ONTARIO POWER GENERATION

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MR. R. JAMMAL
Executive Vice-President and Chief Regulatory Operations Officer
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Canadian Nuclear Safety Commission
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Mr. Jammal:

Status Report on CNSC Request Pursuant to Subsection 12(2) of the General Nuclear Safety and Control Regulations: Lessons Learned from Japanese Earthquake

The purpose of this letter is to provide the CNSC with a progress report on the CNSC requested assessments [1], which were accepted by OPG [2] and on the progress of additional nuclear industry actions undertaken [3] concerning the Fukushima Daiichi Nuclear Power Plant (NPP) event.

OPG has initiated the requested reviews [2] based on the initial lessons learned from the Fukushima event, which includes a re-examination of the safety case for Darlington, Pickering A and Pickering B NPPs, in particular the underlying defence-in-depth concepts with respect to:

a. External hazards such as seismic, flooding and extreme weather events. Progress to date is described later in this letter.

b. Measures for the prevention and mitigation of severe accidents. See discussion below on Severe Accident Management Guidelines (SAMG).

c. Emergency preparedness. Attachment 1 provides a status report on our efforts to date in this area.

OPG has completed its preliminary re-examination of the safety cases and confirms that the risk related to OPG station operation continues to be acceptably low as documented in our licensing basis. OPG has identified areas for further study and follow up. These are described herein, and further information will be provided by the next progress update due May 28, 2011 [2].

1.0 Overview of Safety Features

The Pickering and Darlington NPPs designs consider a wide array of accidents and events and incorporate a number of defense-in-depth features to address these, including:

- Redundant and diverse systems and redundant equipment line-ups to maintain fuel cooling, and
- Application of the two group philosophy to maintain independent lines of defense.

Furthermore, Probabilistic Risk Analysis (PRA) studies have demonstrated the overall robustness of station designs.

Of particular relevance in light of the Fukushima event, are design features related to maintaining electrical power to safety critical equipment and this is discussed below.

1.1 Design Provisions and Approach for Station Black-out

Nuclear power plants (NPP) owned and operated by Ontario Power Generation are designed with a considerable number of redundant back-up power supplies to ensure electrical power is maintained to critical equipment in the event of an interruption of power from the Bulk Electrical System (BES), or the units own Class IV power supply system.

A loss of the grid, termed a LOBES[1], and a loss of Class IV power (consequential or independent) are design basis events which are explicitly addressed in the design of OPG plants. In the event LOBES, the reactor units[2] are designed to run back to lower power levels to provide a continuous supply of power to the unit's electrical systems. Operation in this mode allows sufficient time for operating staff to align other sources of power that are independent from the grid.

In the event that the unit cannot or fails to supply its own Class IV power system, the Standby Generators will automatically operate to re-energize essential equipment (all supplied by Class III power) for maintaining continuous fuel cooling. At Pickering B there are three Standby Generators per reactor unit pair and at Darlington there are four Standby Generators for the four units. A set of redundant, physically separate and seismically qualified Emergency Power Generators (EPGs) can be used to provide essential power to critical equipment at Pickering B and Darlington following a seismic event which causes a station blackout disrupting the normal Class III and Class IV electrical supplies described above. Similar provisions are available at Pickering A, where there are six Standby Generators for the two operational reactor units, which have been confirmed to have adequate seismic margin.

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[1] Loss of Bulk Electrical System, also referred to as a Loss of Off-Site Power.
[2] Except for Pickering A, which does not have use of adjuster rods and proceeds directly to a safe shutdown state following a LOBES event.

The Standby Generators and EPGs are routinely tested and maintained to maximize their availability. Sufficient fuel for operation of these back-up power generators is stored at each station to allow for a minimum of three days of operation[3].

Also at Pickering, an Auxiliary Power System (APS) comprised of two fully redundant 44 MW Turbine-Generators are capable of providing sufficient power for the High Pressure Emergency Coolant System and for cooling down the reactor units in sequence.

The electrical distribution systems at all levels (Class IV, III, II and I) are designed with an ODD and EVEN concept with physical separation and administrative controls to reduce the likelihood of a common mode event adversely affecting the entire power level.

2.0 Initial Review of Fukushima Daiichi NPP Event

Observations of the Fukushima Daiichi NPP event to date suggests that the severity of the initiating event (seismic event followed by tsunami) exceeded the design basis assumptions and has led to severe accident conditions on several reactor units. While design differences (Candu vs. Boiling Water Reactor (BWR)) and the location of the Pickering and Darlington NPPs are such that our stations are not subject to all the equipment issues and natural phenomena observed during the Fukushima event, there remain lessons to be learned for all NPP operators. Table 1 lists the preliminary lessons learned[4] from the Fukushima event and summarizes key activities being undertaken by OPG to:

- Verify system functionality (short term),
- Evaluate identified improvement opportunities (medium term), and
- Conduct further studies as required (longer term).

OPG has completed a preliminary re-examination of the safety cases and confirms that the risk related to OPG station operation continues to be acceptably low. Notwithstanding, OPG has identified several specific areas, such as the irradiated fuel bays, for further investigation. These issues, along with the external events review (discussed below), will assist and direct a more detailed and focused re-examination of specific safety cases.

Also, OPG, in concert with Canadian Industry partners, has been keeping abreast of operating experience and working aggressively on follow-up actions related to the events at Fukushima Daiichi NPP. A Canadian nuclear utility working group (including OPG, Bruce Power, Hydro Quebec, NB Power and AECL) was formed in March and has started working on common issues for the Candu reactor fleet[5].

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[3] The minimum fuel inventory varies based on the station design basis and will be further reviewed. See Attachment 2, Table A2-1.
[4] The lessons learned list will be revised, as required, as further information becomes available.
[5] Both the domestic and international utilities are participating in this initiative

Specific areas of investigation are outlined in the sections that follow below.

2.1 Station Verification Activities

The activities in Reference 3 are nearing completion and OPG is undertaking site verification activities which confirm the adequacy of plant equipment, plant procedures and staff training related to overall response to seismic, station blackout, flooding and fire events. Significant progress has been made and the status of these efforts is provided in Attachment 2.

2.2 Station Robustness

The lessons learned at Fukushima (Table 1) indicate that the plant design and safety cases should be reviewed to identify potential improvement opportunities related to the maintenance of adequate fuel cooling which could arise from:

- Extreme beyond design basis event (BDBE) conditions more severe than previously considered, and
- Consequential event sequences, such as a seismic event leading to a significant fire or flooding.

OPG will be undertaking further studies with a view towards the overall station capability to respond to extreme events.

2.3 Severe Accident Management Guidelines (SAMG)

As part of "measures for the prevention and mitigation of severe accidents," in particular, station response to a BDBE, OPG presented a status report and implementation plan for SAMG at a CNSC-Industry topical meeting held November 24, 2010. As noted at this meeting, OPG had initially focused on SAMG implementation within the Emergency Response Organization (ERO). OPG has completed Phase I implementation of SAMG, including delivering training to specific ERO technical staff and has engaged the SAMG development team to act as the SAMG Technical Support Group.

In view of the Fukushima event, OPG is advancing the remaining elements of its SAMG implementation schedule (Phase II) and will submit its overall SAMG implementation plan and progress report as part of the May 28, 2011 submission to the CNSC.

2.4 Hydrogen Mitigation

OPG was actively pursuing the installation of additional hydrogen mitigation (passive autocatalytic recombiners (PARS)) prior to the Fukushima event. The PARS units provide an additional line of defence (above and beyond current design basis) to the existing Hydrogen Ignition System for hydrogen mitigation. In view of the Fukushima event, OPG is expediting the installation of PARS across its fleet and will submit the implementation plan for the remaining Pickering and Darlington locations to the CNSC by May 28, 2011[4].

2.5 External Events

OPG has also undertaken a review of external hazards for each station such as, seismic, flooding, fire and extreme weather events, with a view towards identifying event sequences which could challenge fuel cooling capability.

Darlington and Pickering NPPs are designed to accommodate a range of external events. This includes provision of mitigating systems, structures and components (SSC), procedures to respond to external events, and implementation of surveillance programs for the mitigating SSC. Based on this, and our review to date, OPG confirms that the risk related to OPG station operation is acceptably low. Further effort to both better characterize this risk and to further assess specific event sequences is in progress, including IFB failure sequences and induced fires and floods as a result of extreme external events.

2.6 Irradiated Fuel Bay (IFB) Issues

The Safety Report analyses of fuel handling system failures does not consider some issues, for example, hydrogen production from spent fuel due to inadequate cooling, that was observed at Fukushima and which is believed to have had an adverse impact on event progression and plant response. OPG will be conducting further assessments of such events for its NPPs to determine the level of risk for hydrogen production in the IFB for BDBEs and evaluate the need for additional measures to prevent hydrogen production and mitigate its consequences.

3.0 Summary

OPG has made significant progress in both evaluating the lessons learned from the events at Fukushima Daiichi NPP, as well as, conducting a rigorous review of the preparedness of the stations to deal with beyond design basis events. To date, no significant issues requiring immediate corrective or compensatory measures have been identified. As is often the case with any broad rigorous review, potential improvement opportunities have been identified and will be prioritized and addressed per normal station processes. Longer term issues are being investigated in an expeditious manner.

OPG is committed to the safe operation of its stations and will review information and operating experience (OPEX) from the Fukushima Daiichi NPP event with priority to ensure that all lessons learned are implemented in an appropriate and timely manner. Table 1 lists key issues noted from OPG reviews to date on the Fukushima Daiichi NPP event.

OPG will provide a more detailed progress update to the CNSC by May 28, 2011 [2] and a further update by July 28, 2011 [3].

If you have any questions regarding this submission please contact Mr. Fred Dermarkar, Director, Engineering Services, at (905) 839-6746, extension 5066.

Sincerely,

W. M. Elliott
Senior Vice-President Nuclear Engineering and
Chief Nuclear Engineer

cc:	T. Jamieson	CNSC (Ottawa)
	J. Cameron	CNSC (Ottawa)
	G. Rzentkowski	CNSC (Ottawa)
	J. Lavoie	CNSC (Ottawa)
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	T. E. Schaubel	CNSC (Ottawa)
	P. A. Webster	CNSC (Ottawa)
	CNSC Site Office	Pickering
	CNSC Site Office	Darlington

References:

1. CNSC Letter, R. Jammal to W. M. Elliott, "Request Pursuant to Subsection 12(2) of the General Nuclear Safety and Control Regulations: Lessons Learned from Japanese Earthquake," March 17, 2011, CD# N-CORR-00531-05254.

2. OPG Letter, W. M. Elliott to R. Jammal, "OPG Response to CNSC Request Pursuant to Subsection 12(2) of the General Nuclear Safety and Control Regulations: Lessons Learned from Japanese Earthquake," March 25, 2011, CD# N-CORR-000531-05080.

3. Bruce Power and OPG letter, D. Hawthorne and T. Mitchell to M. Binder, "Response to Recent Events in Japan," March 18, 2011, CD# N-CORR-000531-05143.

4. OPG Letter, W. M. Elliott to T. E. Schaubel and P. A. Webster, "Submission of PARS Installation Schedules, Action Items 2008-1308, 2008-4-09 and 2008-8-09," March 29, 2011, CD# N-CORR-00531-05221.

Table 1

Preliminary Lessons Learned from Fukushima Daiichi NPP Event

Preliminary Issue (at Fukushima)	**OPG Actions (Short/Medium Term)**	**OPG Actions (Longer term)**
Hydrogen mitigation appeared to have been inadequate	Confirm Hydrogen (H2) Igniter availability – **completed** Expedite SAMG implementation (addresses additional H2 mitigation measures)	Expedite PARS installation [4].
Irradiated fuel bay (IFB) cooling and/or inventory appeared to have been not maintained	Confirm current procedures and equipment readiness - **completed**	Confirm adequacy of current measures - conduct further assessments to determine the level of risk for hydrogen production in the IFB for BDBEs and evaluate the need for additional measures to prevent hydrogen production and mitigate its consequences
Emergency water and power systems appeared to be less than adequate	Confirm current procedures and equipment readiness – **completed**	Evaluate options to improve robustness Evaluate need for additional system (i.e., backup to seismic heat sink provisions)
Station design for external events with consequential failures appeared to be less than adequate	Identify and implement improvements as required in current systems, e.g., via PRA.	Evaluate need for additional mitigation of fires and floods consequential to seismic events
Impacts of beyond design basis events (BDBEs) appears to have not been fully characterized	Assess the extent to which current design deals with BDBEs Confirm adequacy of current safety case for specific BDBEs	Determine if further studies should be undertaken to determine if current designs have a sufficient level of robustness to effectively mitigate BDBEs

Preliminary Issue (at Fukushima)	**OPG Actions (Short/Medium Term)**	**OPG Actions (Longer term)**
Severe Accident Management measures for BDBEs appeared not to be fully effective	Phase I SAMG completed in 2010 Phase II SAMG implementation in progress	Identify areas for improvement
Emergency planning & response was less than adequate.	Awaiting further information from Fukushima	Identify areas for improvement

Attachment 1

Emergency Preparedness Review of the Fukushima Daiichi Event

A detailed "Lessons Learned" assessment around emergency preparedness (EP) will be completed as more information becomes available. In the interim, OPG Emergency Preparedness has completed a full review of the current Consolidated Nuclear Emergency Program (CNEP), N-PROG-RA-0001. The results are documented under OPG Self Assessment NO11-000161. The following items from this review are noteworthy:

- The Design Base Accident for emergency planning is a Loss of Coolant Accident (LOCA) on a single reactor unit with all safety systems functioning as per design and one contaminated casualty. This would be categorized under the Provincial Nuclear Emergency Response Plan (PNERP) as an Abnormal Incident.

- There are agreements in place with the regional municipalities to support the activation of the Reception and Emergency Workers' Centres. All on-site and off-site facilities that support this plan were verified as poised with all equipment operationally ready. All documents (response and supporting procedures) were reviewed for correctness and applicability. Emergency Response Organization (ERO) staffing was reviewed and found to meet requirements.

- The Emergency Preparedness Program is in compliance with the Provincial Nuclear Emergency Response Plan. All potential gaps identified through this process are related to Beyond Design Basis Events (BDBEs) and fall outside the scope of the current CNEP.

- OPG has developed an excellent working relationship with both Emergency Management Ontario (EMO) and the Durham Emergency Management Office (DEMO). OPG works with both organizations to conduct regular exercises and develop program improvement initiatives. The EMO and DEMO are very well resourced to handle emergencies. EMO can also call on resources from outside the province of Ontario if required through existing inter-provincial and international mutual assistance agreements.

In view of the evolution and outcomes of the Fukushima event(s), the adequacy of the EP program will be reviewed as further information becomes available. At this juncture, OPG has noted that the following items require further investigation/resolution:

1. Assess the scope of the current EP program to determine need to include BDBEs,
2. Assess the Drill and Exercise program to determine need to include scenarios for ERO response to a BDBE.
3. Assess site evacuations with compromised offsite egress routes.
4. Assess the provisions required to house staff on site for extended periods of time.
5. Assess Whitby Health Physics Laboratory Continuity of Operations Plan against BDBE conditions concurrent with a large scale event at one of the plants.

Attachment 2

Site Verification Activities

Per Reference 3 of this letter, the following is a progress report on site verification activities which confirm the adequacy of plant equipment, plant procedures and staff training related to overall response to seismic, station blackout, flooding and fire events:

1. Verify the capability of procedures and currently installed equipment to mitigate conditions that result from beyond design basis events (TCD April 8, 2011).

2. Verify that the capability to mitigate station blackout (SBO) conditions required by station design is functional and valid (TCD April 15, 2011).

3. Verify the capability to mitigate internal and external flooding events required by station design (TCD May 6, 2011).

4. Perform walk downs and inspections of important equipment needed to mitigate fire and flood events to identify any potential that the equipment's function could be lost during seismic events appropriate for the site (TCD May 13, 2011).

Items 1 and 2 are complete, and a summary of the results are presented below. Items 3 and 4 are in progress. To date, no significant issues requiring immediate corrective or compensatory measures have been identified. Some minor improvements were identified in the course of this work and are being prioritized and addressed per normal station processes. Longer term issues related to specific BDBEs and their impact on the station's safety cases will require further investigation.

The inspection results for Item 1 and 2 are discussed in greater detail below:

Item 1: Verification of the capability of procedures and currently installed equipment to mitigate conditions that result from beyond design basis events

For this verification activity, four separate elements were reviewed:

a) System and/or equipment capability (via tests, inspections and/or walkdowns as appropriate).

b) Procedures (via walkdown and/or demonstration as appropriate).

c) Training and staff qualification (via review of training and qualification (T&Q) records).

d) Status of required contracts (review and confirmation as to adequacy).

The results for all three NPP sites was quite similar and Table A2-1 summarizes OPG findings for each element (a-d) for Pickering A, Pickering B and Darlington, respectively.

Item 2: Verification that the capability to mitigate station blackout (SBO) conditions required by station design is functional and valid

The review of this item was conducted in a manner similar to item 1, with four separate elements (equipment, procedures, T&Q, and contracts) as per item 1.

Similar results were noted, and no significant deficiencies with the emergency power systems, which are required to function following seismic events and/or a total loss of off-site power, were identified.

Table A2-1
Verification Activity 1 Results: A Summary for Darlington, Pickering A and Pickering B

Verification element	Results
a) Equipment	• Confirmed capability for DBE and BDBE considered at site, as described in current design and licensing basis. • Minor improvements were identified and are being prioritized and addressed per normal station processes. • Potential areas for improvement regarding IFB events were identified for additional review. • Potential areas for improvement around more severe BDBEs should be investigated further (i.e., via the safety case review).
b) Procedures	• Confirmed capability for DBE and BDBE considered at site, as described in the current design and licensing basis. • Minor gaps/issues in the existing procedural suite were identified for correction • Potential areas for improvement regarding IFB events were identified for additional review. • Potential areas for improvement around more severe BDBE should be investigated further (i.e., via the safety case review).
c) Staff Training & Qualification (T&Q)	• No safety significant gaps were noted. • Minor gaps/issues in T&Q were noted for improvement
d) Contracts	• Current minimum requirements for essential supplies and critical consumables (3 days) should be reviewed for adequacy. • Many contracts contain "Force Majeure" (Act of God) clauses which may limit contract obligations under some BDBEs. • Further effort to ensure that adequate critical supplies are stockpiled is required. • Emergency communications equipment should be reviewed in greater detail.

DBE: Design Basis Event
BDBE: Beyond Design Basis Event