Canadian Experience in Implementing Modern Regulations on Existing Research Reactors

Abdul Alwani
Canadian Nuclear Safety Commission, Ottawa, Canada
E-mail: abdul.alwani@cnsc-ccsn.gc.ca

Abstract. The nuclear Regulations in Canada have undergone major changes since the turn of the century. Canada has eight operating research reactors with decades of safe operation and good safety and regulatory performance. Achieving compliance with the new requirements and modern standards has required considerable efforts from both the Canadian research reactor licensees and the Canadian Nuclear Safety Commission [1] (the regulator). This paper describes this experience and highlights the challenges and the approach used to successfully resolve them.

1. INTRODUCTION

1.1. The Regulatory Body

The nuclear energy, applications and industry in Canada are regulated by the Canadian Nuclear Safety Commission (CNSC). The CNSC is an independent agency of the Government of Canada. It reports to the Canadian Parliament through the Minister of Natural Resources and operates in a transparent manner. The mandate of the CNSC is to regulate the development, production and use of nuclear energy, nuclear substances, prescribed equipment, and prescribed information, in order to prevent unreasonable risk to the environment and to the health and safety of persons; prevent unreasonable risk to national security; and achieve conformity with measures of control and international obligations to which Canada has agreed.

The CNSC is composed of two independent organizations: the Commission, which is a quasi-judicial administrative tribunal, and the staff, which forms the regulatory agency.

The Commission makes licensing decisions for major nuclear facilities, including power reactors, research reactors, high-energy accelerators, uranium mines and waste facilities. As part of this process, the Commission is required to hold public hearings that provide opportunities for the applicants and interveners to be heard, and are open to public participation.

CNSC staff provides advice and recommendations to the Commission by assessing applications related to licensing. CNSC staff is also responsible for monitoring and promoting compliance with the regulatory and safety requirements. To that purpose, CNSC staff conducts inspections, audits, investigations and reviews at the licensed facilities and anywhere in the country subject to the nuclear Regulations.

1.2. The Research Reactors

Canada has a long history with research reactors. The first research reactor in Canada, ZEEP (or Zero Energy Experimental Pile) reactor was first operated in September 1945. It was a heavy water and graphite critical assembly. Shortly after, in 1947, the 42 megawatt thermal energy research reactor, called NRX started operation in Chalk River Laboratories in Ontario. This reactor operated for almost 47 years until its retirement. Four additional research reactors were built in the fifties; three of them are still in operation with a full productive life until today.

In the seventies, Atomic Energy Canada Limited, the Canadian Crown Corporation for research and development in nuclear energy and science, launched its small versatile and ultra safe research reactor for universities branded SLOWPOKE (or Safe Low-Power Kritical Experiment). SLOWPOKE reactors are 20 kilowatt low-energy, pool type nuclear research reactors. The SLOWPOKE reactor is beryllium-reflected with a very low critical mass, but provides neutron fluxes higher than available from a small particle accelerator or other radioactive sources.

The newest non-power reactors in Canada are the twin MAPLE reactors. MAPLE stands for Multipurpose Applied Physics Lattice Experiment and theses reactors are dedicated pool type reactors for medical isotope production. The thermal energy of a MAPLE reactor is 10 megawatts. Currently, both reactors are being commissioned.

There are currently eight research reactors licensed to operate and in operation in Canada. Five of them are SLOWPOKEs. They are located at university and college campuses in five provinces. They continue to prove that they are useful teaching tools and also sources of neutrons for activation analyses. In one case, a neutron radiography facility was fitted into the reactor setting. The SLOWPOKEs are inherently safe due to the design feature of a strong negative reactivity feedback which makes it impossible for an operator error to produce a criticality event.

The National Research Universal reactor, commonly known as NRU, is the largest reactor in the non-power category in Canada. The NRU reactor has a thermal power of 135 megawatts. It is a heavy water cooled and moderated tank reactor with Low Enriched Uranium fuel. NRU reactor is one of the world's largest sources of radioisotopes and, in the case of molybdenum 99, it is the world's largest source of production. In addition to radioisotope production, the NRU reactor covers the whole range of research reactor applications including physical neutron beam experiments and material testing. The reactor includes a number of high pressure and high temperature light water testing loops. They are mainly used for research and development in support of power reactor programs. NRU has been in operation since 1957 and now, after fifty years of operation, it is as indispensable as it has always been for the nuclear R&D and the radioisotope production.

Another major research reactor in Canada which continues to operate after almost five decades is the McMaster University Nuclear Research Reactor (MNR). The MNR went critical in 1959. It is located at the McMaster University campus in Hamilton, Ontario. The MNR is a pool type light water reactor fuelled with Low Enriched Uranium (LEU) material testing fuel. Like the NRU reactor, MNR started operation with Highly Enriched Uranium but later converted to LEU fuel. The MNR has 5 megawatts thermal power and has a variety of uses. In addition to education purposes, it is a source of neutron beams mainly used for neutron radiography. Also, the reactor is used for radioiodine production and neutron activation analysis.

Finally, the lowest power research reactor in operation in Canada is ZED-2 (or Zero Energy Deuterium). It is a 200-watts heavy water moderated tank type reactor which went critical in 1960. The reactor in located at Chalk River along with the NRU and the MAPLE reactors and it is used for reactor physics research.

2. NEW ACT WITH NEW CENTURY

Since its inception in 1946, the CNSC, then called the Atomic Energy Control Board (AECB), has been governed by the *Atomic Energy Control Act*. In the mid nineties, the need for a revised legislation became apparent and the work accelerated to promulgate a new Act (The *Nuclear Safety and Control Act* [NSCA]) [2]. The new Act addressed shortcomings in the old Act and provided more clear instruments to the regulatory body to exercise its mandate. Also, the NSCA made a number of changes to the way the Commission conducts its business.

The NSCA came into force in May 2000. The most obvious change was the name change from AECB to CNSC. The new Act provides for more explicit and effective regulation of nuclear activities. It ensures high standards in the areas of health, safety, security and protection of the environment, sustaining our environment and for ensuring a modern regulatory regime to meet the needs of the 21st century.

The NSCA reflects the independence of the regulator from the influence of the industry, government and stakeholders. With the new Act, the promotion of nuclear energy is no longer part of the mandate of the Commission. Also, the NSCA emphasizes the requirement on the regulator to be more transparent and to allow public input into the licensing process. The new licensing process mandates that the Commission holds public hearings when making licensing decisions and allows public interventions.

As for the Regulations pursuant to the Act, the Commission issued 13 Regulations with specific requirements tailored to the specific types of nuclear facilities and materials. This was far more detailed than what it used to be which was essentially under one Regulation with the old Act. Many requirements in the current Regulations are not new to the CNSC licensees but merely written now in the Regulations as opposed to requirements stated in the licences issued for the facilities.

Furthermore, several requirements have been introduced following the new Act. This was not necessarily because of the Act, but due to the natural evolution of the regulatory standards which was enabled by the new statute which gives the Commission certain additional powers. For instance, with the new regulatory instruments the CNSC has clear jurisdiction over looking into the management and organizational structures of the applicants to determine their qualification to operate or build nuclear facilities.

The emphasis on safe decommissioning of nuclear facilities was reflected in the explicit requirement under the NSCA for a licence to decommission or abandon a nuclear facility. In fact, now, an applicant for a licence for a new nuclear facility is required to provide a preliminary decommissioning plan for its proposed facility in order to be issued a construction licence. The Commission may also require financial guarantees to ensure that the nuclear facility will be funded for decommissioning if the operating organization is no longer in business or in capacity to do so.

Another aspect of the current regulatory regime which has not originated from the new Act is another Act called the *Canadian Environmental Assessment Act* [3]. This Act requires all federal departments and all federal government decisions, which may have an impact on the environment, to be assessed beforehand to ensure that the decision is safe for the environment before proceeding. The Commission's decisions with regard to licensing construction, operation, or decommissioning a nuclear facility for instance fall under this category. CEAA compliance may require the Commission to invoke public consultations and intergovernmental panels depending on the scale of the facility or proposal subject to the decision and its potential impact.

The most important and probably visible change to the CNSC licensing and compliance practices in the last decade is the gradual shift of attention to programs rather than activities. With the quality management system (QMS) becoming a regulatory requirement for all large-scale licensees, it is no longer sufficient to ascertain that the licensee is conducting the required activities, be it radiation protection, environment monitoring, etc. The licensee is expected to have programs in place to ensure that these activities are done and continue to be done according to a defined manner. Non-conformance with the specified manner would be detected and corrected by the licensee through the provisions of self-monitoring in the program.

Other examples of such focus areas are training, criticality safety, and fire protection. These aspects have always been subject to continuous regulatory oversight. However, the CNSC now expects the research reactor licensees to have formalized documented programs in place to address these aspects. Several regulatory guidance and standard documents have been published since 2000. They provide recommended or approved methods to formalize the safety area programs.

3. CHALLENGES TO CHANGE

The evolution of the regulatory approach, process and expectations presented a number of challenges to the regulatory agency and the licensees' community alike. Some of these challenges were specific to the existing research reactors. These facilities have long safety track records and established reputations. Below is a highlight of some of these challenges:

3.1. Size Appropriate

Many new requirements for regulatory compliance programs at the licensed facilities have been drawn up with large-scale organizations in mind. Research reactors, in general, have fairly modest and sometimes small organizations. Following a typical model for instance for resourcing a particular program without tailoring it to the size of the organization and its needs would risk imposing requirements for unnecessary resources on the operating organization.

3.2. Diversity of Applications

The CNSC guidelines for training programs, quality management systems, fire protection programs, as well as other programs are more performance based than prescriptive. In general, the requirements state the high-level expectations. Difficulties may arise during the implementation and the interpretation of certain high-level requirements. With the wide range of activities and facilities regulated by the CNSC, it is not feasible to establish customized standards for each and every application. The burden here is on the specific assessment by the CNSC staff and the communication with the licensees to arrive at reasonable interpretations of the high-level requirements to establish the minimum sufficient and necessary for a particular application.

3.3. "Why Program?"

The CNSC has recognized for quite sometime now that a cultural change is required in an organization in order to buy into the program requirements and quality management systems in general. This is not a reflection of a negative attitude toward safety or to regulation by a particular licensee, but in fact is fully justified knowing that resistance to change is a normal phenomenon and the benefits from improvements to the QMS are not transparent or immediate, nor should they be. It takes a while to feel the positive results of enhancement to oversight programs as opposed to fixing a specific problem or equipment.

3.4. Human Aspects

Under the new regulatory regime, there is more emphasis than before on the areas of human performance whether at the level of operators or management. Among the programs the CNSC expects to be in place with various degrees of rigor is training program, quality management program and incident investigation program. Organizational structure is reviewed by CNSC staff as part of its oversight. In addition, human machine interface (or human factors engineering) aspects need to be assessed and accepted when licensing new projects or modifications.

In many respects, these areas of interest are new to the licensees who are unlikely to have subject mater experts in these fields already on board in their operating organizations. Operators and engineers may see these areas as non-technical and of lower importance to the safety of their facilities. Even with the licensees acquiring such additions to their team, it is important to integrate the "technical" and "human" perspectives within the licensee team.

3.5. Ageing vs. Maturity

The operating research reactors in Canada have between 30 and 50 years of operating experience with excellent track records. No major incidents or injuries have resulted from their operation. Also, the doses to staff and public and radioactive releases from these facilities have always been low and within the expected ranges. History wise these facilities are safe and mature. Hence, in some respects, increased regulatory demands may not seem fully justified especially in the eyes of the licensee.

On the equipment side, the research reactor licensees recognize the impact on their facility due to ageing of structures, systems and components. Handling ageing issues is a continuing work and is being performed successfully in general. Examples of ageing problems are leak tightness of old concrete structures for water bodies; upgrades to radiation monitoring systems; and replacement of control system components.

On the safety analysis and safety case side, the CNSC required its licensees to update their safety analysis reports. This is a licence requirement which is to keep the safety documentation up-to-date. There is some understandable reluctance to open the file of safety justification of a facility after decades after its approval. The CNSC demands and promotes the use of the most modern approaches and tools to revisit the safety case of the existing facilities at a reasonably regular interval. This is to further understand the system behaviours in case of accidents and to reconfirm results of analysis done decades ago using less advanced tools.

3.6. Eliminating any Gaps, Conventional Safety

Under the federal / provincial jurisdiction system in Canada, nuclear facilities are federally regulated. Meanwhile, several types of conventional hazard such as fire protection, and electrical safety in addition to workers compensation are normally not. The law declares nuclear facilities subject to federal laws. Human Resources and Social Development Canada is the federal department responsible for conventional occupational health and safety. There is however an overlap in certain areas where the conventional hazards are related to a nuclear facility. To eliminate any potential gap in the regulatory system the CNSC has upgraded a number of its regulatory oversight programs. This is to be able to ensure that these areas are covered and the CNSC works closely with other federal and provincial departments and agencies in the areas of the environment, occupational health and safety, environmental assessments, and emergency preparedness.

3.7. To Upgrade or Not to Upgrade

The increased regulatory expectations mentioned above and the evolution of technology and safety standards add financial and manpower costs to the operation of the research reactor facilities. Meanwhile, for most of the operating research reactors, it is not clear that there is room for an increase of expenditures. All these facilities are non-profit facilities as well as being publicly owned. The CNSC views that upgrading the research reactor safety programs and safety infrastructures is not an option but a necessity. The operating budget for a research reactor facility should have a component covering the continuous upgrade. The facility owners should not ask the question whether to upgrade or not, but whether to upgrade or replace their facilities. The cost of “regulatory” upgrade on the top of the cost of “basic” operation may seem high to the facility owners. However, the proper comparison should be between the cost of the “regulatory” upgrade and the cost of building a new facility and decommissioning the existing one.

4. CNSC APPROACH

Facing the challenges of applying new regulatory requirements to existing research reactor facilities, the CNSC adopted what proved to be an effective and reasonable approach. This approach can be characterized by the following:

4.1. Bottom Line is Risk

The ultimate goal for the regulatory activities is to reduce the risk from the licensed facilities to the worker, public and environment. The interpretation of the overall requirements and the scrutiny on the various programs is guided by the risk argument.

CNSC staff has developed a practical risk ranking system listing various facilities licensed by the CNSC and analyzing them according to five factors. These five technical risk areas are defined as Operating Organization, Facility Design and Condition, Emergency Preparedness, On-Site Personnel

Protection, and Environmental Protection. Each area is given a ranking based on a set of criteria for that risk area. After all areas are assessed, the overall risk level for the facility can be determined. The overall level of risk at a facility will provide the rationale for the regulatory effort assigned for that facility during its licensing term.

Using this technique helped CNSC staff prioritize their efforts as well, and demonstrated to the licensees the appropriateness of the CNSC requirements. Also, this technique allowed the customization of certain requirements and the use of a graded approach to alleviate any unnecessary requirements.

4.2. Transitional Periods

The CNSC recognizes the need for transitional periods for rolling in and implementing the various new requirements. Transitional periods for full compliance with each requirement are imposed after careful assessment of the priority and feasibility of the required action. This is to ensure that the upgrade to the current standard is done within a reasonable time frame and also effectively.

The upgraded requirements are improvements which are not driven by a discovery of negative findings for instance, which would point to a hazardous situation. The upgraded requirements reflect the evolution of the industry, the Regulations and the safety knowledge.

Obviously, a risk reduction is sought from the new requirements; otherwise, there would not be a justification for them. However, the length of time allowed to phase in the new requirements is subject to the discussions between the licensee and the CNSC to ensure that the licensee has been given reasonable time that it needs and the “time at risk” is acceptable.

4.3. Compliance Promotion through Communication

As expected in any change, there is a need to communicate fully with the licensees and provide the rationale for each new requirement. The notion that an issuance of a new requirement by the CNSC does not mean that what was safe yesterday is not safe today, is explained fully to the licensees. All is aimed toward a common goal of ensuring that the Canadian workers, public and environment are protected from undue risk from research reactors by adopting the best safety standards.

The CNSC compliance strategy includes promotion as one of the three pillars of the program. The other two are compliance verification and compliance enforcement. While verification and enforcement activities tend to be very objective and focused on the factual and physical evidence, the promotion aspect of compliance activities focuses on the people, the licensee management and workers as well as the stakeholders. The time and efforts spent on discussions, information meetings, and exploration of views with the licensees and stakeholders are time and efforts well spent. Often, the CNSC finds out that more cooperation and consequently adherence to the requirements is achieved when adequate promotion activities have been performed.

5. CONCLUSION

While the licensing regime for nuclear facilities, including research reactors, continues with the new Act, several changes occurred to the regulatory requirements and the process. Both the licensee and the regulator made particular efforts to face the challenges of defining the implications of the new requirements, managing the expectations, and bringing the licensed activities up to compliance with the new standards.

ACKNOWLEDGEMENTS

The author would like to acknowledge the valuable reviews from staff and management in the

Directorate of Nuclear Cycle and Facilities Regulations of the CNSC and in particular Mr. Barclay D. Howden.

REFERENCES

[1] CANADIAN NUCLEAR SAFETY COMMISSION, Nuclear Safety in Canada, CNSC Cat. No. INFO-0749, Catalogue number CC172-25/2004E, ISBN 0-662-37660-9.
[2] STATUTES OF CANADA, *Nuclear Safety and Control Act*, 1997, c. 9.
[3] STATUTES OF CANADA, *Canadian Environmental Assessment Act*, 1992, c. 37.