Regulatory Oversight of Refurbishment Projects in Canada

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Abstract

CNSC regulatory document RD-360, "Life Extension for Nuclear Power Plants" provides guidance on the overall steps that need to be taken before and during the refurbishment of a nuclear power reactor in Canada. The Canadian Nuclear Safety Commission (CNSC) mandate is to ensure that nuclear facilities to protect the health, safety and security of people and the environment. This paper discusses CNSC oversight of the refurbishment projects in Canada to fulfill its mandate. As the first large-scale refurbishment projects in Canada, there have been many challenges as well as opportunities in developing a regulatory oversight strategy but also many opportunities as well. Lessons learned from oversight of on-going refurbishment project are also discussed.

1. Introduction

As Canadian nuclear power facilities major components are ageing, licensees are presenting life extension projects and requesting the possibility to undertake refurbishment of these aging plants. Canadian Nuclear Safety Commission (CNSC) is responding to the industry to take advantage of the long refurbishment outages to bring plants up to modern requirements as much as practical. This places unique challenges on the regulatory body to balance proper regulatory oversight as licensees opt to undertake life extension projects.

In order to fulfill its mandate and the responsibilities under the *Nuclear Safety and Control Act*, the CNSC conducts oversight activities on the refurbishment of nuclear facilities. The initial planning and scoping of a project are crucial in ensuring that the project is set up properly. The actual execution is conducted in a manner that a high quality of work is completed and that safety issues are being addressed. Finally, at the conclusion of the project, assurances are collected in the form of verification and testing, that work meets all applicable requirements. Through all of these phases, CNSC seeks assurance that there is no unreasonable risk to health, safety and security of workers, the public and the environment.

Regulatory Document RD-360, "Life Extension for Nuclear Power Plants", was created to outline these steps in a refurbishment project. The four major phases of a refurbishment project are:

1. Environmental Assessment
2. Integrated Safety Review
3. Project Execution
4. Return to Service

Each of these phases represents a significant evolution in the project and as such, regulatory oversight is adapted to each step.

2. Environmental Assessment

The first step in a refurbishment project is for the licensee to conduct an *Environmental Assessment* (EA). The overall objective of the EA is to ensure that the refurbishment project will not likely cause significant adverse environmental effects, taking into account all proposed mitigation measures. For a life extension project of a nuclear facility, an EA screening level review is required. The licensee produces an *EA Study Report* which is then reviewed by CNSC staff and used to prepare the *EA Screening Report*. A series of public hearings are held during the process when the Commission makes the determination on the conclusions of the Environmental Assessment.

A *Follow-up Monitoring Program* is established to verify the assumptions and results of the Environmental Assessment. Following CNSC staff acceptance of the program, the licensee carries out the required studies and provides the information to the CNSC in annual reports. An example of verification studies that confirm the assumptions of the EA is the whitefish studies at the Bruce Power. During the consultation phase of the Environmental Assessment, a local aboriginal community, the Saugeen Ojibway Nation, raised concern about the impact on the local whitefish population due to the return to service of the units. The study is aimed to confirm that there will be no significant adverse effect on the whitefish. Outputs from these studies are fed into the Bruce Power Environment Management System.

By conducting an Environmental Assessment, the CNSC can begin oversight of the project before it actually begins. This wide scope assessment inherently ensures the protection of health and safety of people and the environment, with the ultimate objective being to ensure that there are no significant adverse effects as a result of the project. If any issues are raised through the EA process, CNSC staff can begin to monitor and request mitigation of the issues before they actually occur once the project is underway.

3. Integrated Safety Review

The next step in a refurbishment project is to conduct an *Integrated Safety Review* (ISR). An ISR is a comprehensive assessment of plant design, the condition of systems, structures, and components, as well as operation. The ISR is performed by the licensee and will assess the current state of the plant, including performance, against modern codes, standards and practices, to identify any factors which would limit safe, long term

operation. Operating experience, new knowledge from research and development activities and any advances in technology are to be taken into account. This will identify reasonable and practical modifications that can or have to be made to the plant, to processes or to management arrangements, enhancing the safety of the refurbished facility to approach that of a modern nuclear power plant. The review identifies gaps between current and desired plant state and performance, documenting the significance of any gaps and prioritizing corrective actions and safety improvements. Any non-compliances with the current licensing and design basis should be addressed immediately by the licensee. Non-compliances with modern standards and practices should be resolved to the extent practicable. An appropriate justification should be provided for any unresolved shortcomings.

There are four (4) components to an Integrated Safety Review:

1. An *ISR Basis* is established which sets out the scope and methodology of the ISR. The Basis document will include the proposed life of the facility, the scope of ISR (including the CNSC Safety and Control Areas), the set of modern standards and practices that will be used in the assessment, the licensing basis and the process for identifying and addressing any gaps. CNSC staff review the ISR Basis document for acceptance.

2. The ISR is then conducted and complied into a set of *Safety Factor Reports,* following the guidance provided by the IAEA in NS-G-2.10 on Periodic Safety Reviews. They will contain the results of the ISR, including any corrective actions and safety improvements for each of the subject areas. The results of the conformity reviews and the comparison against modern standards and practices are also included.

3. A *Global Assessment Report* is produced which captures all of the significant ISR results, including strengths, with an overall risk judgement on the acceptability of continued plant operation. The global assessment should also show the extent to which the safety requirements of the defence-in-depth concept are fulfilled. CNSC staff reviews the Global Assessment Report for acceptance, and the licence is amended to include licence conditions to be met in the return-to-service phase of the project.

4. With all of the gaps having been identified, the licensee then produces an *Integrated Implementation Plan* (IIP), which contains the corrective actions and safety improvements to address the gaps where reasonable and practical. The IIP also includes a schedule for implementing these safety improvements, including those which may extend beyond the duration of the refurbishment project. The licensee should have a well defined process for the control of any changes to the IIP. The process diagram below shows the overall ISR process, including the oversight conducted by CNSC staff:

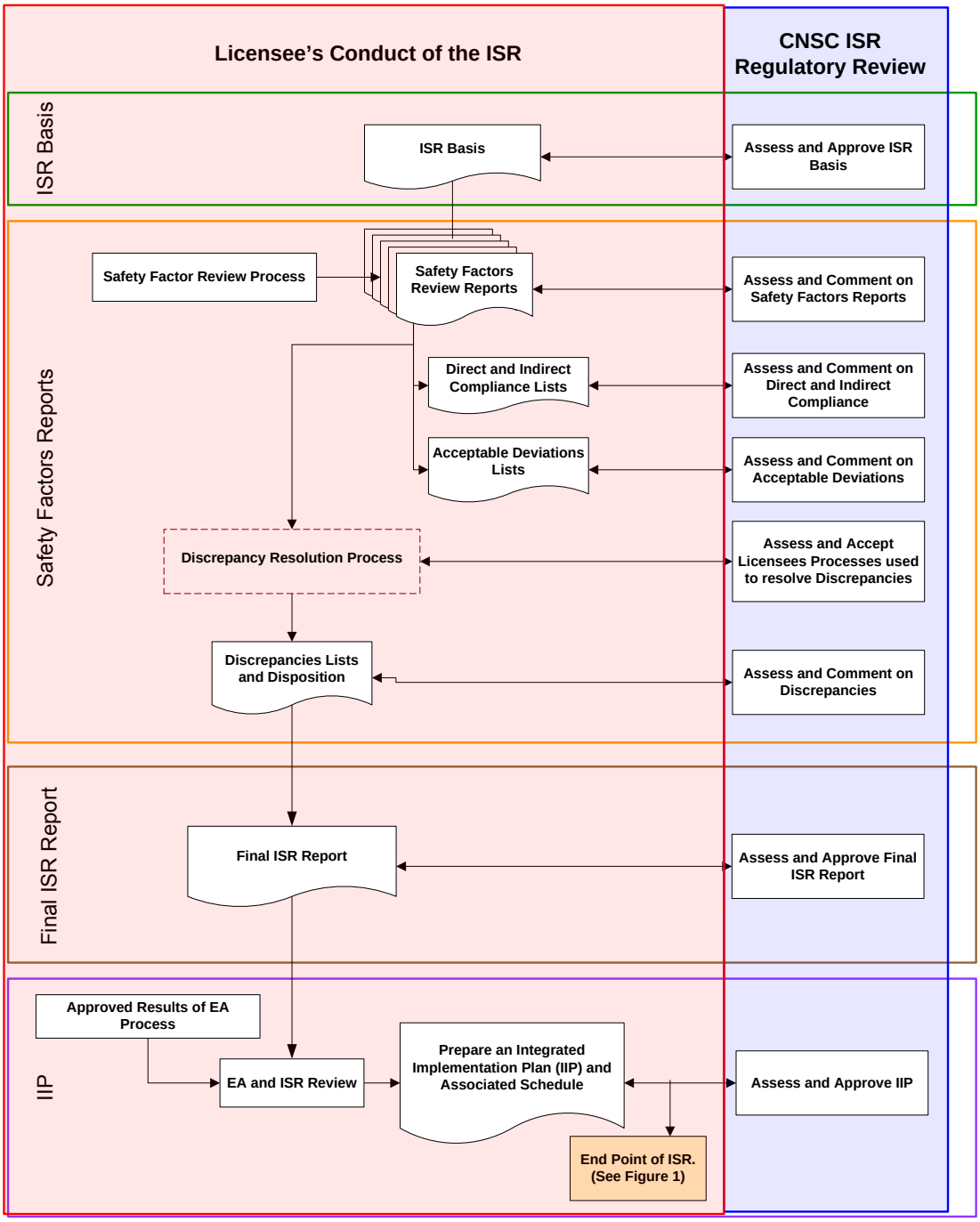

Figure 1: Simplified Flow Diagram for an Integrated Safety Review

Bruce, Point Lepreau, and Gentilly-2 refurbishments were initiated before RD-360 was published. Since the regulatory document was developed based on the IAEA NS-G-2.10 on conducting Periodic Safety Reviews, both licensees used the international guidance or early drafts of RD-360. This allowed them to make reasonable attempts at meeting the current CNSC expectations for refurbishments. There was much discussion between the CNSC and the licensees to ensure that all reasonable and practical improvements to the

stations were being made. In the end, Bruce Power and New Brunswick Power fulfilled the intent of RD-360 and improvements to the stations are being implemented.

Some examples of safety improvements that are being conducted as a result of the Integrated Safety Review are presented below. Note that this list is a short set of examples and is by no means all-inclusive; refurbishments include hundreds of jobs on site, large and small.

Bruce	Point Lepreau
Replacing Steam Generators	Introducing a Probabilistic Safety Analysis program
Replace Fuel Channels	
Installing a Secondary Control Area	Installing a trip function on the main Primary Heat Transport pumps
Shutdown System 2 Neutron Overpower Enhancements	Replacement of the main moderator gate valves
Replacing Obsolete Equipment and Components (PDC/PLC, SDS NOP amplifiers, etc.)	
Seismic Upgrades	Improved capacity of the moderator heat exchanger
Environmental Qualification Upgrades	Replacement of the uninterruptable power system
Fire Protection Upgrades	
Implementing Severe Accident Management Guidelines	
Improving Shutdown System Trip Coverage	

Table 1: Examples of safety improvements being made as a result of the ISR.

The Integrated Safety Review is the key component which enables the CNSC to ensure that all reasonable and practical upgrades are being made. Through the review of the Safety Factor Reports and the Global Assessment Report, CNSC staff can determine if there are any additional gaps that would need to be addressed and if the safety improvements that are proposed should have the desired effect. Good communication between the technical staff from both the CNSC and the licensee is required to ensure that the final Integrated Implementation Plan captures all of the essential modifications that are needed to support safe, long term operation.

4. Project Execution

The next significant phase in a refurbishment project is the Project Execution phase. Now that the work has been completed to identify all of the modifications that are needed in the plant, the licensee prepares a Project Execution Plan to identify what needs to be done to achieve the desired outcomes. Many programs and processes are created or revised to carry out the work during the refurbishment since some will have unique aspects that will need to be considered, such as waste management, large-scale construction, and training and use of contractors. Just as in normal operation of a nuclear

facility, all relevant regulatory requirements need to be met. CNSC staff conducts oversight of project execution that takes the form of inspections at the facility, as well as desktop reviews.

The programs and processes for all refurbishment projects are similar. For example, there is a need for Engineering Change Control processes, Emergency Preparedness measures being established, a radiation protection program, updated training to certified staff, among others. All of these common programs are subject to the same regulatory requirements, and as such, CNSC oversight activities are similar. In fact, in order to facilitate sharing of knowledge and communicating between projects, at times the same CNSC staff conducted the same inspections and/or reviews for both projects. RD-360 lists the programs and processes that may be needed for any refurbishment, and CNSC oversight is conducted accordingly, in a risk-informed manner.

The CNSC launches a first review of the dedicated construction organization. In particular, the CNSC is interested in simple but critical concepts of ownership and accountability of work on the project. The CNSC then reviews the contracting processes at the plant to ensure that the plant is able to get the correct quality of components, especially major components with a long lead time. Inspections at the manufacturing site are common. The CNSC also verifies that new staff being hired for the execution of the refurbishment project received appropriate induction training.

Since each station and licensee is unique, so are the refurbishment projects. Even though the high level requirements are the same across the board, the details of how these requirements are implemented at each site will be different. In order to account for this, CNSC oversight needs to be tailored accordingly. The following is a brief list of differences between the Point Lepreau and Bruce refurbishments that have required minor alterations to the regulatory oversight:

1. ***Point Lepreau was in an operational state up to the point that the refurbishment outage began.*** This required that care was needed while defuelling the reactor, which was monitored by CNSC staff. In addition, without the time to allow for radioactive decay, the radiation fields at Point Lepreau were much higher than what was encountered at the Bruce. Retube and other jobs in the reactor building would need to have extra precautions in order to keep personnel exposure as low as reasonably achievable.

2. ***Bruce Power is refurbishing two units in a multi-unit station.*** Throughout the duration of the project, there were still two operational reactors in the facility. Boundary points were established which separated the operational side of the plant from the construction side. In addition, a construction island was set up, physically separating the project from the rest of the station. CNSC staff performed inspections to ensure that the boundaries were being maintained and performed follow up if any work on the refurbishment had any unexpected impact on the operational units.

3. ***All refurbishment projects will likely experience different events to which CNSC staff will need to conduct targeted, reactive inspections.*** For example, during the calandria tube removal phase for Bruce Unit 2, a calandria tube insert (CTI) ring was dropped and accidentally found a month later by a radiation technician performing vault surveys. CNSC staff ensured that the root cause of the event was identified and that corrective actions were established to ensure that it did not recur. This was particular important as the Unit 1 CTI removal phase still needed to take place. During transport of the new low pressure turbines for Point Lepreau, the crane rigging fell and the turbines were dropped into the bay in the shipping yard. CNSC staff will be monitoring the outcome of the commissioning and functional testing to ensure that the turbines will be safe to use in the operational station.

Though there are minor differences between the projects and oversight is adjusted accordingly, the method in which the CNSC conducts oversight remains the same. In all cases, inspections, surveillance and monitoring and desktop reviews are used, similar to the CNSC's compliance and verification process for all power reactors.

5. Return to Service

The final phase in a refurbishment project is returning the units to service. The licensee needs to establish a return to service plan, which involves returning the reactor, nuclear systems and non-nuclear systems back to full power operation. It includes a demonstration that all relevant licensing conditions have been met and that all work is complete. Commissioning phases demonstrate that the new and existing plant systems, structures and components meet the design requirements. A series of milestones are put in place to ensure that the units are restarted in a systematic and controlled manner. Throughout the unit's staged increases in reactor power up to full power, regulatory hold points are established in order for the CNSC to ensure that work has been completed, protecting health, safety and security of people and the environment.

Each licensee is expected to produce a set of detailed completion assurance documents, which demonstrates that work has been successfully completed for the design, construction and commissioning phases. These documents are reviewed by CNSC staff to ensure that all safety improvements have been implemented as planned before allowing the units to return to service.

As per RD-360 requirements, the commissioning phases are generally separated into the following four steps:

- **Phase A**: testing of systems that are required to ensure that fuel can be safety loaded into the reactor;
- **Phase B**: testing of systems that are required to ensure that criticality can be achieved safely;

- **Phase C**: testing at a low power levels, typically below 0.1%, which confirm reactor behaviour
- **Phase D**: testing at high power levels, confirming reactor behaviour, including tests which could not be completed at low power.

During all phases of commissioning CNSC staff witnesses several of the risk-significant tests, such as shutdown system trip tests among others. CNSC staff reviews the results of the commissioning tests, to ensure that the pre-defined acceptance criteria have been met. This provides assurances that the reactor is behaving as expected, and that it will be operating within the safe operating envelope.

For all return to service processes, the CNSC establishes a set of regulatory hold points. These hold points are used as a tool for requiring that certain pre-requisites are met before the reactors are allowed to proceed past safety-critical milestones. Each refurbishment project has its own unique set of pre-requisites, dependent on the scope of the refurbishment and the results of the Integrated Safety Review. Overall the pre-requisites are established to ensure that the work on the project has been completed. This is the final stage in a refurbishment project in which the CNSC can ensure that the health, safety and security of people and the environment is being protected, prior to the reactors resuming the normal licensing and compliance processes. Licensees however ultimately remain responsible for safety through the whole process.

Since each licensee is different, it is not surprising that the Return to Service Plans that have been established in each case are a bit different. For example, Point Lepreau is producing Commissioning Completion Assurance Reports (CCAR), Design Completion Assurance Reports (DCAR), SAP Completion Assurance Reports (SCAR), Installation Completion Assurance Reports (ICAR) and finally Core Surveillance and Testing Reports (CSTR). All of these completion assurance documents will be completed for each of the restart hold points. Bruce Power has taken a slightly different approach and is producing Modification/Maintenance Completion Certificates (MMCC) for individual modifications, Available for Restart packages for systems, and a Lead-out Book for each hold point for the entire unit. Either of these processes meets the requirements of RD-360; however CNSC staff is expected to fully understand each process and adjust the regulatory oversight accordingly.

6. Public Hearings

Since returning a unit to service following a refurbishment requires a licensing decision, the CNSC holds public hearings towards the end of the project. The licensee submits a request for a public hearing, including any documentation to demonstrate that it is ready to restart the refurbished unit safely. CNSC staff uses this submission, in addition to information collected during the refurbishment outage, and reaches independent conclusions and makes recommendations to the Commission in a Commission Member Document (CMD). This CMD is then published and posted on the CNSC website and

public participation, is requested. Before making the licensing decision, the Commission considers all information from the licensee, CNSC staff and members of the public.

The CNSC and the licensee are also subjected to obligations with respect to aboriginal consultations. Therefore specific discussions are held with interested communities.

Conducting public hearings helps to promote transparency of the CNSC oversight of refurbishment projects in Canada. All information on CNSC oversight activities can be found within the Commission Member Document. During the hearing, members of the public can ask questions or raise concerns about any of the findings or conclusions arising from a licensee's application or the CNSC oversight.

7. CNSC Refurbishment Organization

In order to provide the needed regulatory oversight, the CNSC sets up a team of dedicated specialists, inspectors and project manager. Since such a project usually requires pre-authorization studies, by the time the licensee announces the project, the CNSC is also at work. This is important since many components may be long lead items, which need to be assessed. The team remains in place right through until the reactor is turned back to normal operation to deal with all aspects of the project. Continuity with team members through the project is a priority.

8. Lessons Learned

Both the Bruce and Point Lepreau projects are the first large-scale refurbishments in Canada. This has yielded an opportunity for parties involved to learn how best to conduct activities related to the project; for the CNSC, this means improving on oversight. Within the CNSC, continuous improvement is always strived for and one of the best ways to accomplish this is to look back at what went well and areas need improvement.

As was discussed earlier, several refurbishment projects began before the formal inception of RD-360. While the licensees met the intent of RD-360 by following the IAEA guidance on Periodic Safety Reviews, this was not done without some hurdles, especially since in some cases there was a span of many years between submission of documentation and formal initiation of the project by the licensee. The most significant lesson was the need to come to agreement on the Integrated Safety Review up front. This would have set the rules of the game for the regulatory review of the Safety Factor reports, through defining the modern codes and standards that were to be assessed, the definition of the licensing basis, and agreeing on the process for addressing any gaps. With RD-360 now published, both CNSC staff and licensees have a better understanding of what is needed. Work is currently in progress for upcoming life extension projects, beginning with the ISR basis.

It has been observed that if all of the information related to a refurbishment is held until the end of the project, there is a lot of information that needs to be considered and discussed during a public hearing. In future projects, it is expected that a public proceeding will be held once the review of the Integrated Safety Review is complete. This way, the Commission and the public will receive information regarding the refurbishment projects in a planned, phased manner. This will allow for better understanding of the material when the licensees request approval to load fuel following the project, and hence a more informed decision on that request.

There have also been some significant successes in the way that the CNSC oversight has been conducted on the projects. One of method of verifying 'compliance', for submissions is to mix compliance strategies. When a licensee will make a submission about the refurbishment project, there are times where more clarification is needed beyond what has been provided. Normal CNSC practice is to contact the licensee for this clarification; however this may not work if there is a significant amount of information that is still needed. In these cases, CNSC staff conducted inspections focused around the subject of the submissions. This allows for more immediate responses to questions, acquisition of additional documentation under the scope of the inspection and a better understanding of the submission overall. For the Bruce refurbishment project, this was how the plant condition assessment as eventually accepted by CNSC staff.

Quarterly updates and other topical meetings that were held throughout the duration of the projects were very useful. These updates allowed the licensee to inform CNSC technical specialist staff regarding the status of the various safety and control areas. This information was extremely valuable when other compliance activities were taking place or when Commission Member Documents were being written. For Point Lepreau, updates were regularly held in the areas of training, human factors, radiation protection, among others. These update meetings improved the overall communication between organizations on the project.

As none of the refurbishment projects has been completed yet, it is expected that there will more lessons that can be learned in particular during commissioning and return to service. At the end of significant phases of the project, CNSC staff conducts lessons learned exercises to gather these lessons and consider them for improvements for future project. A lessons learned exercise was conducted on the Pickering B, Bruce A Units 1 & 2 and Point Lepreau Integrated Safety Review in early 2009. There were several experiences that were learned from and not only are future projects going to be able to benefit from this information, but a revision to RD-360 is also in progress. Currently, there is a lessons learned exercise being conducted on the Bruce A Units 1 & 2 refurbishment project, including everything from the on-set of the project to the recent public hearings that were held. As more projects are completed, the CNSC will continue to review past performance in order to continuously improve.