

Assuring CANDU Nuclear Safety Competence in Korea: Regulatory Research and Development Program

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ABSTRACT

According to a two-reactor policy developed in the late 1980s in Korea, the national short- and mid-term power reactor strategy has been established in such a way that PWR should play a principal role in the development of nuclear power plants and CANDU a supplementary role taking advantage of its localization potentials. However, the diversification of reactor types and vendors has caused some difficulties in the process of the individual nuclear power plants licensing and regulation. During the licensing of Wolsong units 2, 3 and 4, every effort has been made to harmonize the Canadian regulations with those of Korea by establishing the various and specific regulatory positions and guidelines. The safety assuring method of CANDU reactors has been improved substantially through these efforts, resulting in the improvement of regulatory system and procedure in Korea.

However, the incident of heavy water leaks from Wolsong Unit 3 in October 1999 and recently raised CANDU generic safety issues, such as feeder wall thinning, have motivated the need to re-emphasize the operational safety of CANDUs. As the necessity of improving and developing regulatory requirements, procedures, and technologies considering the design and operating characteristics of CANDUs was recognized, a need of a new mid- and long-term R&D program with an aim to develop and improve regulatory infrastructure such as legal system, generic regulatory requirements and technical standards for CANDUs was sought. The regulatory research programs for CANDUs were launched last August and the 1st phase of the project will go on to March 2002. The R&D program consists of four sub-programs; (i) development of regulatory requirements and technical standards, (ii) development of regulatory inspection manuals, (iii) development of Performance Indicators (PIs), and (iv) development of Safety Review Guides (SRGs).

In this paper, the overview of the mid- and long-term regulatory R&D program for CANDU NPPs and its perspectives for the future are summarized.

1. INTRODUCTION

Korea has carried out a very ambitious nuclear power program since the early 1970s with strong commitment to nuclear power development as an integral part of the national energy policy. Kori Unit 1, a PWR type, began its first commercial operation of nuclear power plant in 1978 and sixteen (16) nuclear units (twelve PWRs and four CANDU-PHWRs) are now operating and four (4) nuclear units (four PWRs) are under construction [1].

According to a two-reactor policy developed in the late 1980s, the national short- and mid-term power reactor strategy was established in such a way that PWR could play a principal role in the development of nuclear power plants and also in export markets, and CANDU-PHWR a supplementary role taking advantage of its localization potentials. To ensure a stable and

economic supply of electrical energy, independently of foreign market changes, as part of the national energy security, the policy has led to extensive development and localization of nuclear power technologies on both PWRs and CANDUs [2].

Implementing the two-reactor policy, Korea experienced regulatory as well as some technical difficulties in the early days of construction and operation of nuclear power plants due mainly to the differences in applicable technical criteria and regulatory philosophy, practice, requirements, and licensing procedure of the supplying countries, likely, U.S. and Canada. In the early stages, vendor country's laws and regulations such as 10 CFR, Regulatory Guide and Standard Review Plan (SRP) of the US NRC were applied to the licensing review of Westinghouse PWRs. As for CANDUs, Canadian laws and regulatory requirements were applied as mandatory requirement.

However, the nuclear regulatory system including licensing of nuclear power plants (NPPs), has undertaken a series of evolution in parallel and tightly coupled with the development of national nuclear power program. As accumulating valuable experiences and knowledge on siting, design, installation, test, commissioning and maintenance through the construction and operation of many units of PWRs and CANDUs over about two decades, Korea has developed a regulatory infrastructure of its own using these experiences and knowledge as follows:

- Two-step licensing system (construction permit and operating license) is now established and functioning very efficiently.
- Regulatory requirements, criteria and necessary procedures are now set up so that safety reviews and inspections can be performed effectively for both PWRs and CANDUs.
- For CANDUs, mostly Canadian regulatory requirements were adopted in the beginning but they were gradually modified with a feedback of regulatory experiences with PWRs.

From these efforts, the two-step licensing is now official even for CANDUs starting from Wolsong Unit 2 and the submission of safety analysis reports such as Preliminary Safety Analysis Report (PSAR) and Final Safety Analysis Report (FSAR) are equally required. The format and contents of these reports should follow virtually the same specifics prescribed in the U.S. NRC Regulatory Guide 1.70 as for PWR licensing. Detailed regulatory programs, guidelines, procedures, and technical criteria have been restructured mainly based on the framework of PWR regulations. Thus safety reviews and inspections are now conducted for both PWRs and CANDU-PHWRs applying basically the same procedures and criteria.

However, the incident of heavy water leaks from the Wolsong Unit 3 in the October 1999 and recent generic safety issues, such as feeder wall thinning, have motivated the need to re-emphasize the operational safety of CANDU NPPs. In this regard, the necessity of improving and developing regulatory requirements, procedures, and technologies considering design and operating characteristics of CANDU was recognized so that the new regulatory R&D program for enhancing the safety of CANDU operation was considered to be more important. In recognition of need of regulatory R&D program for CANDUs, the Korean Government, MOST (Ministry of Science and Technology), made a new mid- and long-term R&D program with a view to developing and improving regulatory infrastructure such as legal system, generic regulatory requirements, regulatory guides, and technical standards.

2. RESEARCH AND DEVELOPMENT PERSPECTIVES

Laws and regulations between Korea and Canada are quite different since Korean laws and regulations are prescriptive approach similar to those of U.S. such as application of established codes and standards, technical criteria and procedures. In other words, Canadian laws and regulations are consultative approach based on the skills and technical consultation between regulatory body and nuclear industry, thereby the safety of plant design is reviewed continuously even after the issuance of license.

Therefore, Korea has developed a regulatory infrastructure of its own; the licensing system (construction permit and operating license), regulatory requirements, criteria and necessary procedures, which are applicable to both PWRs and CANDUs, using these experiences and knowledge on siting, design, installation, test, commissioning and maintenance through the construction and operation of many units of PWRs and CANDUs over last 20 years,

However, most regulatory infrastructures in Korea are mainly addressed to and based on PWRs. Therefore, the characteristics of design and operation for CANDUs are not well explicitly considered and documented into both the legal and regulatory systems. As an increase of CANDU NPPs operational experience, these issues caused a confliction between regulatory body and utility.

Over the years, there have been concerns about the need to complement and stipulate the nuclear regulatory requirements for CANDUs in the Atomic Energy Act. This is an ongoing process as we work to do a better job of regulating the CANDU NPPs rationally. KINS launched several initiatives in this regard. It is being undertaking a program to develop comprehensive regulatory requirements that covers all aspects of nuclear facilities for both PWRs and CANDUs, so as to support us in fulfilling this modern mandate. However, regulatory overlap and duplication between PWRs and CANDUs are a sensitive issue that will continue to require our attention. KINS is, therefore, committed to streamline the regulatory regime, minimizing the regulatory burden and reducing administrative costs to the degree possible in terms of regulation of both PWRs and CANDUs while ensuring an effective and efficient regime.

To this end, the Korean Government, MOST, made a new mid- and long-term R&D program with an aim to develop and improve regulatory infrastructure such as legal system, generic regulatory requirements and technical standards for CANDUs. The regulatory research programs for CANDU-PHWRs are currently in progress since last August until March 2002. It was established and undertaken as part of the "National Mid- and Long-Term Nuclear R&D Program". And Korea will strengthen its international cooperation activities with CNSC and AECL particularly in its area of joint researches with an aim to cooperate and exchange its regulatory expertise in the future.

The mid- and long-term regulatory R&D program for CANDUs, which consists of four (4) sub-programs; (i) development of regulatory requirements and technical standards, (ii) development of regulatory inspection manuals, (iii) development of performance indicators, and (iv) development of safety review guides (SRGs). Besides, in industrial side, there is a mid- and long-term R&D program consist of four sub-programs as shown in Figure 1.

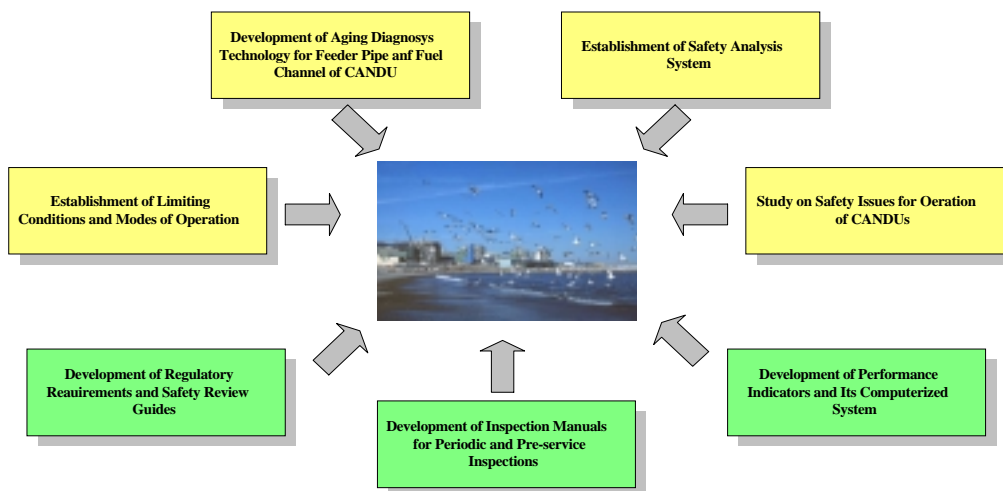
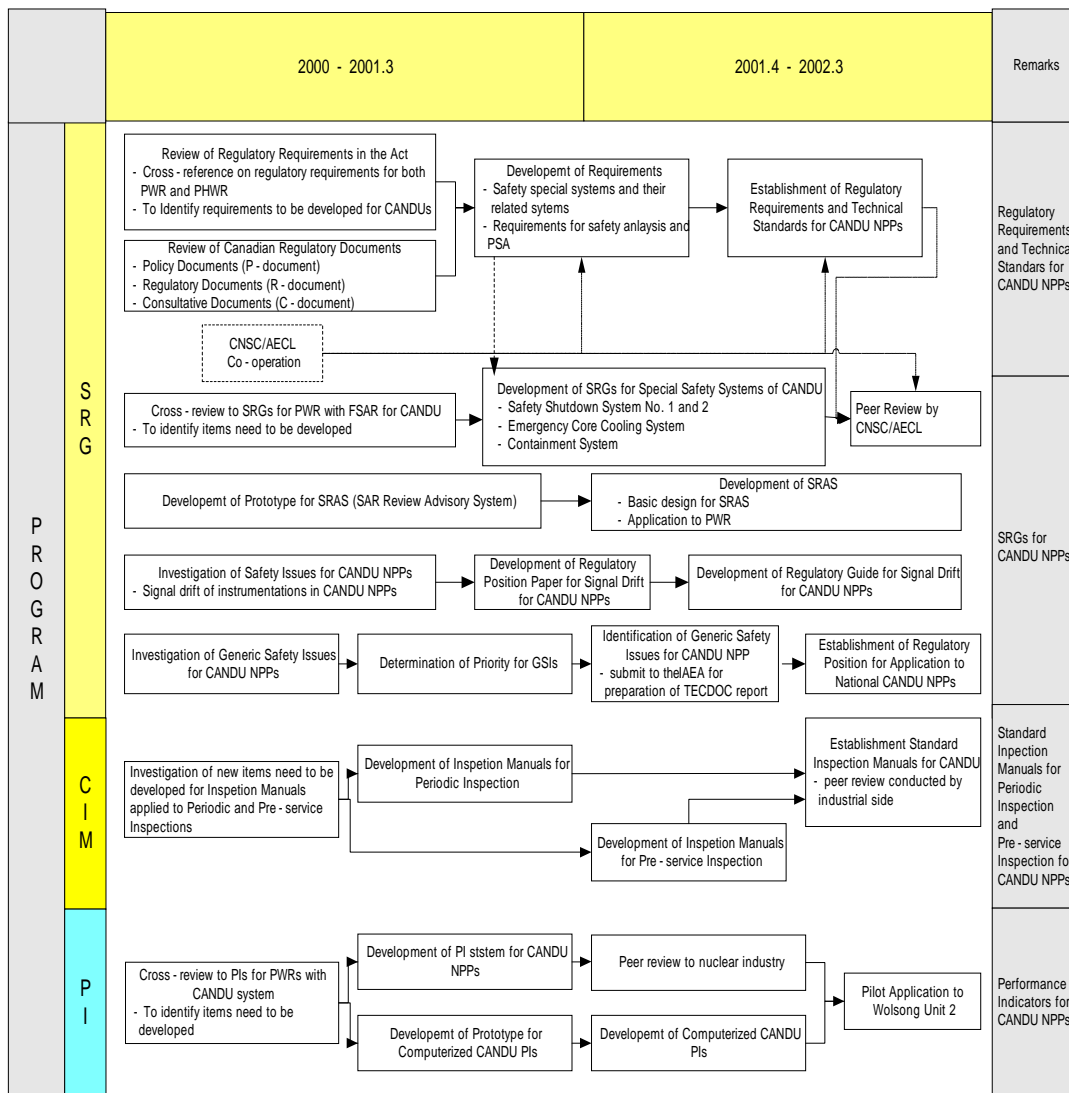


Figure 1 Overview of CANDU R&D Program

For the project, it will be continuing until March 2002 for two (2) years as shown in Table 1. During the project, mostly Canadian regulatory requirements will be comprehensively evaluated in the beginning stage and they will be modified and complemented, mutatis and muntandis, with a feedback of regulatory experiences with CANDU NPPs. As for conducting the regulatory R&D for CANDU, We would prioritize our work and allocate our resources accordingly to increase effectiveness based on changing needs and circumstances.

Table 1 Overall Schedule of CANDU R&D Program



A. Regulatory Requirements and Technical Standards

Current regulatory requirements for the safety analysis of CANDU system are given as C-series and R-series, such as C-6, R-7, R-8, R-9, and R-10, etc. Consultative document C-6 describes the requirements for the safety analysis of CANDU plants. Some of the requirements are not clearly defined and described in detail compared with the U.S. regulatory requirements so that it is often difficult to apply for these as regulatory guidelines. Moreover, there is not the

regulatory guide such as *ECCS Evaluation Models* (10 CFR 50 Appendix K of US NRC), to confirm the validation and verification of the computer codes used in the accident analysis including performance of ECCS in Canadian regulatory system.

Despite the different national approaches to nuclear regulation, it should be possible to identify some basic principles of regulatory effectiveness and to develop methods of evaluating or measuring it. However, it is not an easy task, but the degree of difficulty inherent in this task should not discourage us from attempting to meet the challenge to regulation for CANDUs.

These days, it is worldwide trend to make the regulatory requirements clear and well-defined and well-documented. And also from the Public Acceptance point of view, the general public in Korea asks for a regulation according to the prescriptive requirements. To reflect these modern circumstances, KINS will provide for more explicit regulation of CANDU NPPs in Korea. Among other improvements, the KINS will have a clearer mandate to establish and enforce national standards for CANDUs in the areas of health, safety and the environment.

In Korea, we are now in the midst of developing a completely new set of regulations and other regulatory documents that will clearly spell out what our requirements are. We believe that clear and comprehensive documentation of regulatory requirements is essential to providing for more effective regulation of the CANDUs.

We have also expanded our efforts to develop new guidance documents needed to accompany the regulations. The guidance documents further define our expectations for specific aspects of nuclear operations, and are being developed in consultation with out-resources. Therefore, it would be an important task to establish a regulatory framework, which can be applied to the regulation of CANDU plants.

B. Regulatory Inspection Manuals

Although CANDU has its own operational characteristics like on-power refueling, regulatory periodic inspection requirement is applied to this reactor type just the same way as to PWRs. While the periodic inspection for a PWR has been conducted during its refueling outage, for a CANDU, the whole plant should be shutdown to receive its inspection as well as to perform the periodic test and maintenance. Currently, a 20-month inspection period is being applied to both PWRs and CANDUs without any difficulty. Standard inspection items for CANDUs were also established based on PWR's format. However, the inspection manual for Wolsong Unit 1, developed by 1985, 15 years ago, has a need to be updated and revised with reflecting current regulatory technology and methodologies. Safety requirements and plant & system technology have changed much since the manuals were first developed, and the application of new technology to old plants is a necessary and challenging task.

Besides the safety review activities, the pre-operational inspection was performed to verify whether the nuclear facility, which has been given the CP, is constructed properly in accordance with the CP conditions and also to verify that the constructed facility demonstrates its function according to design requirements. After the plant construction work and functional tests met the relevant requirements at each phase, the initial fuel loading and power operation commenced.

To develop and sustain effective regulatory inspection manual, clear and comprehensive documentation for regulatory activities is essential to provide for more effective regulation. In this regard, KINS recognizes the need to perform compliance activities in a more transparent, systematic and consistent way. Therefore, we are now in the process of updating and revising the periodic inspection manual for CANDU NPPs, which will apply to all operating Wolsong NPPs.

C. Performance Indicators

Many operating organizations, regulatory bodies, and international organizations have developed and used performance indicators for the quantitative assessment of NPP operation. The

performance indicators (PIs) can be used to monitor and to gain perspective on performance and progress of a nuclear power plant. The PIs also provide an indication of the possible need to adjust priorities and resources to achieve improved performance.

The importance and usefulness of performance indicators were recognized also in Korea. KINS is recognized the need to look more closely at operational management issues, as well as the conventional safety issues, when assessing a licensee's performance. In this regard, the PIs for NPPs were developed through a government-funded project in 1997 by KINS with the cooperation of the Korea Electric Power Corporation (KEPCO).

The PIs, currently used after one-year trial application and modification, are composed of 8 indicators for PWR plants. As for the PI for CANDU reactors, it is under development because CANDU reactors have different characteristics with PWRs and relatively less operating experience than PWRs. The project for development of CANDU PIs will be completed in the end of 2001. The KINS is currently attempting to develop indicators to measure our performance in terms of the volume, quality and level of service we provide. We would also like to develop indicators that will measure the overall impact of our activities in terms of improving the safety of nuclear operations. This is more challenging, because it is often difficult to attribute good industry performance to the actions of the regulator. We need to develop a new set of skills and assessment tools to measure how well a facility is being managed or will be managed in the future.

D. Safety Review Guides

The Standard Review Plan (SRP), which was developed by U.S. NRC, is one of measure to enhance regulatory effectiveness since it is the guidance of regulators for reviewing safety of licensing applications to construct or operate nuclear power plants. The principal purpose of the SRP is to assure the quality and uniformity of staff reviews and to present a well-defined base from which to evaluate proposed changes in the scope and requirements of review. It is also a purpose of the SRP to make information about regulatory matters widely available and to improve communication and understanding of the staff review process by interested members of the public and the nuclear power industry.

It is important that the regulator not only be effective, but also be seen to be effective and credible by all stakeholders such as the industry, the government and the public. This means that a high level of intrusion by the regulator can be a sign that regulatory requirements are not being met or are not well understood.

In such case, the regulator may be perceived as not being effective. Moreover, the unprejudiced and consistent regulation is heavily influenced by the regulator's ability to review the safety of the NPPs effectively and efficiently.

Because there is no sufficient information on Canadian regulatory system, it is not easy to assure the qualified regulatory review being performed based on the well-defined procedures and it will take much time and effort to prepare the SRP for CANDU plants

Nevertheless, the KINS is recognizing the need to develop the Safety Review Guide (SRG) for CANDU NPPs, which will be similar to the U.S. SRP, to enhance reviewing process to licensing applications as well as to implement a more transparent decision-making process. It is also essential to create a common understanding of safety objectives and regulatory requirements, so that the regulator must be seen as being fair. The general procedure for developing CANDU SRGs is shown in Figure 2.

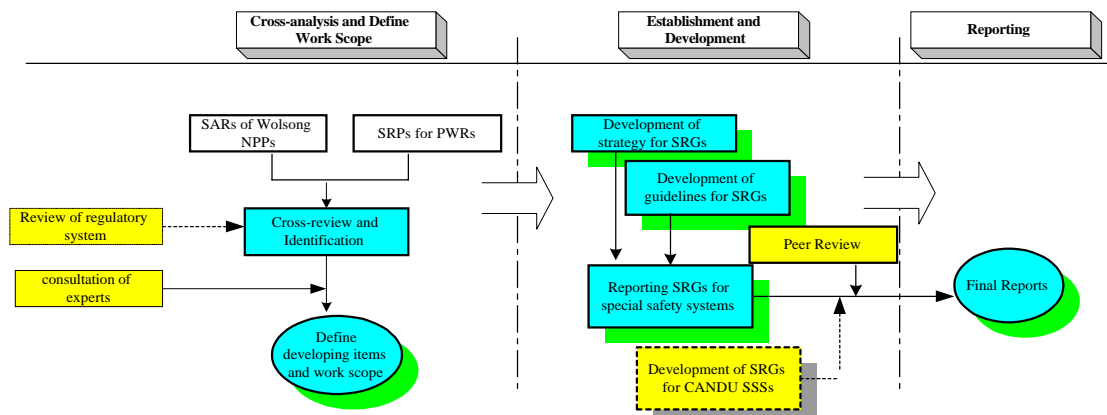


Figure 2 General procedure for developing CANDU SRGs

3. CONCLUDING REMARKS

Korea has made remarkable achievements in the development, construction and operation of nuclear power plants in a relatively short period of time, employing a two-reactor strategy in which PWR played a principle role and CANDU a supplementary role. This two-reactor strategy has been working quite well and the operational performance of these reactors has been excellent. Their combined unit capacity factor has been much higher than the world average.

However, as the operational safety of CANDU NPPs is getting emphasized in the nation, there have been concerns expressed about the need to complement and stipulate the nuclear regulatory requirements for CANDU NPPs. KINS has launched a new mid- and long-term R&D program, which consists of four (4) sub-programs with an aim to develop and improve regulatory infrastructure such as legal system, generic regulatory requirements and technical standards for CANDUs. The regulatory research programs for CANDUs are currently in progress since last August and will continue to March 2002. KINS will strengthen its international cooperation activities with CNSC and AECL particularly in its area of joint researches with an aim to cooperate and exchange its regulatory expertise in the future. It is being undertaking not only to develop a comprehensive regulatory requirements that covers all aspects of nuclear facilities, but also to streamlining the regulatory regime, minimizing the regulatory burden and reducing administrative costs to the degree possible in terms of regulation of both PWRs and CANDUs. These efforts have been conducted to harmonize the Canadian regulations with these of the Korea by establishing national regulatory positions and guidelines. It will demonstrate how to operate two different types of reactors successfully and safely using PWR and CANDU as complementary technologies.

It is expected that Korean approach to and experience with both PWR and CANDU will provide a valuable lesson and advise to other countries considering a similar nuclear development strategy.

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