



UNPROTECTED/NON PROTÉGÉ

ORIGINAL/ORIGINAL

CMD: 21-H112,
21-H114

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Approval to Restart

Authorization de redémarrage

CNSC staff assessment of information submitted by Ontario Power Generation Inc. to support Pickering NGS Units 5-8 and Darlington NGS Units 1 and 4 requests for authorization to restart following any unplanned outages and following the Darlington Unit 4 and Pickering Unit 7 planned fall 2021 outages (pursuant to Orders issued due to hydrogen equivalent concentration discovery events at Bruce NGS A and B)

Évaluation par le personnel de la CCSN des informations soumises par Ontario Power Generation Inc. à l'appui des demandes de redémarrage des tranches 5 à 8 de la centrale de Pickering et des tranches 1 et 4 de la centrale de Darlington après tout arrêt imprévu, et à l'appui des demandes de redémarrage de la tranche 4 de la centrale de Darlington et la tranche 7 de la centrale de Pickering après les arrêts prévus à l'automne 2021 (conformément aux ordres délivrés en raison d'événements de découverte liés à la concentration d'hydrogène équivalent aux centrales de Bruce A et B)

Ontario Power Generation Inc.

Ontario Power Generation Inc.

Pickering Nuclear Generating Station Units 6-8

Tranches 6 à 8 de la centrale nucléaire de Pickering

Darlington Nuclear Generating Station Units 1 and 4

Tranches 1 et 4 de la centrale nucléaire de Darlington

Hearing in writing based solely on written submissions

Audience fondée uniquement sur des mémoires

Scheduled for:

Prévue pour :

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Submitted by:

Soumise par :

CNSC Staff

Le personnel de la CCSN

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Summary

Ontario Power Generation Inc. (OPG) was issued an Order requiring Commission approval to restart units in extended operation. OPG presented their restart request to the Commission on September 10, 2021. Subsequently, OPG submitted additional requests for authorization to restart following any Pickering Units 5-8 and Darlington Units 1 and 4 unplanned outages. These requests also included requests for authorization to restart following the Pickering Unit 7 and Darlington Unit 4 planned fall 2021 outages.

The purpose of this CMD is to provide CNSC staff's:

- Assessment of the submitted information, and
- Conclusions and recommendations on the restart of Pickering Units 6-8 following any unplanned or planned outage.
- Conclusions and recommendations on the restart of Darlington Units 1 and 4 following any unplanned or planned outage.

CNSC staff conclude that Pickering NGS Units 6-8 and Darlington NGS Units 1 and 4 fitness for service analyses are in compliance with Option (b) of the Order. Therefore, CNSC staff recommend that the Commission authorize Pickering NGS Units 6-8 and Darlington Units 1 and 4 restart following any unplanned or planned outages.

Résumé

Un ordre a été délivré à Ontario Power Generation Inc. (OPG) exigeant l'autorisation de la Commission avant le redémarrage des tranches en exploitation prolongée. OPG a présenté leur demande de redémarrage à la Commission le 10 septembre 2021. Subséquemment, OPG a soumis des demandes supplémentaires d'autorisation pour le redémarrage des tranches 5 à 8 de la centrale de Pickering et des tranches 1 et 4 de la centrale de Darlington après tout arrêt imprévu. Les soumissions comprenaient également des demandes d'autorisation pour le redémarrage de la tranche 7 de la centrale de Pickering et de la tranche 4 de la centrale de Darlington suite aux arrêts prévus à l'automne 2021.

Ce CMD présente à la Commission :

- l'évaluation par le personnel de la CCSN de les informations soumises
- les conclusions et recommandations du personnel de la CCSN sur le redémarrage des tranches 6 à 8 de la centrale de Pickering après tout arrêt prévu ou imprévu
- les conclusions et recommandations du personnel de la CCSN sur le redémarrage des tranches 1 et 4 de la centrale de Darlington après tout arrêt prévu ou imprévu.

Le personnel de la CCSN a conclu que les analyses par OPG de l'aptitude fonctionnelle des tranches 6 à 8 de la centrale de Pickering et des tranches 1 et 4 de la centrale de Darlington sont conformes à l'option (b) de l'ordre. Par conséquent, le personnel de la CCSN recommande que la Commission autorise le redémarrage des tranches 6 à 8 de la centrale de Pickering et des tranches 1 et 4 de la centrale de Darlington après tout arrêt prévu ou imprévu.

Signed/signé le

October 27, 2021 / 27 octobre 2021



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EXECUTIVE SUMMARY

Ontario Power Generation Inc. was issued an Order requiring Commission approval to restart units in extended operation. Ontario Power Generation (OPG) presented their restart request to the Commission on September 10, 2021. Subsequently, OPG submitted additional information in support of requests for authorization to restart Pickering Units 5-8 and Darlington Units 1 and 4 following any unplanned outages, as well requests for authorization to restart Pickering Unit 7 and Darlington Unit 4 following the fall 2021 planned outages.

The purpose of this CMD is to provide CNSC staff's conclusions and recommendations founded on their assessment of the information submitted by OPG, specifically for restart of Pickering NGS Units 6-8 (Pickering Unit 5 has already been granted authorization to restart) and Darlington NGS Units 1 and 4.

Having reviewed the OPG submissions, CNSC staff conclude that Pickering Units 6-8 and Darlington Units 1 and 4 requests comply with Option (b) of the Order. Therefore, CNSC staff recommend that the Commission authorize the restart of Pickering Units 6-8 and Darlington 1 and 4 following any unplanned or planned outages.

1. PREAMBLE

In early July, Bruce Power Inc (Bruce Power) reported to CNSC a discovery of elevated hydrogen equivalent (Heq) concentrations at Bruce NGS A and B, Units 3 and 6. On July 27, 2021, a Canadian Nuclear Safety Commission (CNSC) Designated Officer (DO) issued an order to Ontario Power Generation Inc. (OPG), for the Darlington NGS and the Pickering NGS, requiring that the licensee obtain an authorization from the Commission prior to the restart of any operating unit with pressure tubes in extended operation, following any outage that results in the cooldown of the heat transport system. The discovery of Heq concentrations exceeding the licensing limit for Bruce NGS, was considered by the DO to put into question the predictive capability of the model for the hydrogen equivalent concentration levels in all operating reactors with pressure tubes in extended operation.

OPG requested an Opportunity to be Heard on the DO Orders, which was reviewed by the Commission on September 10, 2021. On September 22, 2021, the Commission issued a Summary Record of Decision [1], which confirmed the DO order issued to OPG. The Summary Record of Decision stated that, *“The Commission does not, at this time, pre-authorize the restart of any designated reactor unit pursuant to the terms of the orders. The Commission will consider requests to restart a designated reactor unit, or group of units with similar characteristics, on a case-by-case basis, upon the submission of a specific request by a licensee. Any request shall contain qualitative and quantitative analyses to satisfy the conditions of the order.”* The September 22, 2021, Summary Record of Decision also confirmed that, *“the Commission, pursuant to subsection 37(6) of the Nuclear Safety and Control Act, amends the DO order issued to Ontario Power Generation Inc. on July 27, 2021, for the Pickering Nuclear Generating Station by removing Pickering NGS A Units 1 and 4.”*

On October 1st, 2021, OPG requested authorization to restart Pickering Unit 5 following the potential unplanned outage where cooling down the primary heat transport system (PHTS) is necessary, which was reviewed by the Commission on October 12th, 2021. The Commission has issued a Summary Decision (via e-mail to OPG) [2], which states that, *“The Commission has determined that Pickering Unit 5 has satisfied the terms of the DO Order and that, consequently, Unit 5 is no longer subject to the DO Order”*. Therefore, Pickering Unit 5 no longer requires authorization to restart and is excluded from this CMD.

On September 29th, OPG submitted requests for authorization to restart Pickering Units 5-8 and Darlington Units 1 and 4 [3, 4] following any unplanned outages, as well as for authorization to restart Pickering Unit 7 and Darlington Unit 4 following the planned fall 2021 outages.

2. PURPOSE

The purpose of this document is to provide the Commission with CNSC staff recommendations regarding OPG’s requests for authorization to restart Pickering Units 6-8 and Darlington Units 1 and 4 following any unplanned outages, as well as for authorization to restart Pickering Unit 7 and Darlington Unit 4 following the planned fall 2021 outages. CNSC staff recommendations

are based on the information submitted by OPG [3-7] and are specific to the requirements of the Order issued on July 26th, 2021 [8].

3. CNSC STAFF'S ASSESSMENT OF SUBMITTED INFORMATION TO SUPPORT PICKERING UNITS 6-8 AND DARLINGTON UNITS 1 AND 4 RESTART REQUESTS

In order for CNSC staff to recommend restart of a unit, given the potential for elevated Heq concentration near the outlet burnish mark, OPG must demonstrate compliance with the Order issued on July 26, 2021 [8]. CNSC staff applied the restart criteria [9, 10] communicated to OPG on August 12, 2021, to assess the request for restart. OPG was required to satisfy either Option (a) or (b) of the criteria for restart:

Option (a):

- 1. Licensee shall demonstrate an understanding of the mechanism leading to high Hydrogen equivalent (Heq) concentration in the region of interest, and are able to conservatively model Heq concentration in this region.*

Option (b)

- 1. Sufficient inspection data shall be available for the reactor unit to justify, with a high degree of certainty, that no flaws are present in the region of interest greater than 0.15 mm in depth.*
- 2. Corrective actions shall be implemented for tubes containing flaws greater than the specified depth.*

3.1 OPG's Compliance with Option (a) of the Order

To comply with Option (a) of the Order [8] and the associated restart criteria [9, 10], a licensee must demonstrate a thorough understanding of the mechanism that resulted in elevated Heq concentrations in the Bruce Unit 3 and Bruce Unit 6 pressure tubes. This is to ensure with certainty that the predictions of Heq concentration in the region of interest near the outlet burnish mark remains below the licensing limit of 120 ppm, as established by the Commission.

CNSC staff conclude that OPG does not comply with Option (a) since there is insufficient information to confirm that Pickering Units 6-8 and Darlington Units 1 and 4 pressure tubes satisfy the associated restart criteria, as stated above.

3.2 OPG's Compliance with Option (b) of the Order

To satisfy Option (b), the licensee must demonstrate, through an evaluation of the inspection history data and knowledge of the potential flaw formation mechanisms, that in the region of interest:

- Flaws deeper than 0.15 mm are unlikely to exist in the population of pressure tubes in a reactor that have not been inspected; and
- Appropriate compensatory measures have been implemented for detected flaws deeper than 0.15 mm.

These criteria permit a licensee to demonstrate that pressure tubes are safe to operate if the region of interest contains Heq concentration in excess of 120 ppm near the outlet burnish mark.

CNSC staff conclude that, as elaborated in sections 3.2.1 and 3.2.2, OPG has demonstrated compliance with Option (b) of the Order and, consequently, Pickering Units 6-8 and Darlington Units 1 and 4 meet criteria for restart from any unplanned or planned outage.

This conclusion is based on all the information available, and submitted, to CNSC staff at the time of writing this CMD. Findings from inspections to be conducted by OPG during future outages and the results of planned crack initiation tests on material with elevated Heq concentration [12] will be reviewed by CNSC staff to confirm that any new findings do not invalidate the above conclusion.

The basis for this conclusion is further discussed in the following Sections.

3.2.1 Pickering Units 6 - 8

Reduction in Size of Region of Interest for Pickering Pressure Tubes

For Pickering Units 6-8, CNSC staff recommend a reduction of the axial length of the region of interest from 75 mm to 60 mm from the outlet burnish mark.

As discussed in CMD 21-H111 [13], the length of the region of interest for the Pickering pressure tubes can be reduced to 60 mm from 75 mm that was originally proposed for the restart criteria [9, 10]. For the Pickering Units, OPG has consistently obtained the first Heq concentration scrapes from an axial location of approximately 50 to 55 mm inboard of the burnish mark. None of the first inboard scrape samples from Pickering pressure tubes have produced measured Heq concentration values that exceeded 120 ppm. This reduction in the size of the region of interest is important because there is high confidence that Heq concentration does not exceed 120 ppm beyond the 60 mm region of interest.

Flaws at Risk of Cracking in the Region of Interest in Uninspected Population of Pickering Units 5-8 Pressure Tubes

CNSC staff found that OPG has demonstrated a low likelihood of flaws deeper than 0.15 mm in the region of interest of the uninspected pressure tubes of Pickering Units 6 to 8 that could lead to crack initiation. This was achieved through a statistical evaluation using the historical flaw population in the Pickering pressure tubes and a review of the flaw formation mechanisms.

In order to perform the statistical evaluation, OPG first evaluated the population of flaws in the region of interest on inspected pressure tubes at Pickering and Darlington Units [3, 4 and 6]. CNSC staff's review treated the Pickering and Darlington pressure tube populations as separate populations since the fuel bundle configurations are different. The information obtained from the inspected population of tubes was then used to infer the likelihood of the existence of flaws in the pressure tubes that have not been inspected at Pickering Units 6-8.

OPG has inspected 299 pressure tubes in total for flaws in Pickering Units 1, 4, 5-8. A total of six flaws with a depth greater than 0.15 mm were observed in the original region of interest in this population of pressure tubes. These flaws had all been evaluated in the past by OPG and it was determined that they had no impact on safe operation of pressure tubes as they would not lead to crack initiation due to their size and shape. CNSC staff accepted this conclusion.

CNSC staff's independent evaluation of these flaws, can be summarized as follows:

- Five of the six flaws are attributed to bearing pad frets due to cross flow during fueling activities. Analysis of these flaws demonstrated they are not susceptible to crack initiation [13]. In 2015, OPG implemented procedures to limit the formation of similar flaws during the remainder of the operating lives of the Pickering units. No flaws of this type have been observed since the change in procedure. Hence, CNSC staff accept OPG's conclusion that it is appropriate to exclude these five flaws from consideration in the statistical analysis to estimate the expected number of flaws in the uninspected population of Pickering Units 6-8 pressure tubes.
- The sixth flaw, identified as P5O05-IND1, was discovered in 1999 and located in the region of interest in a Pickering Unit 5 pressure tube. It was attributed to debris fretting and is small, measuring 0.17 mm deep, 4.6 mm in length and 1.2 degrees in width. As detailed in CMD 21-H111 [13], staff conclude that this flaw was not due to a mechanism that was likely to be repeated in other pressure tubes because the shield plug extends approximately 85 mm past the outlet burnish mark and supports the last fuel bundle. Thus, it is concluded that this flaw could also be excluded from the statistical evaluation.
- Given that mechanisms that led to formation of the six flaws historically observed in Pickering pressure tubes have been eliminated, it is reasonable to assume in the statistical analysis the number of observations being zero.

OPG completed a statistical evaluation to estimate the likelihood of flaws in the region of interest of the uninspected population of pressure tubes in Pickering Units pressure tubes (see Table 1). This evaluation is based on zero observations of flaws in the 299 Pickering pressure tubes that were inspected [6]. The evaluation provided a hypothetical, expected number of 0.8 flaws in the uninspected tube population in each unit. Therefore, CNSC staff conclude that this satisfies the assumptions of the Deterministic Safety Analysis for Canadian CANDU nuclear reactors, which demonstrates safety systems are able to mitigate the consequences of a single pressure tube failure, as discussed in Section 3.3.

Table 1: Estimates of the Number of Dispositionable Flaws within the Region of Interest in the Uninspected Populations of Pickering Pressure Tubes

Unit	No. of Uninspected Tubes in each Unit (total tubes in reactor)	Expected No. of Flaws [6]
P5	318 (380)	0.8
P6	335 (380)	0.8
P7	316 (380)	0.8
P8	326 (380)	0.8

3.2.2 Darlington Units 1 and 4

Reduction in Size of Region of Interest for Darlington Pressure Tubes

For Darlington Units 1 and 4, CNSC staff recommend a reduction of the axial length of the region of interest from 75 mm to 60 mm from the outlet burnish mark.

For the same reasons discussed in the previous Section for Pickering, the length of the region of interest for the Darlington pressure tubes can be reduced to 60 mm from 75 mm that was originally proposed for the restart criteria [9, 10]. However, this reduction in the size of the region of interest has no impact on the Darlington pressure tubes since there have been no dispositionable flaws detected within a distance exceeding 75 mm of the outlet burnish mark in the Darlington reactors.

Flaws at Risk of Cracking in the Region of Interest in Uninspected Population of Darlington Units 1 and 4 Pressure Tubes

CNSC staff conclude that OPG has demonstrated a low likelihood of flaws deeper than 0.15 mm in the region of interest of the uninspected pressure tubes of Darlington Units 1 and 4 that could lead to crack initiation. This was achieved through a statistical evaluation using the historical flaw population in the Darlington pressure tubes and a review of the flaw formation mechanisms.

OPG has inspected 232 pressure tubes in Darlington Units 1-4 (data from Units 2 and 3 were also considered). There were no observations of dispositionable flaws within the CNSC defined region of interest in any of the inspected pressure tubes. OPG's supplemental sensitivity analysis [6] provided a hypothetical, expected number of 1.2 and 1.3 flaws in the uninspected tube population in Darlington Units 1 and 4, respectively, based on a best estimate (see Table 2).

In their analysis, CNSC staff conclude that the higher expected number of flaws in the Darlington units compared to the Pickering units (despite zero observed dispositionable flaws) is due to the slightly smaller sample size of the inspected tube population (299 in Pickering Units vs 232 in Darlington Units) and the larger sample size of uninspected tubes in each of the Darlington units. To further illustrate the impact of the inspection sample size, it should be noted that the Darlington and Bruce Power reactors have similar fuel bundle configurations at the outlet end of pressure tubes and use fuel carriers, which limits the potential for pressure tube damage during fueling operations. Hence, the Darlington and Bruce Power pressure tube

inspection results could be combined into a single population. This would generate a sample of 713 similar pressure tubes¹ with no dispositionable flaws in the region of interest. Using this sample size, CNSC staff estimate that the expected number of flaws in each of the uninspected tube populations in each of Darlington Units 1 and 4 is below 0.5. This satisfies the assumptions of the Deterministic Safety Analysis for Canadian CANDU nuclear reactors, which demonstrates safety systems are able to mitigate the consequences of a single pressure tube failure, as discussed in Section 3.3.

Table 2: Estimates of the Number of Dispositionable Flaws within the Region of Interest in the Uninspected Populations Darlington Pressure Tubes

Unit	No. of Uninspected Tubes in each Unit (total tubes in reactor)	Expected No. of Flaws [6]
D1	410 (480)	1.2
D4	419 (480)	1.3

3.2.3 Observations Applicable to Pickering and Darlington Units

OPG's original statistical evaluation provided a conservative, upper bound estimate of 7 flaws in the region of interest for the Pickering A and B Units [3] and 5 for the Darlington Units [4] (see Tables 1 and 2). CNSC staff have examined these evaluation results and conclude that they are very conservative estimates based on the following observations:

- The original Pickering assessment [3] assumed a 75 mm long region of interest, which resulted in the inclusion of 2 flaws in the region of interest (Unit 5 flaw P5O05-IND1 and Unit 6 flaw P6N04-IND9) in the population of 299 inspected pressure tubes.
- P6N04-IND9 resides outside of the redefined 60 mm long region of interest. OPG has sufficient scrape measurements from Pickering pressure tubes that demonstrate the Heq concentration models are acceptable for the location of this flaw and that Heq concentration are below 120 ppm.
- There were no flaws deeper than 0.15 mm in the 232 Darlington pressure tubes (and none in the combined Darlington and Bruce Power populations of 713 pressure tubes), so assuming 5 flaws deeper than 0.15 exist in a population of 419 uninspected Darlington Unit 4 tubes is very conservative.
- There is no contact between the fuel bundle bearing pads and the pressure tube wall in the region of interest of any of the Pickering and Darlington pressure tubes during normal operation, which limits the potential for the formation of deeper flaws.

3.3 Impact on Deterministic Safety Analysis

Deterministic safety analysis (DSA) is used to analyze the behaviour of a nuclear power plant (NPP) following a postulated event. For the analyzed event, the DSA allows prediction and quantification of challenges to the plant's physical barriers, and the performance of plant structures, systems and components (particularly safety systems), in order to predict failures of

¹ 232 from Darlington Units 1-4, 448 from Bruce Units 3-8 prior to the Bruce Unit 3 2021 outage and 33 during the Bruce Unit 3 2021 outage.

barriers to radioactivity releases. This is performed by determining the bounding initiating events/failures, mapping out the accident sequence, modeling the plant and safety system responses, analyzing the consequences and then comparing against regulatory limits.

A simultaneous pressure tube and calandria tube rupture is explicitly analyzed as a design basis accident in the safety analysis for all Pickering Units and as a Class 1 design basis accident in the safety analysis for all Darlington Units. These analyses demonstrate that the plants are able to perform the fundamental safety functions of control, cool and contain. This includes being able to shutdown the reactor with one shutdown system alone, adequately cooling the reactor core, preventing further failures of other pressure tubes and limiting radiological releases to below regulatory limits.

CNSC staff's assessment conclude that the potential of elevated Heq concentration in the region of interest do not impact the currently assumed accident sequence, the key analysis parameters (sub-criticality margin and fuel temperatures), nor the ability of PNGS or DNGS systems from performing fundamental safety functions or the accident consequences (dose).

3.4 Considerations of the Probabilistic Safety Analysis

Probabilistic Safety Analysis (PSA) is a comprehensive and integrated assessment of the safety of a reactor facility. The safety assessment considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates of frequencies of severe core damage (SCD) and large radioactive release (LF). PSA is used to complement Deterministic Safety Analysis (DSA) to demonstrate the safety of the nuclear power plant.

OPG has completed PSAs for Pickering Units 5-8 and Darlington Units 1 and 4 (Enclosures 2-4 of [3, 4]), which have demonstrated that the plant risk is low and that the safety goals are met with sufficient safety margin. Pressure Tube Leak (PTL, leak rate is less than 1 kg/sec) and Pressure Tube Failure (PTF, leak rate is above 1 kg/sec) are two initiating events modelled in a PSA. Pickering Units 5-8 and Darlington Units 1 and 4 PSA has modelled both PTL and PTF initiating events. CNSC staff have verified OPG's estimation and calculation and confirmed that all information provided in Enclosures 2-4 [3, 4] remain valid.

CNSC staff concludes that OPG has demonstrated that the Heq concentration findings at Bruce NGS Unit 3 and 6 do not impact the likelihood of a pressure tube failure or pressure tube leak and do not change the PSA estimations. Therefore, the plant risk does not change and all the conclusions from the PSA remain valid.

4. CONCLUSIONS

4.1 Conclusions for Pickering Units 6-8 (CMD 21-H112)

Based on the information provided by OPG [3-7], CNSC staff conclude that:

- Pickering models have reliably predicted Heq concentration measurements taken at locations greater than approximately 50 to 55 mm from the outlet burnish mark. Therefore, the axial length of the region of interest for the restart evaluation for Pickering Units 6-8 pressure tubes can be reduced, conservatively, to 60 mm.
- There are no known mechanisms that can result in deep flaws in the region of interest during normal operation.
- OPG has met the restart criteria for Option (b) of the Order as they have demonstrated with a high degree of certainty, that no flaws greater than 0.15 mm in depth are expected in the region of interest in the population of uninspected pressure tubes in Pickering Units 6-8.

4.2 Conclusions for Darlington Units 1 and 4 (CMD 21-H114)

Based on the information provided by OPG [3-7], CNSC staff conclude that:

- Darlington models have reliably predicted Heq concentration measurements taken at locations greater than approximately 50 to 55 mm from the outlet burnish mark. Therefore, the axial length of the region of interest for the restart evaluation for Darlington Units 1 and 4 pressure tubes can be reduced, conservatively, to 60 mm.
- There were no flaws deeper than 0.15 mm (within the region of interest) in the 232 Darlington pressure tubes that were inspected.
- There are no known mechanisms that can result in deep flaws in the region of interest during normal operation.
- OPG has met the restart criteria for Option (b) of the Order as they have demonstrated with a high degree of certainty, that no flaws greater than 0.15 mm in depth are expected in the region of interest in the population of uninspected pressure tubes in Darlington Units 1 and 4.

5. RECOMMENDATIONS (CMDs 21-H112 and 21-H114)

The restart criteria for Option (b), as stated in the order, has been met. Therefore, CNSC staff recommend that the Commission authorize the restart of Pickering Units 6-8 and Darlington Units 1 and 4 following any unplanned or planned outages when all other pressure tube fitness for service requirements in the licensing basis are satisfied. Although the OPG requests were specific to unplanned outages and the fall 2021 planned outages for Pickering Unit 7 and Darlington Unit 4, the conclusions are applicable to any outage provided future inspection findings continue to verify the results of OPG's evaluations that were submitted to address Option (b) of the Orders.

6. REFERENCES

1. CNSC Summary Record of Decision DEC 21-H11, R. Velshi to Ontario Power Generation Inc., "Review by the Commission of the Designated Officer Orders Issued to Bruce Power and Ontario Power Generation Inc. on July 26-27, 2021; and Requests to Restart Reactors subject to the Orders", September 22, 2021, e-Doc [6644319](#).

2. CNSC E-Mail, M. Leblanc to OPG, “OPG Pickering 5 – Summary decision”, October 12, 2021, e-Doc [6664730](#).
3. OPG Letter, J. Franke to M. Leblanc and Dr. Viktorov, “Pickering NGS: Request for Authorization to restart following the Pickering Unit 7 fall outage 2021 and pre-authorization to restart following any Pickering Units 5-8 Forced Outage with Heat Transport System Cooldown”, September 29, 2021, CD# NK30-CORR-00531-08328, e-Doc [6652773](#).
4. OPG Letter, S. Gregoris to M. Leblanc and Dr. Viktorov, “Darlington NGS: Request for Authorization to Restart following the Darlington Unit 4 Fall Outage and Authorization to Restart following any Darlington Unit 1 or 4 Forced 2021 Outage with Heath Transport System Cooldown”, September 29, 2021, CD# NK38-CORR-00531-22869, e-Doc [6652785](#).
5. OPG Letter, J. Franke to M. Leblanc and A. Viktorov, “Pickering NGS: OPG responses to CNSC staff inquiries related to OPG’s request for expedited authorization to restart following the Pickering Unit 5 2021 fall forced outage”, October 6, 2021, CD# NK30-CORR-00531-08334, e-Doc [6655147](#).
6. OPG Letter, M. Knutson to M. Leblanc and A. Viktorov, “Darlington and Pickering NGS: Sensitivity Analysis to Supplement NK30-CORR-00531-08328 and NK38-CORR-00531-22869”, October 8, 2021, CD# N-CORR-00531-22916, e-Doc [6656745](#).
7. CMD 21-H11.1B, “Supplementary written submission from Ontario Power Generation”, September 8, 2021, e-Docs [6636778](#)
8. CNSC Designated Officer Order, R. Jammal to Bruce Power, “Order by a Designated Officer Under Paragraph 37(2)(f) and Subsection 35(1) of the *Nuclear Safety and Control Act*”, July 26, 2021, e-Docs [6618972](#) and [6618965](#).
9. CNSC Letter, A. Viktorov to J. Franke, “Pickering NGS – CNSC Staff Assessment for Restart Requirements”, August 12, 2021, e-Doc [6621914](#).
10. CNSC Letter, A. Viktorov to S. Gregoris, “Darlington NGS, Units 1 and 4 – CNSC Staff Assessment Criteria for Restart Requirements”, August 12, 2021, e-Doc [6621921](#).
11. CMD 21-M4, “Status Update: Condition of Pressure Tubes in Operating CANDU Reactors in Canada”, January 21, 2021, e-Doc [6367848](#).
12. OPG Letter, M. Knutson to M. Leblanc and A. Viktorov, “Rationale for Application of Crack Initiation Models to High Hydrogen Equivalent Concentration [Heq] Region of the Pressure Tube”, October 15, 2021, CD# N-CORR-00531-22917, e-Doc [6661358](#).
13. CMD 21-H111, “CNSC staff assessment of information submitted by Ontario Power Generation Inc. to support Pickering NGS Unit 5 request for return to service (pursuant to Orders issued due to hydrogen equivalent concentration discovery events at Bruce NGS A and B)”, October 8, 2021, e-Doc [6657134](#).