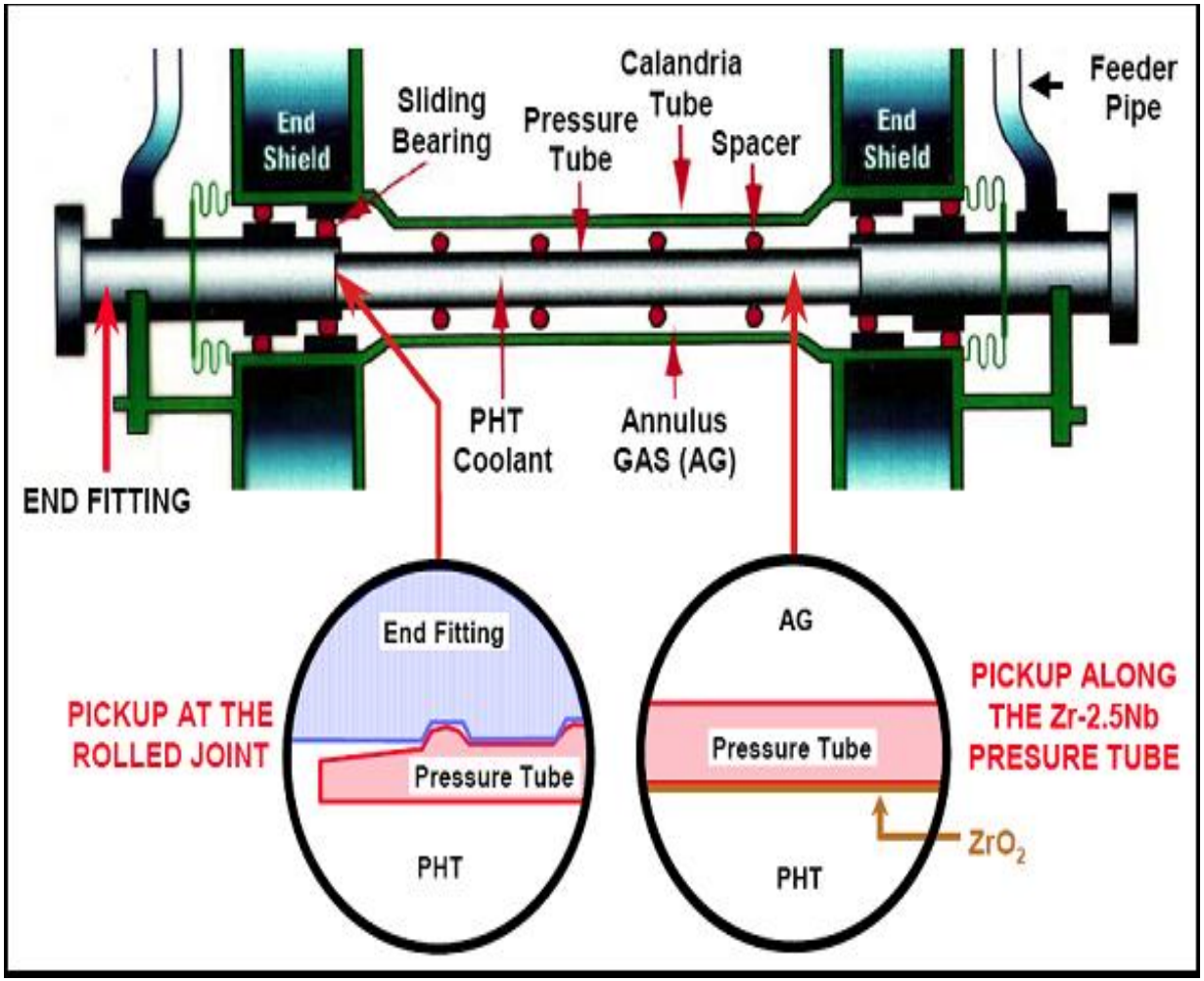
Pressure Tubes – (cont'd)

- **A reduction in fracture toughness can cause a stable, time-dependent crack growth mechanism called Delayed Hydride Cracking (DHC). During DHC, hydrides migrate to stress regions and promote crack growth. When a critical condition is reached, probably related to size, a fracture develops, the crack extends, and the process continues on the newly exposed metal.**
- **DHC is most pronounced during the reactor's transition states between shut down to full power and vice versa.**

Deuterium Ingress and Corrosion

- **Pressure tubes absorb deuterium in two main locations, the inside surface of the main body and the end fittings where the ingress of hydrogen is much more rapid than in the body of the tube.**
- **The rolled joints at the ends of the pressure tubes are particularly susceptible to enhanced deuterium pickup, primarily due to corrosion in the crevices between the pressure tube and the end-fittings.**
- **Pressure tube material has a limited solubility of hydrogen that increases with increasing temperature. If this limit is exceeded, zirconium hydrides are formed. These hydrides weaken the cladding of the pressure tubes by decreasing its hardness, ductility and density, making them susceptible to DHC, and could cause pressure tube failures.**
- **Although hydrogen pick-up has been researched for decades, it remains a major source of uncertainty.**

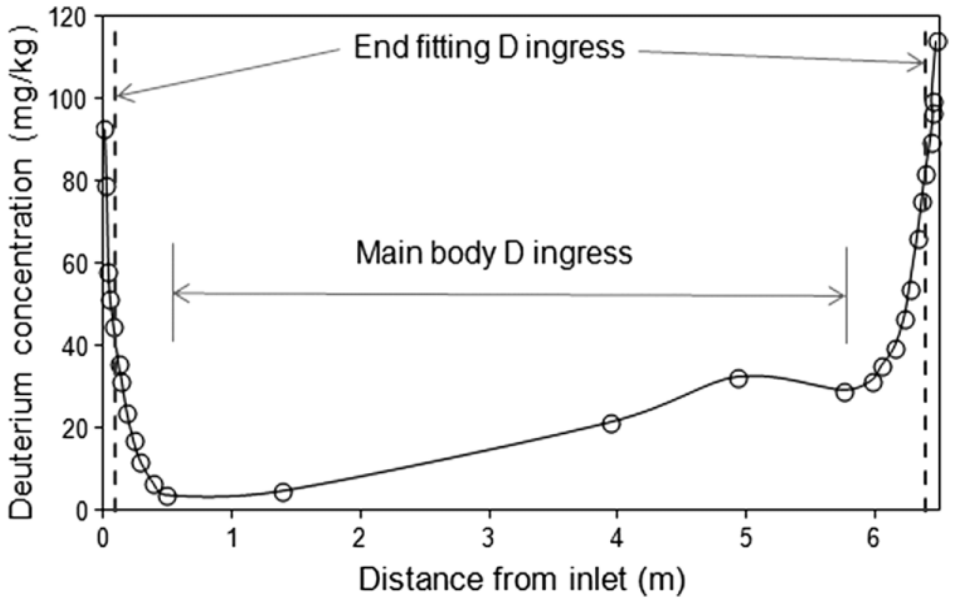
Sources of Deuterium Uptake



Reference: Technical Update Fuel Channel Fitness for Service – CNSC staff report January 23, 2018, CMD 18-M4

Deuterium Concentration Profile

The following figure shows a typical deuterium profile (in mg/kg) along the axial length of a pressure tube after ~17 hot years of service.



The deuterium concentration increases along the main body of the pressure tube peaking near the outlet end. Approximately 2%–10% of the deuterium generated by the corrosion process is absorbed along the body of the tube.

PERFORMANCE OF PRESSURE TUBES IN CANDU REACTORS, June 2016; Malcolm Griffiths et al, Canadian Nuclear Laboratories, Chalk River, ON, K0J 1J0 Canada p.8 http://pubs.cnl.ca/doi/full/10.12943/CNR.2016.00007

Reactor Operating Time - Metrics

- **Many aging mechanisms affecting fuel channel components are driven by thermal conditions, and depend on the time that a reactor is at its operating temperature, that is, "hot hours", whether or not the reactor is producing power.**
- **"Hot Hours" includes all periods when the Heat Transport System exceeds ≈200^{o}C. Since Pressure Tubes corrode at these temperatures, Hot Hours is an important metric for assessing H_{eq} levels.**
- **EFPHs include only the time during which power is produced.**
- **"Hot Hours" which are ≈ 5% greater than EFPHs, may be more relevant than EFPH in assessing the safety of fuel channel components, especially pressure tubes .**

Emergency Preparedness

- **The population of the Pickering region is expected to double to 190,000 by 2031. The Greater Toronto Region within 50 km of the Pickering Station is also experiencing rapid growth.**
- **Many residents, both present and future, may be totally unaware of how close they are to the Pickering plant. If a severe worst-case scenario accident were to happen at Pickering today or at any time in the future, are essential emergency planning and preparations in place?**

Emergency Preparedness (cont'd)

Are essential emergency planning and preparations in place? Is the planned management well-coordinated?

- Are there enough well-trained personnel to ensure that there is rapid response to an emergency and that large populations can be evacuated quickly enough?
- Are public alarm systems adequate and properly functioning?
- Are there sufficient provisions to provide safe food, drinking water, and medical assistance for the sick, and for those exposed to large amounts of ionizing radiation?
- Are the planning zones appropriate?

Emergency Preparedness (cont'd)

- Will the distribution of KI pills cover the number and ranges of people most likely to be affected by exposure to radiation, especially children, in the brief time period for which the pills are most effective?
- Are there sufficient and appropriate safe sheltering buildings to protect against external radiation?
- What actions are planned to protect farmland and livestock?
- What considerations have been given to evacuating children, the sick, the elderly, and those with disabilities?
- Will workers be required to take heroic actions to mitigate damage to a reactor?

Recommendations

In the interests of public safety, the time has come to shut down all units of the Pickering station rather than risk an accident which could be devastating for so many, both now and for all generations to come.

Recommendations (cont'd)

Therefore it is recommended that:

- **CNSC provide explicit instructions to OPG to prepare for the shutdown of the Pickering station by 2020 -1 at the latest, and issue an operating licence specifically for that period.**
- **During this time, preparations for safe storage and decommissioning will be undertaken and the CNSC will engage the public in sessions, meetings and further hearings to inform the public about these preparations and ensure that they are properly carried out.**
- **Furthermore, OPG must have a complete decommissioning plan prepared which would be subject to due public process and consultation under a separate licence issued by the CNSC.**

Conclusion

There is no justification to proceed with a 10-year licence period. Such a long licence period is unacceptable, unnecessary, risky, and a serious impediment to public scrutiny.

Given the age of the station, the numerous problems encountered for decades, its proximity to a highly populated region, safety issues regarding aging reactor components, and shortcomings of current emergency and evacuation plans, to continue operating Pickering beyond 2018 as proposed by OPG for at least six more years, poses enormous risks to public safety that no regulator should accept.

Continuing operating Pickering blocks far more affordable, safer and cleaner alternative sources of energy for residents of Ontario.