Pickering Nuclear Generating Station B Integrated Safety Review

N. H.H. Smith[1], R. Arora[2]
[1]Ontario Power Generation, Pickering, Ontario
[2]Consultant, Toronto, Ontario

Abstract

OPG is performing a feasibility study to determine if there is a sound business case for Pickering B Nuclear Generating Station (NGS) refurbishment. One component of the feasibility study is the execution of an Integrated Safety Review (ISR). The ISR is a comprehensive assessment of Pickering B NGS, including a comparison of existing OPG governance at the plant, with modern codes and standards for each of the review areas in accordance with "Periodic Safety Review of Nuclear Power Plants Safety Guide" published by the International Atomic Energy Agency (IAEA). Additionally, the ISR will address factors of quality management, security and safeguards as identified by the CNSC in G-360 "Life Extension of Nuclear Power Plants" [1].

Figure 1 Pickering B NGS

1. Introduction

Located on the shores of Lake Ontario just east of Toronto, in the City of Pickering, is one of the world's largest nuclear generating facilities – Pickering Nuclear. Its two stations, Pickering A and B, are operated by OPG and produce enough electricity to serve a city of 1.5 million people. The Pickering B NGS has four CANDU reactors which have been producing electricity for more than 20 years, and with a regular maintenance schedule, are expected to continue to operate safely for another decade or so. The units could be shut down at the end of their predicted service lives, or could be refurbished and continue to produce electricity for Ontario an additional 30 years. Refurbishing Pickering B NGS would extend its service life by replacing major components such as feeder tubes, fuel channels and/or steam generators, among other things.

Pickering B NGS - units five, six, seven and eight - continue to operate safely since they were brought into service in 1983. They have a combined capacity of approximately 2,100 megawatts.

OPG has begun the Pickering B NGS Refurbishment Study to determine the feasibility of refurbishing the reactor units at Pickering B NGS in order to extend their operating lives an additional 30 years.

In May 2006, the CNSC introduced a draft Regulatory Guide, G-360, "Life Extension of Nuclear Power Plants" [1] which establishes the CNSC approach to life extension of nuclear power plants. Draft Regulatory Guide G-360 identifies that licensees are required to perform an Integrated Safety Review (ISR) in accordance with the Periodic Safety Review (PSR) of Nuclear Power Plants safety guide [2] published by the International Atomic Energy Agency (IAEA).

This paper outlines how OPG is performing the Integrated Safety Review of Pickering B NGS as outlined in Draft Regulatory Guide G-360.

2. Requirements of Draft Regulatory Guide G-360

The draft Regulatory Guide G-360 identifies three major activities necessary to carry out a nuclear plant life extension in Canada. These are:

- Participation in the Environmental Assessment process;
- Carry out an ISR; and
- Apply the results of the above two assessments to develop a Safety Improvement Plan.

The Safety Improvement Plan incorporates all necessary corrective actions, proposed plant modifications, safety upgrades, compensatory measures, and improvement to operations and management programs identified in the Environmental Assessment and the ISR, to allow the plant to operate over the planned extended life.

The draft Regulatory Guide G-360 also requires that prior to performing an ISR, the licensee prepares an ISR Basis Document that sets out the scope and methodology for conducting the ISR. As outlined in draft Regulatory Guide G-360, the scope of the ISR Basis Document is for the licensee to provide the following:

- the topics to be considered in the ISR
- statement of modern high-level safety goals, applicable regulatory requirements, and relevant industry standards
- the licensing basis of the plant at the time of initiating the ISR
- the process for identifying, recording, tracking and addressing gaps between current and desired plant state and performance.

OPG submitted the Pickering B NGS ISR Basis Document to the CNSC on August 30, 2006. The document was subsequently revised based on feedback from the CNSC and revision 1 was submitted to the CNSC on December 22, 2006.

3. Objective of an ISR

The objective of an ISR is to determine, by means of a comprehensive assessment of an existing nuclear power plant, the following:

- The extent to which the plant conforms to modern high-level safety goals and requirements
- The extent to which the licensing basis remains valid
- The adequacy of the arrangements that are in place to maintain plant safety for long-term operation
- The corrective actions required to address gaps with respect to modern safety requirements identified by the ISR process

In order to facilitate this comprehensive assessment of Pickering B NGS, existing OPG governance at the plant is being compared with modern codes and standards for each Safety Factor listed in the IAEA guide for conduct of a PSR. Additionally, the ISR addresses factors of quality management, security and safeguards as required by the Draft Regulatory Guide G-360.

The Pickering B NGS Safety Report and OPG Governance for operations in conjunction with the operating history of the plant already address the topics to be covered by the PSR. The ISR will provide a comparison of the current licensing basis against the modern regulatory and safety standards.

4. Scope of an ISR

4.1 Pickering B NGS Life Extension Project

A life extension project is being considered for Pickering B NGS with a life extension period of 30 years. It has already been determined that likely a number of major components including boilers, pressure tubes, calandria tubes and feeders will be replaced as part of the life extension project. The ISR review is performed to assess the condition of the plant and adequacy of the programs, including ageing management programs that are in place to maintain plant safety throughout the extended lifetime of the plant. Through this review process, additional required modifications to plant equipment and programs may be identified and evaluated for inclusion in the proposed life extension project.

Pickering B NGS is comprised of four nuclear reactors, four turbine/generators and their associated equipment, services and facilities, including the following buildings and structures:

- Four reactor buildings numbered 5 to 8,
- A reactor auxiliary bay that houses the main control room and a number of reactor auxiliary systems,
- A powerhouse, which includes the turbine hall and turbine auxiliary bay running the full length of the station,
- A screen house,

- A pressure relief duct and a vacuum building that serves the entire eight-unit Pickering Nuclear Generating Station,
- Unit emergency control centres (UECC), one for each unit, located under the pressure relief duct,
- A high pressure emergency coolant injection (HPECI) pumphouse and an HPECI water storage tank
- Six standby generators, and an emergency water (EWS) /power supply (EPS) building including two emergency power generators (EPGs).

The scope of the review encompasses all of the Safety Related Systems. Safety Related Systems are those systems, and the components and structures thereof, which, by virtue of their failure to perform in accordance with the design intent, would have the potential to impact on the radiological safety of the public or plant personnel from operation of the nuclear power plant. Such Safety Related Systems are associated with the provision of the following safety related functions:

- Regulation (including controlled startup and shutdown) and cooling of the reactor core under normal conditions (including all normal operating and shutdown conditions).
- Regulation, shutdown, and cooling of the reactor core under anticipated transient conditions, accident conditions, and the maintenance of the reactor core in a safe shutdown state for an extended period following such conditions.
- Limiting the release of radioactive material, and exposure of plant personnel, the public and the environment to meet the criteria established by the licensing authority with respect to radiation exposure during and following normal, anticipated transient and accident conditions.

The list of Safety Related Systems is documented in OPG document P-PROC-MP-0006, “List of Safety Related Systems.”. The review will focus in greater depth on a subset of this list comprised of the Systems Important to Safety as defined by OPG in compliance with S-98, “Reliability Programs for Nuclear Power Plants,” and those systems defining the boundary of the Safe Operating Envelope.

Any interdependencies between Pickering B NGS and Pickering A NGS structures and systems will be identified during the ISR process and managed throughout the proposed life extension as required.

5. Safety Factors

This section lists the Safety Factors to be considered for the Pickering B NGS ISR from the IAEA safety guide and Reference 1.

The IAEA recommended Safety Factors are grouped into five subject areas to facilitate the review. In addition to the Safety Factors identified by the IAEA, the CNSC requires that the ISR will also address factors of quality management, security and safeguards as identified in the draft Regulatory Document G-360. Due to the sensitive nature of the subject, the security issue will be dealt with in a forum and manner that ensures the confidentiality and security of this information. As such, the scope and methodology for assessment of security will not be included in this document.

These subjects and the corresponding Safety Factors are listed in Table 1 below, demonstrating how the IAEA and CNSC requirements will be grouped in the Pickering B NGS ISR.

Subject	**Safety Factors**
Plant	Plant Design
	Actual condition of systems, structures and components
	Equipment Qualification
	Ageing
Safety Analysis	Deterministic Safety Analysis
	Probabilistic Safety Analysis
	Hazard Analysis
Performance and Feedback of experience	Safety Performance
	Use of experience from other plants and research findings
Management	Organization and administration
	Procedures
	Human Factors
	Emergency Planning
	Quality Management - CNSC recommended
Environment	Impact of nuclear and hazardous substances
Security & Safeguards	*Security – CNSC recommended*
	Safeguards – CNSC recommended

Table 1: Safety Factors

In carrying out the ISR, each Safety Factor is further broken into Review Elements (topics) to address specific areas within the broad categories defined by the Safety Factors. The concept behind the ISR is to review each of the Safety Factors by comparing the activities covered by the governing programs in use at Pickering B NGS with modern regulatory requirements, codes, standards and "good practices". The gaps, if any, in the conformance to these currents codes and standards will be compiled as "ISR Findings" of the ISR.

6. Regulatory Documents and Industry Standards Applicable to ISR

Pickering B NGS was designed in the 1970's in conformance with the then current codes, standards and regulatory requirements. The ISR process requires that the licensees perform the review against modern standards. In cases where the modern standards cannot be met and the original requirements are not satisfactory, a systematic review will be carried out to identify practicable corrective actions and upgrades or to provide justification for exemption.

6.1 Regulatory Documents

The CNSC uses four types of Regulatory Documents to define and communicate regulatory guidance: Regulatory Policies, Regulatory Standards, Regulatory Guides and Regulatory Notices. CNSC Policies, Standards and Guides normally originate as Consultative Documents which are issued as drafts to obtain comments from stakeholders. Compliance is mandated through the Operating License for the plant.

Consultative Documents, issued for public or industry comments or trial use are intended for eventual use as Regulatory Documents. They are generally not used in licensing except in cases where one may have been used on a trial basis on a particular station.

6.2 Codes and Standards

The current Pickering B NGS Operating Licence identifies the codes and standards applicable to the design, construction, commissioning and operation of the plant. A complete list of codes and standards typically used in the CANDU industry contains over 700 codes and standards, a subset of which will be considered in the Pickering B NGS ISR as described in this document.

In order to ensure all the relevant codes and standards for the Pickering B NGS ISR have been captured, a list of codes was developed based on the following sources:

- Codes, standards and regulatory documents referred to in Pickering B NGS Operating License
- Initial list based on work for Pickering A Restart
- Updates from CSA and CNSC websites and the IAEA Safety Standards for NPP
- Codes used in the Bruce A and Point Lepreau refurbishments.

From these documents and current regulatory trends and requirements, a comprehensive list of codes and standards that are likely to apply to a new plant was created. This list was submitted to the CNSC.

The modern versions of codes, standards and regulatory documents referred to in the current Pickering B NGS Operating License are undergoing a clause by clause examination that will form the core of the ISR review. The review of these codes, standards and regulatory documents will take into account the fact that in some cases only certain clauses of codes are applicable.

For the purpose of assessment of design against the latest version of these codes and standards, the code effective date is June 30th, 2006, corresponding to the ISR Methodology submission to the CNSC.

The non-mandatory practices in place at the plant have also been identified for the purpose of this review, to capture built in safety margin resulting from compliance with these practices.

7. Current Licensing Basis

Pickering B NGS is currently licensed to operate under the Power Reactor Operating License Number PROL 08.11/2008.

8. Integrated Safety Review Process

The ISR process involves an assessment of the current state of the plant and plant performance to determine the extent to which the plant conforms to modern safety goals and requirements. In addition to the review of Regulatory Documents and Industry Standards applicable to ISR, OPG Governance is being reviewed to determine the station Policies, Programs, Standards, Procedures and Manuals, which most closely align with the objectives associated with the Safety Factors.

A schematic of the overall review process for an ISR is shown in Figure 2.

9. Review and Reporting

9.1 CNSC Expectations In G-360

(1) An Integrated Safety Review that meets the intent of a Periodic Safety Review (PSR) as defined by the IAEA [2] is to be completed to assess: the extent to which the plant conforms to modern national and international safety standards and practices; the extent to which the licensing basis remains valid; the adequacy of the arrangements that are in place to maintain plant safety to the end of plant lifetime; and the safety improvements to be implemented to resolve the safety issues that have been identified.

(2) The scope and methodology to be followed during the ISR is to be planned, scheduled, developed and documented.

(3) The identification of regulatory documents and Codes and Standards to which a new plant would be built.

(4) The CNSC is to be kept informed of progress and their comments are to be considered in the conduct of the review.

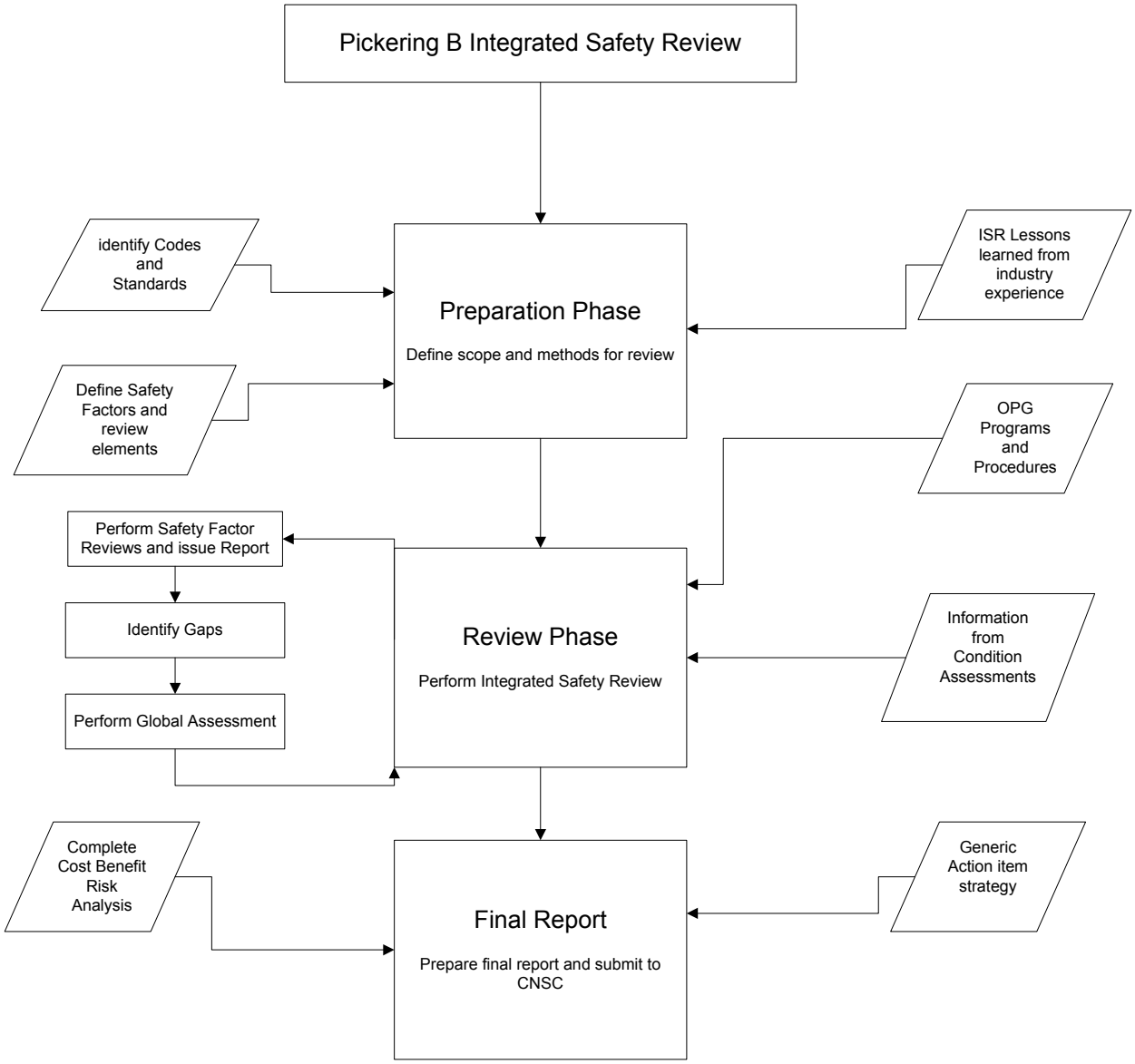

Figure 2 – ISR Overall Review Process

10. Preparing to Conduct an ISR

Prior to conducting an ISR the following activities were performed:

(1) Established a project-planning group, with suitably qualified staff to control the execution of the ISR and to provide assistance to the staff that will conduct the reviews.

(2) Established an understanding of the CNSC's expectations in G-360 for the ISR and prepared a project plan and schedule for the conduct of the ISR.

(3) Reviewed and studied the methodology recommended by IAEA for the conduct of a PSR and other documents referred to in the draft CNSC regulatory guide G-360 and IAEA safety guide NS-G-2.10 [2].

(4) Prepared a methodology to conduct the ISR (this document).

(5) Identified the applicable regulatory documents and compiled a list of the Codes and Standards to be used for the ISR.

(6) Interfaced with other nuclear plant owners, Canadian and international, who have or are intending to extend the life of their Nuclear Power Plants (NPPs). While the methodology among the NPPs may not be identical, lessons learned and review activities provided ideas to be considered for inclusion in the ISR for Pickering B NGS.

(7) Established an interface with the CNSC to communicate the intent and general methodology.

11. Review Phase

Some of the activities of the Review Phase were executed in parallel with the Preparation Phase.

(1) The Safety Factors and Review Elements identified in the ISR are tailored to the Pickering B NGS review. CNSC concurrence will be sought for any significant deviation from the PSR recommended review scope and methodology.

(2) Several Safety Factors or elements of the Safety Factors are grouped together to make best use of both the internal and external expert resources required to perform these reviews.

(3) Developed and documented the methodology for each of the Safety Factors reviews.

(4) Safety Factor specific reports are produced to document the methodology, assumptions, and findings of the review. Where required, a set of recommended Corrective Actions will be developed. These reports are submitted to the CNSC prior to the final ISR report for their feedback.

(5) A Global Assessment to evaluate all identified gaps in their totality is performed in order to capture the combined impact of identified deficiencies.

12. Reports

12.1 Safety Factor Reports

The Safety Factor reports will include both clause by clause reviews and higher level intent reviews of the codes, standards and regulations based on their relevance to the particular safety factor.

- Direct Compliance – Compliance has been demonstrated with the code/standard/regulation based on a clause by clause review.
- Indirect Compliance – Compliance has been demonstrated with the intent of the code/standard/regulation based on higher level intent review.
- Acceptable Deviation – Compliance with the code/standard/regulation could not be demonstrated; however, technical assessment has determined that the deviation is acceptable. For these cases, detailed discussion and explanation will be provided.
- Discrepancies – System design and/or operation improvements are deemed necessary. These items will be categorized as discrepancies and recorded in the ISR Discrepancy Database (See Section 6.3) for orderly disposition to determine corrective actions.

12.2 Global Assessment Report

The objective of the global assessment, in reference to plant life extension of Pickering B NGS, is to present an overall assessment of plant safety taking into account all gaps, corrective actions and the plant strengths identified in the ISR.

The Global Assessment Report takes the following aspects into account:

- results of the reviews, in particular the gaps and the strengths,
- recommended corrective actions and/or safety improvements to address individual gaps or a group of gaps,
- demonstration of the extent the safety requirements of the defense in depth concepts are fulfilled, in particular for the basic safety functions of control, cool and contain, and
- an estimate of global risk associated with plant operation with any unresolved gaps

The Global Assessment Report is prepared at the conclusion of the review phase and incorporated into the final report. Note that the Global Assessment Report does not include a review and discussion related to Security. The issues relating to security are dealt with separately in a forum and manner that ensures the confidentiality and security of this information.

13 Final Report

As an input to develop the Safety Improvement Plan, a final report to summarize the results of the ISR is prepared.

The final report summarizes the results and major findings of all of the Safety Factors, the Global Assessment, dispositions the discrepancies, and identifies the prioritized recommended corrective actions.

A benefit-cost risk analysis, based on the process developed by COG and submitted to the CNSC will be applied for the identified gaps and the corrective actions.

14 Summary

This comprehensive Integrated Safety Review of Pickering B NGS assesses the condition of the plant and adequacy of the programs that are in place to maintain plant safety. The review process identifies reasonable and practical modifications to plant equipment and program improvements that will be evaluated for inclusion in the proposed life extension project.

REFERENCES

1. CNSC Draft Regulatory Guide, G-360, "Life Extension of Nuclear Power Plants," issued for public comment May 2006.

2. IAEA Safety Standards Series, Safety Guide No. NS-G-2.10, "Periodic Safety Review of Nuclear Power Plants," 2003.