Canada's Nuclear Regulator

December 31, 2010

Phase 3 Executive Summary: Pre-Project Design Review of AECL's Advanced CANDU Reactor ACR-1000[-1]

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Canada

Executive Summary

Background

The Canadian Nuclear Safety Commission (CNSC) is Canada's sole nuclear regulatory agency and operates under the *Nuclear Safety and Control Act* (NSCA). The CNSC regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment, and to respect Canada's international commitments on the peaceful use of nuclear energy.

A vendor pre-project design review is a high-level assessment of a vendor's reactor technology. It is an optional service provided by the CNSC when requested by a vendor. This service does not involve the issuance of a licence under the NSCA, and it is not part of the licensing process. The conclusions of such reviews will not bind or otherwise influence the decisions made by the Commission.

The review is solely intended to provide early feedback on the acceptability of a nuclear power plant design, based on Canadian regulatory requirements and expectations. The CNSC will require a much more detailed review of the design and safety case for a specific application and a specific site.

Atomic Energy of Canada Limited (AECL), a vendor of nuclear power plants, is designing a two-unit Advanced CANDU Reactor (ACR-1000) nuclear power plant, each unit with a gross electrical output of 1165 Megawatts electrical. The ACR-1000 design is largely based on the design concepts and the reactor and process system designs of current CANDU plants. Despite these similarities, there are some important differences between the ACR-1000 design and existing CANDU technologies.

In April 2008, AECL requested the CNSC to perform a pre-project design review of the ACR-1000 design. The CNSC completed Phases 1 and 2 of the pre-project review in December 31, 2008 and August 31, 2009, respectively. Subsequently, AECL requested the CNSC to extend the review to Phase 3 in order to follow up on some specific technical aspects. In November 2009, the ACR-1000 Memorandum of Understanding (MOU) was amended to include the Phase 3 review. The MOU outlines the objectives, the technical scope of review, schedule guideline, deliverables, costs, working arrangements and general conditions. The Phase 3 review for the ACR-1000 design is now complete, and the principal findings are provided in this summary.

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1- ACR-1000®

Objectives and Review Phases

The objectives of a pre-project design review are to:

- Assess whether a reactor design is, at an overall level, compliant with the CNSC regulatory requirements;
- Assess whether the design meets the CNSC's expectations for new nuclear power plants in Canada; and
- Identify potential fundamental barriers to licensing a reactor design in Canada.

To achieve the above stated objectives, CNSC staff assesses the safety and security aspects of the design. This review provides an opportunity for CNSC staff to assess the design prior to any licensing activities, and to identify potential issues for resolution relating to the compliance of the design with regulatory requirements and expectations. Such a review will help increase regulatory certainty and ultimately contribute to public safety.

The pre-project design review process is divided into three phases:

- **Phase 1: Compliance with Regulatory Requirements:** This phase is an overall assessment of the information submitted in support of a reactor design against the CNSC regulatory requirements and regulatory documents. Its purpose is to determine whether the design intent is compliant with CNSC requirements and meets the CNSC's expectations for the design of new nuclear power plants in Canada;
- **Phase 2: Identification of Fundamental Barriers:** Subsequent to Phase 1, this phase goes into further detail with a focus on identifying whether there are any potential fundamental barriers to licensing the reactor design in Canada; and
- **Phase 3: Follow-up:** In this phase, the vendor chooses to follow up on specific aspects of the Phase 2 review findings by requesting the CNSC to review activities taken by the vendor towards the readiness of the reactor design for licensing.

Phase 3 Review Process and Selected Review Topics

For the Phase 3 review, AECL requested that CNSC staff review in more detail specific aspects of some of the previous topics considered for the Phase 2 review. An important distinction for the Phase 3 review is that the scope is determined by AECL and it is reduced from Phases 1 and 2 – CNSC staff's Phase 3 review considers only certain technical aspects of the design and AECL's proposed safety case.

The objective is for CNSC staff to follow up on the implementation of some of AECL's planned activities for selected review topics (identified below) and to assess the progress that AECL is

making towards the completion of these activities. Such a review will increase the efficiency of a regulatory review during an assessment of a construction licence application.

The topics for the Phase 3 review are mainly related to:

- A new methodology;
- A new application of a methodology;
- Research and development (R&D) related to new design features or analysis;
- Topics identified during Phase 2 for which CNSC staff would require further information during an application for a licence to construct; and
- Topics that would give significant opportunity for AECL to minimise licensing risk for a construction licence application.

The Phase 3 selected review topics are:

- Classification of structures, systems, and components (SSCs);
- Use of the TSUNAMI computer code for ACR-1000 physics applications;
- Reactor core nuclear design;
- Fuel design;
- Online preventive maintenance strategy;
- Severe accidents;
- Probabilistic safety assessment;
- Human factors;
- Quality assurance (QA) actions following CNSC staff's Phase 2 inspection findings;
- Safety analysis methodology; and
- R&D in support of the emergency core cooling system.

The scope for each of the topics varied according to the purpose of the review. The scope for two topics, human factors and QA, was significantly less than for the others.

To facilitate the Phase 3 review, AECL submitted documentation required for each of the review topics, and provided CNSC staff with progress updates on each of the topics in meetings. Additional information was submitted, as requested by CNSC staff, in support of the review.

Phase 3 Review Criteria

For each of the selected review topics, CNSC staff assessed the submitted documentation against the following requirements and expectations:

- CNSC regulatory documents, in particular regulatory document “Design of New Nuclear Power Plants” (RD-337); and

- Canadian CSA Standards and Codes, and International Standards.

Phase 3 Review Findings

CNSC staff acknowledges that, throughout the Phase 3 review, AECL staff was open and transparent in sharing available information, and that they responded diligently to every CNSC request for clarification and additional information.

AECL has introduced a number of new design features and analytical methodologies to support the ACR-1000 design. In many cases, these are evolutions of existing practices and while some aspects are new, overall, these are not fundamentally different from those previously used in licensing. CNSC staff finds that AECL has, in general, developed satisfactory methodologies for classification of SSCs, online preventative maintenance, severe accidents, probabilistic safety assessments and safety analysis.

While the application of the TSUNAMI computer code is new to licensing in Canada, CNSC staff recognizes the significant effort that AECL has undertaken to address CNSC staff's comments made during the Phase 2 review. The information provided to CNSC staff indicates that AECL has made progress in developing an analytical methodology that could be applied to support licensing.

With regard to some of the new design features of the ACR-1000 design – core nuclear design, fuel and emergency core cooling system – CNSC staff finds that AECL has made satisfactory progress in its design, R&D and testing activities.

CNSC staff also finds that, overall, AECL is satisfactorily taking into account CNSC observations made during the Phase 2 review on the topics of human factors and QA.

Phase 3 Review Conclusions

Based on the Phase 3 pre-project review of the information provided by AECL, CNSC staff concludes that:

- AECL has provided sufficient design and analysis information for the purpose of this review;
- AECL is progressing satisfactorily towards completing of a number of activities to resolve questions arising from CNSC's Phase 2 review; and
- The progress made to date, and subject to the successful completion of the remaining planned activities, the specific items on each of the eleven topics covered in Phase 3 will be satisfactorily addressed within a reasonable timeframe.

In addition, the Phase 3 review has provided the CNSC staff a further opportunity to understand in greater detail various aspects of AECL's proposed safety case for the ACR-1000 design. This is of particular value for those aspects of the design and analysis which are new to the CNSC.

The above overall conclusions are based on the progress made in each of the review topics selected by AECL for the Phase 3 review.