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Written submission from Paul Sedran, RESD Inc.

In the Matter of the

Ontario Power Generation Inc.

Application to extend the operation of Pickering Nuclear Generating Station Units 5 to 8 until December 31, 2026

Commission Public Hearing

June 2024

Exposé oral

Mémoire de Paul Sedran, RESD Inc.

À l'égard d'

Ontario Power Generation Inc.

Demande visant à prolonger l'exploitation des tranches 5 à 8 de la centrale nucléaire de Pickering jusqu'au 31 décembre 2026

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Review of the Operation of PNGS to 2026, the Technical Issue of Partial Nip-Up of the Spacer and the Calandria Tube

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Date: April 19th, 2024

Definition of Abbreviations and Symbols

CNSC – Canadian Nuclear Safety Commission
CT – Calandria Tube
EFPH – Effective Full Power Hours
ID – Inner Diameter
OPG – Ontario Power Generation
PNGS – Pickering Nuclear Generating Station
PT – Pressure Tube
OD – Outer Diameter

t – Time in-Service

1. Introduction

The current power reactor operating license for the Pickering Nuclear Generating Station (PNGS) will expire in December, 2024.

OPG is planning to operate PNGS Units 5 - 8 to December 31st, 2026 and has submitted an application to the CNSC for a extension of the PNGS operating license to the end of 2026. As part of the review of the license extension application by OPG, the CNSC will be conducting a public hearing on the license extension, scheduled for June 2024.

Under Contribution Agreement reference number: PFP 2023 PIC01, the CNSC has funded the author to review the submissions by OPG related to the Fuel Channel integrity aspect of their application for an extension of the PNGS operating license to 2026.

A summary of the review is presented in this report.

2. Reference Documents

2.1 Submissions Released to the Intervenors by the CNSC

The following public hearing documents were released to the intervenors prior to the public meeting and were reviewed by the author:

1. A License Amendment Ontario Power Generation Inc. Pickering Nuclear Generating Station, CMD 24-H5, Reference 1.

2. Written submission from Ontario Power Generation Inc, Application to extend the operation of Pickering Nuclear Generating Station Units 5 to 8 until December 31, 2026 CMD 24-H5.1, Reference 2.

3. Supplementary Information, Written submission from Ontario Power Generation Inc., Application to extend the operation of Pickering Nuclear Generating Station Units 5 to 8 until December 31, 2026 CMD 24-H5.1A, Reference 3.

3. Fitness for Service of the PNGS Fuel Channels for Operation to the End of 2026

A brief review of the Fuel Channel-related content of References 1 through 3 was conducted. The author agrees with the prediction that the Pickering Fuel Channels are fit-for-service to the end of the assessment periods given in Table 1.

4. Partial Nip-Up of the CT and PT from CT Ovalisation

At the 2018 Public Meeting on the PNGS license extension, the technical issue of Partial Nip-Up was raised in CMD 18-H6.20, Reference 4. During a follow up meeting after the December 2023 public hearing on the PNGS midterm review, it was recommended to OPG that an assessment of the effects of Partial Nip-Up on the Pickering Fuel Channels be performed and that Partial Nip-Up be included in the Pickering Fuel Channel Stress Report (if the onset time was within the operating life of the Fuel Channels). From recent discussions with OPG, it is believed that Partial Nip-Up of the PNGS Fuel Channels has not yet been investigated by OPG engineering, as recommended in Reference 4.

Therefore, as part of the PNGS Fuel Channel fitness-for-service review, the author has undertaken a brief assessment to illustrate the development of Partial Nip-Up in the Pickering Fuel Channels, using Fuel Channel M11, from Pickering Unit 4 as an example. The assessment is intended to keep the Partial Nip-Up issue in sight and reiterate its importance to the Fuel Channels.

The assessment, summarised below, was performed as follows:

1. Fuel Channel P4 M11 was selected for assessment.

2. Reduction of the horizontal inner diameter of the CT was identified as the critical mode of CT deformation for Partial Nip-Up.

3. Increase of the horizontal outer diameter of the PT was identified as the critical mode of PT deformation for Partial Nip-Up.

4. Partial nip-up was defined as the condition in which the horizontal outer diameter of the spacer annulus, on the outside of the PT, reaches the horizontal inner diameter of the CT. This definition assumes that the PT and CT are perfectly concentric. In reality, there is an approximate 3 mm centre-to-centre eccentricity in how the PT and the CT would line up at the spacer location. The assumption results in slight inaccuracy in the predicted onset time for Partial Nip-Up but is ignored for the purposes of the assessment.

5. The rate of contraction of the CT horizontal inner diameter, assumed to be linear with EFPH, was determined using Figure 1. The rate of contraction is for the point on the CT at the spacer at the 2 m location. The contraction rate was used to find the CT horizontal inner diameter versus EFPH.

6. For the PT of P4 M11, Fuel Channel-specific diametral expansion measurements were never performed. Instead, generic diametral expansion data from Figure 2 was used as a substitute to get the horizontal outer diameter of the spacer annulus versus EFPH, which would result from PT diametral expansion at the spacer location.

7. Finally, the spacer annulus horizontal OD and the CT horizontal ID were plotted versus EFPH in Figure 3.

Figure 1
ID Profiles from the CT Removed from Fuel Channel P4 M11

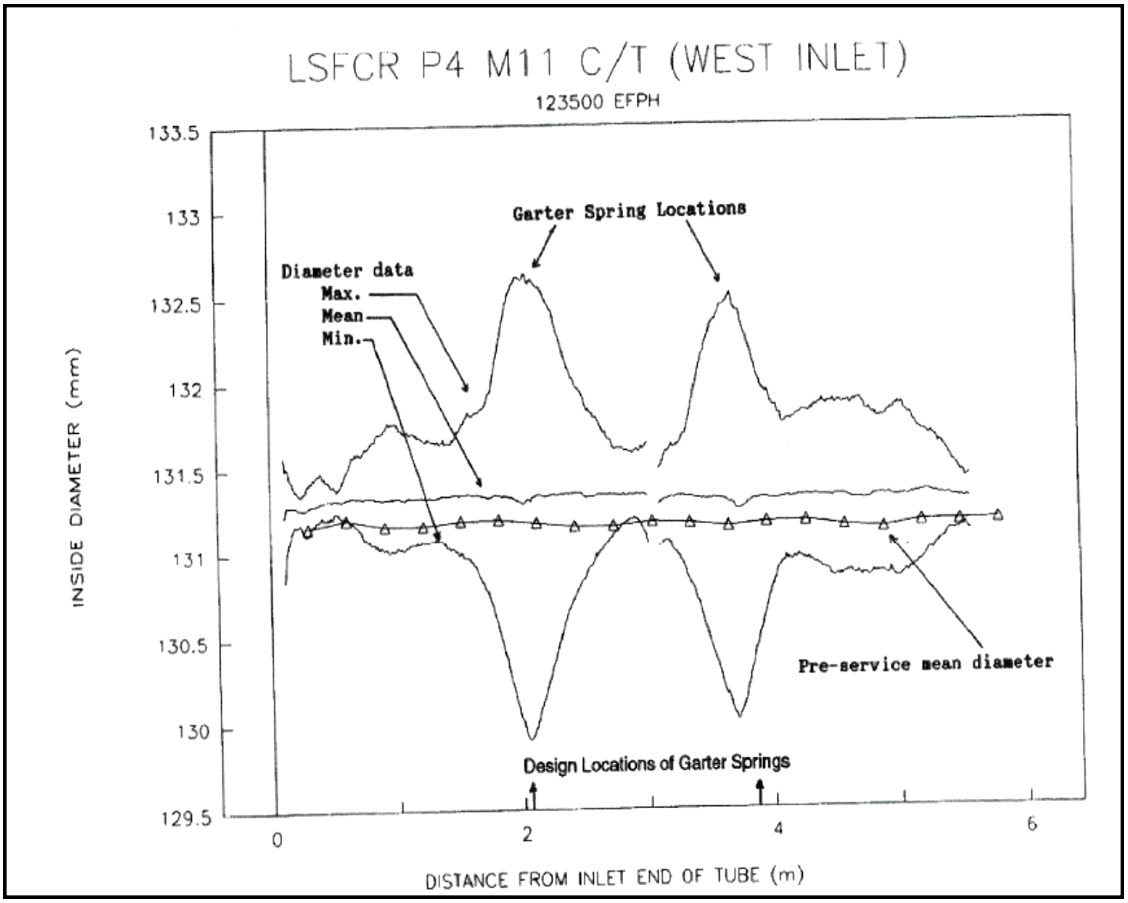

Figure 1 (from Reference 5) provides plots of axial profiles for the minimum, mean, and maximum ID values, for the CT removed from P4 M11 at 123,500 EFPH. For the spacer location at 2 m, it was found that the horizontal ID of the CT had contracted at a rate of 0.0105 mm/kEFPH.

The data from Figure 1 was used to generate the following linear model for the horizontal CT ID (at the 2 m location) versus time in-service, for use in Figure 3:

$$\text{CT ID} = 131.2 - 0.0105\, t$$

where CT ID is in mm and t is the time in-service in kEFPH.

Note that wall thinning for the CT has not been considered.

Figure 2
Plot of PT ID versus Axial Position

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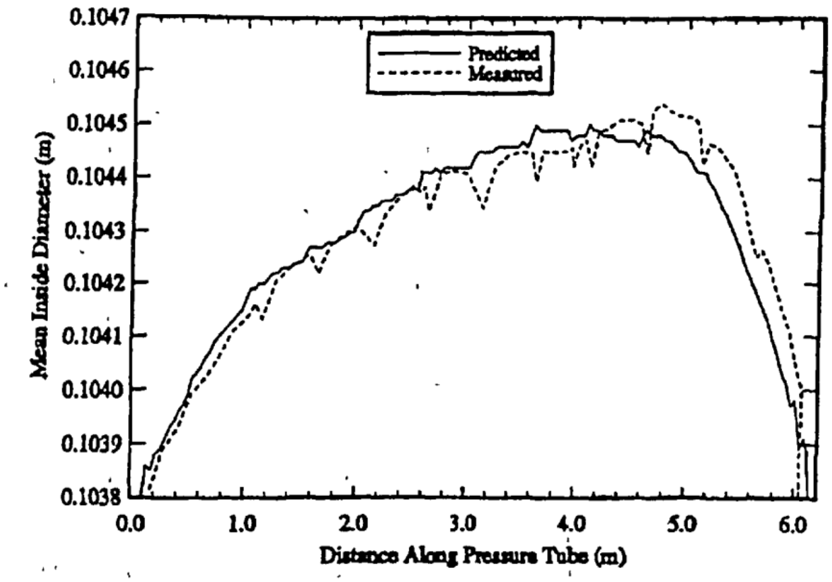

FIG. 15a—Diametral profile of a Pickering pressure tube after ten years of operation. The calculated curve was determined from H3DMAP with Eq 1 as a materials routine.

Figure 2 is plot of the ID of a typical PT from PNGS, from Reference 6. At the time of the measurements, the PT had been in service for 10 years or approximately 70 kEFPH. From Figure 2, the rate of diametral expansion of the PT, at the 2 m location, was found to be 0.007 mm/kEFPH. The above rate of diametal expansion was ascribed to the horizontal outer diameter of the spacer annulus on the outside of the PT at the 2 m location in P4 M11.

The data from Figure 2 was used to generate the following linear model for the horizontal OD of the Spacer Annlus (at the 2 m location) versus time in-service:

$$\text{Spacer OD} = 121.6 + 0.007\,\mathbf{t}$$

where Spacer OD is in mm and t is the time in-service in kEFPH.

Note that for the PT, ovality and wall thinning have not been considered and the spacer coil diameter was assumed to be constant at 6.81 mm.

Figure 3
Plot of the Horizontal ID of the CT and the Horizontal OD of the Spacer Annulus at the 2 m location in P4 M11

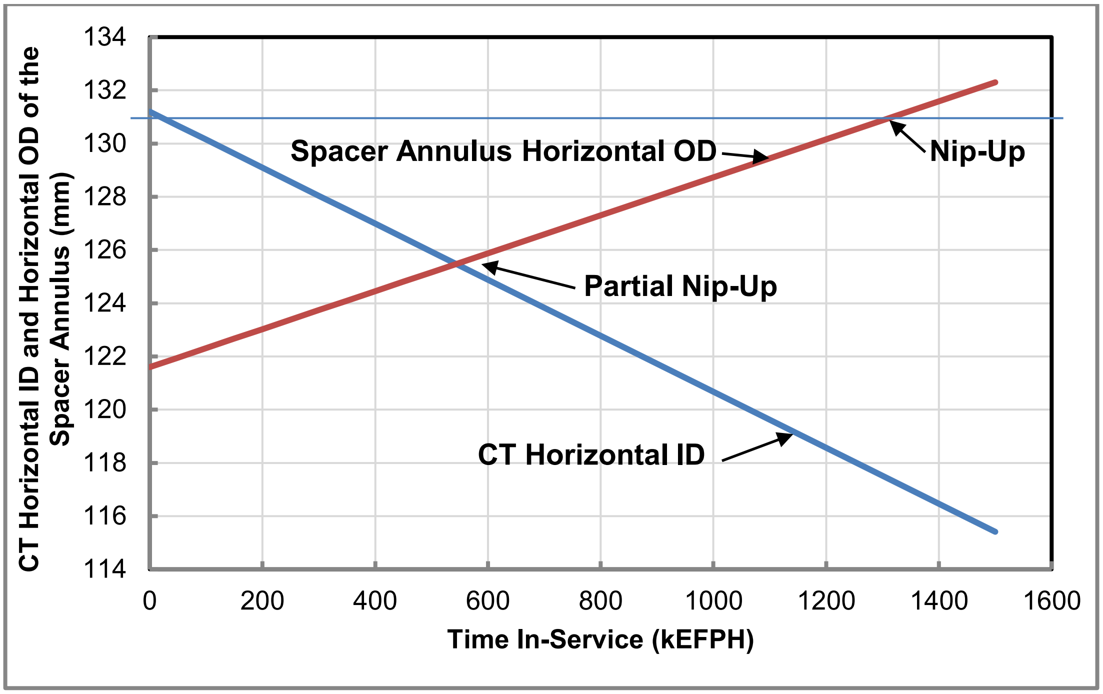

Figure 3 presents a summary of the assessment. In the figure, the CT horizontal ID at the 2 m location in P4 M11 is plotted versus time in-service, as the blue line.

The red line in Figure 3 is a plot of the Spacer Annulus horizontal OD, versus time in-service, for the spacer at the 2 m location in P4 M11.

In Figure 3, Nip-Up, which assumes no deformation of the CT, is predicted to occur at1300 kEFPH.

Also, as seen in Figure 3, Partial Nip-Up is predicted to occur at an earlier time than Nip-Up, at about 550 kEFPH. The earlier onset of Partial Nip-Up is expected, because the Partial Nip-Up analysis accounts for both the deformation of the CT and the PT, while the Nip-Up analysis accounts only for PT diametral expansion.

It should be noted that Figure 3 is not a good example of Nip-Up and Partial Nip-Up because the onset times are very far above the operating life of the Fuel Channels. However, Figure 3 demonstrates clearly that with CT ovalisation, all Fuel Channels will encounter Partial Nip-Up significantly earlier than the Nip-Up condition.

Over time, in the current Nip-Up analysis, with no ovalisation of the CT assumed, the interactions of the PT, the Spacer, and the CT, would be different than the actual interactions, once Partial Nip-Up starts. Once Partial Nip-Up starts, temperature and stress distributions in the PT, CT, (at Spacer locations) and in the Spacer will be different than those in the current Spacer Nip-Up analyses, with no ovalisation of the CT assumed.

Overall, it is expected that with Partial Nip-Up accounted for, the PNGS Fuel Channels will remain fit-for-service for operation to the end of 2026.

5. Conclusions

1. Based on an independent review of the 3 documents listed in Section 2.1, the author concurs that the PNGS Fuel Channels are fit-for-service for operation to the end of 2026.

2. With ovalisation of the CT at spacer locations, with time in-service, Partial Nip-Up of the spacer and CT will occur earlier than Nip-Up, but is not expected to be an issue for Fuel Channel fitness-for-service.

3. To date, it is believed that the Partial Nip-Up condition has not been included in the Pickering Fuel Channel Stress Report but should be assessed for possible inclusion in the Report.

6. References

1. A License Amendment Ontario Power Generation Inc. Pickering Nuclear Generating Station, CMD 24-H5, CNSC Staff, 27 February, 2024.

2. Written submission from Ontario Power Generation Inc, Application to extend the operation of Pickering Nuclear Generating Station Units 5 to 8 until December 31, 2026 CMD 24-H5.1, 2023-06-16.

3. Supplementary Information, Written submission from Ontario Power Generation Inc, Application to extend the operation of Pickering Nuclear Generating Station Units 5 to 8 until December 31, 2026 CMD 24-H5.1A, 2024-02-28.

4. Submission From Paul Sedran, RESD Inc. CMD 18-H6.20, File / dossier: 6.01.07 2018-06-06.

5. The Generation of Calandria Tube (CT) Inner Diameter Profiles from Fuel Channel (FC) Inspection Data, P.J. Sedran, 35th Annual Conference of the Canadian Nuclear Society, Saint John, NB, May, 2015.

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