IMPLEMENTATION OF A NUCLEAR CRITICALITY SAFETY PROGRAM AT AECL

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Abstract

Atomic Energy of Canada Limited (AECL) operates two major licensed sites, Chalk River Laboratories (CRL) and Whiteshell Laboratories (WL), where for several decades a number of diverse activities involving fissile materials have been carried out in support of research and development, commercial activities and to produce medical radioisotopes. AECL established controls to ensure that these activities were carried out safely. Recently, specific Nuclear Criticality Safety conditions were included in the CRL and WL site licences. These conditions include a requirement to develop and implement a Nuclear Criticality Safety Program that meets various requirements set by the Canadian Nuclear Safety Commission.

1. Introduction

Chalk River Laboratories (CRL) is an Atomic Energy of Canada Limited (AECL) site located about 200 km northwest of Ottawa, Ontario, on the Ottawa River. The site features a diverse collection of facilities including nuclear research reactors, several hot cell facilities, fuel fabrication and processing facilities, various labs, waste management areas, and various storage facilities for fissionable materials. These facilities, many of which have been operating for several decades, are used to carry out research and development, support various commercial activities, and produce medical radioisotopes.

Whiteshell Laboratories (WL) is an AECL site located about 150 km east of Winnipeg, Manitoba. The site features a collection of facilities, most of which are in the process of being decommissioned, although some, such as the waste management areas, continue to be operational. Prior to this decommissioning work, the WL site featured an operating research reactor, a large number of hot cells, and many labs supporting nuclear research and development.

The activities carried out in the CRL and WL facilities involve fissionable materials with various chemical and physical forms, including both irradiated or unirradiated material with a large range of fissile enrichments. During storage and handling of these materials outside of a reactor core or reactor fuelling process, the quantities of fissile materials present may require that specific controls be established and maintained to prevent accidental nuclear criticality. This is the goal of nuclear criticality safety.

The renewed licences for these two sites include new conditions specific to nuclear criticality safety. This has resulted in a change to the way nuclear criticality safety is managed, including the development of a Nuclear Criticality Safety (NCS) Program. A transition is taking place from the existing requirements and processes to new ones still being developed by the NCS Program. As might be expected, there have been some challenges during this transition.

2. Nuclear criticality safety at AECL prior to the new licence requirements

AECL has had operating sites for several decades. During this time, activities have been carried out with fissile materials in quantities that have made it necessary to put in place requirements and processes to ensure nuclear criticality safety. As Nuclear Criticality Safety has not historically been governed by specific regulations, AECL established a set of nuclear criticality safety requirements as well as independent oversight to ensure that activities involving fissile materials were carried out safely. Considerable knowledge and experience with nuclear criticality safety has been gained during these many years.

Criticality Safety Documents (CSD) were prepared by the areas in which activities involving fissile materials were being carried out. These documents had three parts. The first part listed the limits and restrictions for the area(s) in which the fissile material would be handled, stored, or processed. The second part described the activities involving the fissile materials that were to be carried out. The third part provided a summary of the nuclear criticality safety analysis (the detailed analysis is documented in a report that is prepared and filed in the AECL documentation management system) that was carried out by the nuclear criticality safety analyst (generally a physicist trained in the use of special codes that are used to assess activities and determine appropriate limits and restrictions as well as calculate k-effective). Once prepared, CSDs were submitted to AECL's Nuclear Criticality Safety Panel (NCSP) for review and approval.

2.1 Nuclear Criticality Safety Panel

AECL has had an independent group in place for many years whose responsibility is to perform independent internal review to the breadth and depth necessary to ensure that proposed and existing facilities or activities are acceptable with respect to the health and safety of persons and the protection of the environment. The group charged with this responsibility at present is the AECL Safety Review Committee (SRC).

The Nuclear Criticality Safety Panel (NCS Panel), a sub-committee of the SRC, has the role to review, and if found satisfactory, approve CSDs for activities involving fissile material, with the exception of those fissile materials within a reactor core or its fuelling machines.

3. Current licence conditions

3.1 CRL site

While AECL had set up what they believed to be a comprehensive process with specific requirements and procedures, the CNSC initiated discussions on the need to ensure that the nuclear criticality safety process at AECL followed established standards.

Before Licence renewal began, the CNSC outlined its intent to include specific nuclear criticality safety requirements in the CRL Site Operating Licence, which was set to expire in the summer of 2006. These discussions culminated in the inclusion of four nuclear criticality safety conditions in the CRL Licence, as summarized below. AECL also brought Mr. T. McLaughlin, Chairman, ANSI/ANS-8 Committee to CRL to assess the present processes and offer advice on nuclear criticality safety practices.

3.1.1 CRL Licence condition 14.1

CRL Site Licence condition 14.1 requires that AECL ensure that operations involving fissile materials outside reactors be carried out such that the Upper Subcritical Limits (USL) established in the CSD will not be exceeded under both normal and credible abnormal conditions. USL is a term used to define the maximum allowed value of either the k-effective or single parameter value that ensures that both under normal and credible abnormal conditions, including allowance for bias, uncertainty and a minimum margin of subcriticality, that systems assessed to be subcritical actually are subcritical.

3.1.2 CRL Licence condition 14.2

CRL Site Licence condition 14.2 requires that AECL develop, and submit for approval, Nuclear Criticality Safety Program(s) that conform to applicable requirements of a specific list of ANSI/ANS-8 standards (listed, with specific revision numbers, in the CRL licence), as well as other additional requirements, including the establishment of an adequate margin of subcriticality (complete with requirements for the methods used), the need to maintain this margin of subcriticality under all normal and credible abnormal conditions (including a definition of credible abnormal and what is deemed to be an acceptable method for demonstrating the defined frequency), and the need to demonstrate that adequate mitigation measures are in place so that off-site consequences of a criticality accident do not trigger a public evacuation.

3.1.3 CRL Licence condition 14.3

CRL Site Licence condition 14.3 requires that AECL develop and submit for approval by the Commission or a person authorized by the Commission, the schedule for implementation, including updates of the CSDs.

3.1.4 CRL Licence condition 14.4

CRL Site Licence condition 14.4 states that AECL may implement the requirements of condition 14.2 on a risk-graded approach. The CNSC recognized that there were a large number of areas in which the requirements would need to be implemented, and thus included this clause, which allowed for the implementation to take place over a period of time, starting with the areas considered to have the greatest hazard.

3.2 WL site

The renewed WL Site Decommissioning Licence was issued in 2009 January and included nuclear criticality safety conditions, as summarized below.

3.2.1 WL Licence condition 15.1

WL Licence Condition 15.1 states that AECL shall implement and maintain an authorized NCS Program, such that the Upper Subcritical Limits established by the program will not be exceeded under both normal and credible abnormal conditions of operations with fissile materials outside reactors.

3.2.2 WL Licence Condition 15.2

WL Licence Condition 15.2 states that AECL shall implement the NCS Program, including updates of the CSDs on a risk-graded approach starting with high priority activities, before 2011 December.

4. Meeting these new licence conditions

4.1 Establishing the program

4.1.1 Assembling a team for the Program

AECL established a new nuclear program entitled, the Nuclear Criticality Safety Program. The new Program provides an operational framework for the prevention and mitigation of nuclear criticality accidents at CRL by conforming to all applicable regulatory requirements, company policies and procedures. It was determined that the same Program would be implemented at WL to satisfy the WL Licence conditions.

4.1.2 Understanding of the requirements

Once the team was assembled, it was necessary to develop a thorough understanding of the requirements, not only within the Program itself but also among the numerous and diverse groups within AECL. The new Licence conditions for both sites featured some requirements that were already being addressed within the present nuclear criticality safety processes, as well as other new requirements. The strategy developed was simple: put in place a Program and corresponding procedures that not only meet the new Licence conditions, but do so in a manner that makes the process of nuclear criticality safety easy to follow. Some key areas were identified to which specific attention would be given:

- Processes and procedures;
- Communication
- Documentation management;
- Training; and
- Awareness of Nuclear Criticality Safety.

4.1.3 Identifying areas of improvement

An early assessment of the NCS Program identified the following areas for improvement:

- Calculating the frequency of occurrence of abnormal events for nuclear criticality safety for AECL facilities;
- Standardizing of processes and procedures relating to Nuclear Criticality Safety;
- Establishing clear acceptance criteria for required documents and processes.
- Understanding of the present processes to be followed, and in some cases about nuclear criticality safety in general;
- Increasing in service provider resources;
- Planning of activities that are in support of nuclear criticality safety;
- Availability of documentation;

- Updating training requirements
- Regular assessment of facilities to determine areas where improvements related to nuclear criticality safety could be identified and implemented;
- Awareness of nuclear criticality safety among all personnel at AECL;
- Developing an AECL internal working group for Nuclear Criticality Safety, and also formation of an industry working group to benchmark nuclear criticality safety practices; and
- Making the existing nuclear criticality safety processes easy and efficient.

4.1.4 Preparing the team.

Many of the NCS Program staff had not been involved with nuclear criticality safety at AECL, so there was a need for training to ensure that they had a solid understanding of nuclear criticality safety. This was and continues to be done in a variety of ways:

- Training courses on nuclear criticality safety were limited, however Program staff were sent to those that were available such as courses at the University of New Mexico;
- Program staff began to attend American Nuclear Society (ANS) meetings and have become involved with some of the working groups on the ANS-8 standards. This provides them the opportunity to interact with subject matter experts to learn about other areas related to nuclear criticality safety;
- Working groups were also formed, one within AECL, and a second within the Canadian industry, to provide Program staff with the opportunity to learn about nuclear criticality safety at AECL, as well as in the rest of Canada; and
- A working relationship between AECL and the CNSC staff was established to ensure that requirements were met as per the licence conditions.

4.1.5 Establishing roles and responsibilities

Roles and responsibilities were included in the NCS Program governing documentation. As these roles and responsibilities evolve, updates to these documents will be carried out.

4.1.6 Developing Program documentation

In order to comply CRL Site Licence condition 14.2, AECL personnel drafted the initial version of the NCS Program document, known then as the "Nuclear Criticality Safety Program Manual". This document has since gone through several revisions to incorporate comments received from both AECL oversight groups as well as the CNSC.

As the result of CNSC comments, the Program Manual was split into two documents, one that lists only the Licence Requirements, and the other, an operational document that describes how AECL plans to meet the requirements and references AECL processes and procedures. The former would be eventually referenced in the CRL and WL Licences, which require that it not contain any references to specific AECL processes or procedures.

An initial schedule for implementation was prepared that provided an estimate of the dates by which the new Program will be implemented. Updates to that schedule will continue to be sent to the CNSC on an annual basis.

4.2 Maintaining the Program

To maintain the Program, the following activities are either underway, or are planned:

- Establish a long-term plan;
- Establish services needed; and
- Develop a strategy to ensure that the new Program is effectively communicated to AECL staff.

4.2.1 Establishing a long-term plan

The implementation of the NCS Program is expected to take several years, so a long-term plan was needed that took into consideration actions, anticipated changes and other factors coming from within AECL.

A five-year plan will be established by mid-2009 for the NCS Program. It, along with an action management process will be used to ensure that Program staff, management and service providers remain aware of what is needed for both the short term and long-term.

4.2.2 Establishing services needed

4.2.2.1 Probabilistic safety assessment

One of the new licence conditions required the creation of a process to determine event and event sequence frequency related to nuclear criticality safety. Initially it was determined that a probabilistic safety assessment-type process would be used. While this type of assessment had been used at AECL in the past in other areas, such assessments had never been used for nuclear criticality safety before.

To date, a procedure has been issued for this probabilistic safety assessment-type process. It is presently being tested and adjustments will be made to the process and procedure as necessary.

4.2.2.2 Nuclear criticality safety analysis

Nuclear criticality safety analyses have been carried out for several years by a defined group, however there was no standardized procedure for it.

To date, a procedure has been issued and a test of the new procedure is being carried out and adjustments will be made as necessary.

4.2.2.3 Preparation of the Criticality Safety Document

It was agreed that CSDs would continue to be used, however they all needed to be revised to incorporate the new requirements. It was noted that these revisions are the responsibility of the individual facilities, and that this could be a challenge for most facilities since they may not have the expertise required.

In order ensure that the CSDs are prepared in a consistent and high quality manner, a CSD template, and two procedures (one for revising existing criticality safety documents, and the other for creating new criticality safety documents) have been issued to replace the general guidelines for preparing a

CSD that had been available previously. Tests of the new template and procedures are being carried out and adjustments will be made as necessary.

4.2.3 Developing a strategy to ensure that the new Program is effectively communicated to AECL employees

Nuclear criticality safety is an area that needed to be communicated effectively across AECL. The Program is determined to ensure that the awareness of nuclear criticality safety is raised with special attention drawn to the new Licence conditions.

The development of materials and the awareness sessions themselves are planned for later in 2009.

4.3 Working with the Nuclear Criticality Safety Panel

The sole source for nuclear criticality safety requirements had been the Safety Review Committee (SRC) documents, and oversight had been provided by their subcommittee, the Nuclear Criticality Safety Panel (NCSP). The NCSP consists of a collection of AECL personnel representing various disciplines and having knowledge and experience in various areas pertinent to nuclear criticality safety. Their role is to carry out technical reviews of submissions (generally in the form of CSDs) from areas in which activities involving fissile materials are carried out, and when satisfied, approve these submissions. These approvals must be obtained before work outlined in these submissions is carried out.

With the introduction of new Licence Conditions at CRL and WL, and the formation of the NCS Program, the requirements changed, making it necessary to re-visit the SRC documents and the roles and responsibilities of the NCSP as they pertain to nuclear criticality safety.

To date, meetings have been held with the NCSP and roles and responsibilities have been discussed. While it was agreed that a number of the more administrative functions that had been carried out by the NCSP would now be taken over by the NCS Program, it was agreed that the independent oversight function provided by the NCSP would be retained as one of the roles of the NCSP, as it was agreed that it plays a vital part of nuclear criticality safety for AECL.

Revisions to NCS Program and SRC documents is underway and communication of these revised roles and responsibilities for both the NCSP and the Program will be included as part of the NCS Program awareness sessions.

5. Moving Forward

As noted previously, the implementation of the NCS Program at AECL is expected to take several years to fully implement. The significant activities planned for the NCS Program include:

- Testing of the procedures issued under the new Program, which will culminate with the completion of the revision of the first Criticality Safety Document (CSD) that meets the new licence conditions;
- Revising Program documentation to include WL;
- Rolling out of the new Program across both sites;
- Carrying out Program awareness sessions for facilities;

- Improving training;
- Standardizing process and procedures;
- Holding internal working group meetings on nuclear criticality safety with various AECL groups;
- Participating in meetings of the Canadian Industry Working Group on Nuclear Criticality Safety; and
- Participating at both the Canadian Nuclear Society and the American Nuclear Society meetings, working groups and conferences.

6. Conclusion

Nuclear criticality safety is an important area of safety and one that AECL has been deeply involved and taking seriously for decades. There have been, and will continue to be, a number of challenges facing the new NCS Program at AECL as it fulfils its many goals, which include making the nuclear criticality safety processes at AECL easy to follow, ensuring adequate nuclear criticality safety training, and adequate documentation management.

It can be happily concluded that AECL, in compliance with its site licences, and in alignment with the ANSI/ANS-8 standards, is making steady progress in implementing an NCS Program that meets the company's business, regulatory, health, safety, security, environment, and quality-assurance responsibilities.