
# ATOMIC ENERGY OF CANADA LIMITED

# NATIONAL RESEARCH UNIVERSAL REACTOR

# SAFETY SYSTEM UPGRADES

# AND THE

# CANADIAN NUCLEAR SAFETY COMMISSION'S

# LICENSING AND OVERSIGHT

# PROCESS

## A LESSONS LEARNED REPORT

## BY

TALISMAN INTERNATIONAL, LLC

June 2008

ATOMIC ENERGY OF CANADA LIMITED

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## Executive Summary

This report provides the results of an independent review of implementation of Atomic Energy of Canada Limited's (AECL) National Research Universal (NRU) reactor safety system upgrades and the Canadian Nuclear Safety Commission's (CNSC) licensing and oversight process. The review, performed by a team from Talisman International, LLC, consisted of document reviews and interviews, and was focused on the renewal of the NRU licence in 2005 and 2006, and the extended outage in late 2007.

In November 2005, CNSC renewed the operating licence for the NRU reactor with a licence condition that "*all 7 NRU upgrades are fully operational by December 31, 2005*." In July 2006, the licence was renewed for 63 months, based on "*recently completed safety upgrades*".

In November 2007, CNSC staff brought to AECL's attention a discrepancy between NRU documentation and the physical state of the plant. Specifically, two of the main heavy water pumps (MHWPs) were not connected to the hazards qualified Emergency Power Supply (EPS), even though some AECL documents described the upgrades as fully operational. Further investigation led to the following:

- confirmation from AECL that the connection was not in place;
- concerns from CNSC staff that operation without the connection was outside the licensing basis, and that the reactor should not operate in such a configuration without approval from the CNSC Commission;
- an ensuing unplanned extended outage of NRU, leading to an interruption in the supply of medical isotopes, until the NRU reactor operation was authorized by an Act of the Canadian Parliament.

AECL and the CNSC have taken this series of events very seriously, and commissioned Talisman International to examine the performance of the CNSC and AECL - both before and after the decisions to renew the NRU license - , identify the underlying causes of the extended outage, and make recommendations for improvements in both organizations, which would prevent a repeat occurrence or similar situation.

Based on a review of the events, and related internal and external communications of both organizations, a fundamental observation of the Talisman Team is that the CNSC regulatory program and the AECL regulatory compliance program are "expert based" and not "process based". The regulatory effectiveness of both organizations can be significantly improved by developing and implementing formal processes, to be used for establishing and complying with regulatory requirements.

The key conclusions reached by the Talisman Team are:

1. The main reasons for the MHWPs not being connected to the EPS were the following:
   a) The AECL licences that included the NRU reactor Operating Licence (OL) conditions issued in 2005 and 2006 were not clear, and did not specify in any detail exactly which

NRU safety upgrades were to be installed. The installation of the safety upgrades was part of the information relied on by the CNSC Commission in making its decision to renew the AECL OL in 2006, and was a licensee commitment, although it was not a specific licence condition.

b) The connection of the MHWPs to the EPS required the installation of seismically qualified DC Motor Starters, which had not yet been installed at the time of licence renewal because NRU reactor management did not believe there was a licensing requirement to install them.

c) The NRU commitment tracking system was not effective in tracking and monitoring the EPS connections to the MHWPs. Despite the fact that these connections were part of the EPS safety upgrades planned by AECL, by 2007 this safety upgrade was not being tracked in the NRU commitment tracking system.

d) In 2005, NRU management separated the planned connection of the EPS to the MHWP from the EPS safety upgrade activities. Some CNSC staff members were aware that the connections had not been made, but did not elevate this to CNSC management as an issue that had to be agreed with or challenged. The CNSC management continued to believe, based on earlier documentation, that the planned safety upgrades included the hazards qualified EPS being connected to the MHWPs. Consequently, the status of the EPS connections was not effectively communicated within each organization and between organizations.

e) The safety benefit of implementing the modification to connect the MHWPs to the EPS was not agreed upon or well understood by NRU site management.

2. The main reasons for the NRU reactor's 2007 extended outage were the following:

a) There was no regulatory process for resolving deviations from the information relied on by the CNSC Commission in making its decisions, if the information had not been included in the licence itself. The CNSC staff considered the EPS tie-in to the MHWP to be part of the "licensing basis", but there is no CNSC-documented regulatory definition of this term.

b) Once CNSC management considered NRU to be operating outside its licensing basis because the tie-in had not been made, they concluded that a licence amendment was needed. CNSC staff did not have authority to issue a licence amendment, and needed documentation from AECL (i.e., a licence amendment application request and safety case) to prepare its recommendation for submittal to the CNSC Commission. AECL submitted a safety case and a formal request for approval for a one-pump configuration, and additional time was needed for the CNSC staff to review and prepare the CMD documentation. Both the AECL and CNSC staffs recognized that it would be unlikely that a prompt resolution would be reached.

c) There was no CNSC regulatory guidance or AECL-established process for assessing whether the operation outside the licensing basis (or in a degraded condition) presented an acceptable condition from a safety standpoint.

3. The main reasons why the EPS connections to MHWPs P-104 and P-105 were not made in a timely fashion, after December 2005, were as follows:

   a) The CNSC compliance inspection of the safety upgrades, which included the EPS upgrades, did not classify the missing connections as a licence violation or an issue that warranted identification as a Directive or an Action Item. The missing connections were not highlighted, even though members of the audit team were aware that the connections were not made. This further supported NRU management's belief that the EPS connections to the MHWPs were not a regulatory requirement.

   b) The NRU reactor staff refocused essentially all available safety upgrade resources to address other significant items that had been identified by the CNSC compliance inspection report, in order to support the licence renewal.

   c) The NRU commitment tracking system was not effective in tracking and monitoring the EPS connections to the MHWPs. Despite the fact that these connections were part of the EPS safety upgrades planned by AECL by 2007, this safety upgrade was not being tracked in the NRU commitment tracking system at all.

   d) The safety benefit of implementing the modification to connect the MHWPs to the EPS was not acknowledged by NRU management following review by the Safety Review Committee and was not elevated to AECL Corporate Management for resolution.

To address process issues that caused the conclusions discussed above, and the factors that contributed to their existence, the Talisman Team has identified recommendations for specific short-term and long-term process and procedure improvements for both CNSC and AECL. The specific recommendations, as provided in the attached report, have been combined and summarized below:

Short-Term:

- CNSC should clarify current OL requirements, particularly regarding the Licence Strategy document referred to in Licence Condition 19.1 of the current OL. CNSC should reach agreement with AECL on open regulatory commitments, and concur that those open items adequately address the licensing requirements.

***CNSC Management Response***

At the end of May, the CNSC conducted a follow-up audit to review the status of the seven upgrades identified in the Licensing Strategy document. The CNSC is currently reviewing all the findings and will issue a set of directives and actions to AECL which will need to be completed. The final report should be issued within the next 60 business days. CNSC will work with AECL to review all open regulatory commitments, including any remaining commitments specified in the Licensing Strategy document, to ensure they are clear, that they adequately address the licensing requirements and that both CNSC and AECL are clear on the necessary actions and timelines to meet the commitment. These will be reviewed by legal counsel for clarity and enforceability. This will be completed by October 31, 2008.

- CNSC and AECL should implement a licensing commitment management system to control the initiation, prioritization, implementation, tracking, close-out and maintenance of licensing commitments.

***CNSC Management Response***

CNSC will work with AECL to review and update the AECL's existing commitment tracking system to identify licensing and compliance commitments that are considered of greater risk significance and higher priority. AECL will carry out an effectiveness review of this system by September 30, 2008. In addition, the CNSC will introduce its own simplified tracking system for licensing and compliance commitments that are considered of greater risk significance and higher priority. This tracking system will be developed and implemented by September 30, 2008.

***AECL Management Response***

AECL is implementing an internal process for managing licensing commitments and obligations. To ensure that Talisman's recommendations are addressed, an effectiveness review of the commitment process will be completed by September 30, 2008. AECL will share its process with the CNSC and reach agreement on a combined approach to commitment and obligation management. In addition, AECL is embarking on a major initiative to ensure the licensing basis for its nuclear facilities is properly captured (see response to overall recommendation 13). As the first step of that initiative, a review and reconciliation of licensing commitments and obligations will be undertaken (this review and reconciliation will provide input to the first recommendation above).

- CNSC should delegate sufficient authority to the Directors General, so that they are authorized to issue licence amendments.

***CNSC Management Response***

In alignment with the NSC Act, CNSC will review and seek Commission approval to further delegate authority from the Commission to Designated Officers including the Executive Vice-President and the Director Generals or seek to further streamline of the Commission decision making process to approve license amendments in abbreviated time periods. The two options will be reviewed by October 31, 2008 and presented to the Commission in November 2008 with implementation to follow pending Commission approval.

- CNSC and AECL should develop a formal process to promptly determine whether, and under what conditions, continued NRU reactor operation may be justified during off-normal conditions.

***CNSC Management Response***

AECL is adapting and adopting a process referred to as Technical Operability Evaluation (TOE) currently used at operating Nuclear Power Plants. The CNSC will provide guidance and regulatory oversight to AECL to ensure the process is effective in identifying and assessing off-normal conditions and for identifying and implementing any necessary mitigative measures to ensure continued safe operation under those conditions. The CNSC will formalize and document the CNSC's internal processes where CNSC reviews and approvals are required to allow for continued NRU reactor operation. The process will include a clear identification of roles, responsibilities, authorities and accountabilities for CNSC staff, management and the Commission to ensure for the timely review and disposition of any requests for continued NRU reactor operation during off-normal conditions. An interim process will be established by September 30, 2008 and fully documented by January 31, 2009.

***AECL Management Response***

AECL is developing a Technical Operability Evaluation (TOE) process aligned with best industry practise, and the procedure will be completed by January 31, 2009. The purpose of the TOE process is to provide a framework for determining the impact of discovery conditions on reactor operation, and deciding whether continued operation still meets approved safety goals. Once the TOE process has been developed, AECL will work with CNSC staff to ensure that the TOE process is acceptable from a regulatory perspective. AECL will also work with CNSC staff to agree upon a set of safety goals that can be used in operability risk assessments.

- AECL should strengthen its risk management assessment program (including use of probabilistic safety analyses tools), to support its use in the safety assessment process.

***AECL Management Response***

Risk assessment tools are required to support a broad range of safety-related decisions including TOEs (see overall recommendation 4), and prioritizing modifications and improvements. AECL will use the NRU Probabilistic Safety Assessment (PSA) and Safety Analysis Report (SAR), with the safety goals agreed under recommendation 4 to perform risk-based assessments.

- CNSC and AECL should strengthen the quality and timeliness of internal and external communications, including a process to elevate issues of differing views to higher levels of management for resolution when needed.

***CNSC Management Response***

The CNSC and AECL have recently developed a protocol for communications at the working level. CNSC and AECL will extend that protocol to ensure it promotes effective (timely and high-quality) communications, to include a process for escalating

issues to senior management for resolution (where required), and to include senior- and executive-level meetings. An agreed schedule for senior and executive level meetings between AECL and the CNSC will be completed by June 30, 2008. The formalized communications and problem resolution process will be developed, documented and implemented by December 31, 2008.

***AECL Management Response***

CNSC and AECL have developed a protocol for communications at the working level. AECL will work with the CNSC to extend that protocol to ensure it promotes effective (timely and high-quality) communications, to include a process for escalating issues to senior management for resolution (where required), and to include senior- and executive-level meetings. In addition, AECL will develop an internal Regulatory Communications Protocol based on the fundamental principle of "no surprises". The protocol will include practises for 3-way communication with CNSC staff on regulatory issues and the status of regulatory commitments, and for ensuring open and complete communications with the Commission. The protocol will be developed, and rolled out (including training) by March 31, 2009. Also an effectiveness review for the protocol will be included in the annual self-assessment plan for Licensing.

Long-Term:

- CNSC should improve the clarity of future NRU OL conditions, by using specific regulatory terms and references, and enforceable language. Safety requirements, such as the limiting conditions for operations, should be included in the OL. CNSC counsel should review licence terms and conditions language for enforceability.

***CNSC Management Response***

The CNSC will review the current license for NRU to improve the structure, content and clarity of the license, license conditions, limiting conditions of operations and any reference documents. The review will be completed by October 31, 2008. The CNSC will work with AECL to agree on a timeline for completing any necessary changes to the license and any reference documents. The plan and timeline for implementing the changes will be presented to the Commission in February, 2009. The CNSC will improve its review process for licensing documents, including reviews by legal counsel, to ensure more precise regulatory language. As part of establishing licence conditions and the development of the Commission Member Documents, CNSC staff will:
(a) ensure the required actions and timelines to fulfill the condition are understood by both the licensee and staff;
(b) ensure the compliance plan for verifying, enforcing and reporting compliance on the license condition are understood by both AECL and CNSC staff.

- AECL should clearly define the licensing bases (e.g., licence applications must include the current FA, the FSAR and the applicable LCOs and their bases) in the future OL for the NRU reactor, to ensure future licensing bases are clear.

***AECL Management Response***

In December 2007, AECL submitted to the CNSC an updated Facility Authorization (FA) that reflects the current plant configuration and references the most recent SAR (Safety Analysis Report), and will work with CNSC staff to get the new FA included in the licence. For future modifications, AECL will ensure the FA is promptly updated to include new Limiting Conditions of Operation (LCOs), and submitted for approval and inclusion in the licence. Furthermore, AECL agrees that the licensing bases for NRU (and other Nuclear Facilities) should be clearly established and is embarking on a major initiative to ensure the licensing bases are properly captured. This will be a multi-year project requiring the review and consolidation of all licensing documentation into a single repository, and a verification that all licensing commitments and obligations from these documents are captured in facility and program documentation with references to ensure commitments are not changed without a proper assessment. As part of this initiative, all existing commitments and obligations will be reviewed and rationalized by September 30, 2009. The updated licensing basis will be complete to support the application for the next licence renewal.

- CNSC should develop and issue guidance to the CNSC staff and industry for preparing and evaluating a request for the exercise of enforcement discretion for temporary conditions of low safety significance.

***CNSC Management Response***

The CNSC recognizes the need to ensure clarity on the range of enforcement tools to be applied commensurate with the severity of non-compliance and the overall safety significance. The CNSC will complete a review and ensure clarity on the range of existing enforcement tools and their application by September 30, 2008. The CNSC will also document the process for graduated enforcement including guidance for assessing the risk significance of temporary conditions on NRU safety systems and identifying appropriate regulatory actions. This will be communicated to both licensees and staff. This will be completed by November 15, 2008.

- CNSC should strengthen its enforcement capability by requesting the authority to issue civil penalties without referral to the Justice Department.

***CNSC Management Response***

This is currently under review and will be further examined for possible application. The implementation of this proposal would require changes of the Nuclear Safety and Control Act, legal reviews and the establishment of qualified staff and supporting tools to ensure its effective execution. The CNSC will review this option with its Legal Counsel and provide a recommendation to the Commission by November 2008 that will include a proposed timeline for bringing the necessary changes for parliamentary approval and executing the implementation pending the approval.

- In a generic sense, CNSC should adopt the concept of "timely renewal", to eliminate any perceived need to "rush" in order to avoid the pending termination of an OL. This should be coupled with a requirement for licence renewal applications to be filed early enough, so as to allow for a reasonable period for licence renewal application reviews, while retaining the ability to take the additional time needed to finish a licence review and to have a clear understanding - by both the licensee and the CNSC staff - as to the licence details.

***CNSC Management Response***

CNSC already extends licenses as appropriate through license amendments. The CNSC further explored opportunities to further utilize license amendments to extended licenses as appropriate. This was completed on June 30, 2008. In addition, the CNSC is currently reviewing the use of Periodic Safety Reviews for Nuclear Power Plants and NRU to support a more systematic and timely approach to safety review that could lead to extended licence durations. This in turn will facilitate the timely submission and review of license renewal applications. The CNSC will bring forward a proposal to the Commission by December 31, 2008.

- AECL should strengthen its long-term planning process to ensure that all functional departments understand the scope, priority, and schedule for regulatory projects. The commitment date and project schedule should be based on safety significance, plant staff resource requirements and availability, plant operations, and shutdown schedules.

***AECL Management Response***

AECL has implemented into its work management processes the requirement to identify regulatory commitments or obligations so that all involved understand the context and priority for the scope and schedule. Major project schedules currently include regulatory interactions and commitments. In addition, AECL's commitment management process will be reviewed to ensure that commitment schedules are based on safety significance, resource availability, and impact on plant operations and shutdown work schedules. Plant operations should also sign off on any planned work to ensure they agree with the scope and schedule, and so that they can identify operational safety concerns that need to be addressed. These items will be included in the effectiveness review under recommendation 2 above.

- AECL should strengthen its work execution and configuration management processes, to ensure that safety significant improvements are promptly implemented and properly closed-out. Specific improvements are recommended in project management, modification management, and work management.

***AECL Management Response***

AECL has recently issued an engineering change control procedure that addresses many of the findings in modification and commissioning management. An effectiveness review will be conducted to ensure that use of the procedure is addressing the specific

recommendations by June 30, 2009. With the formation of a consolidated project delivery organization in April 2005, AECL has implemented a project quality program and associated project management procedures that are based on Project Management Institute guidelines (Project Management Book of Knowledge). AECL will ensure that these procedures include requirements for Project Managers to include regulatory commitments in project plans, schedules and documents, and will ensure accountability statements for Project Managers include responsibilities to meet regulatory requirements, by December 31, 2008. AECL is also implementing improved work management practises, based on industry best practises. A 13-week rolling schedule has been implemented and work is under way on a 52-week rolling schedule that will include project work.

- The CNSC should define the term "licensing basis" in a regulatory guidance document.

***CNSC Management Response***

The CNSC will review the definition of "licensing basis" as documented in an existing Regulatory Document RD-360 and develop any additional guidance document to clarify its applicability to existing facilities. This will be completed by September 30, 2008.

- AECL should continue to strengthen its ability to self-identify and affect performance improvements. Specific recommendations have been made to improve the Corrective Action and Self-Assessment Processes and independent oversight functions, such as the Safety Review Committee.

***AECL Management Response***

AECL will be conducting a performance-based audit to drive further improvement of its corrective-action and self-assessment programs by March 31, 2009. Industry peers will be included on that audit. AECL will provide additional training in root cause analysis methodology as follows: a week long Root Cause Analysis (RCA) training session for 2008 September to be delivered and attended by industry peers, participation in the COG Corrective Action Working Group, and focussed RCA training to be delivered in 2008 October by a third party expert. Lastly the mandate of the Safety Review Committee (SRC) has been revised to ensure that the committee is properly integrated into AECL's safety oversight functions. A managed transition process is being followed to move to the new mandate, and as part of the transition, external experts are being sought to become members of the SRC.

During its review, the Talisman Team identified a number of factors that contributed to these problems. The report discusses these factors and provides additional recommendations to correct them.

The Talisman Team received the full cooperation of both the CNSC and AECL. The views expressed in this report are those of the Talisman Team, and do not necessarily represent the views of the CNSC or AECL.

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## I. Introduction

This report was prepared by an Independent Review Team from Talisman International, LLC (Talisman Team) at the request of the Canadian Nuclear Safety Commission (CNSC) and Atomic Energy of Canada Limited (AECL). Talisman was requested to recommend improvements to the CNSC and AECL processes, based on a review of lessons learned stemming from the extended outage of AECL's National Research Universal (NRU) reactor in November and December 2007.

The Talisman Team was initially asked by CNSC to identify the licensing basis, review the 2006 licence renewal activities, investigate enforcement, and evaluate communications. AECL asked the Talisman Team to review the clarity of licensing requirements, AECL's management of the safety upgrades particularly from January 2006 to November 2007, and to identify options that could have avoided or shortened the outage. The Talisman Team indentified process and program improvements, some that apply separately to either CNSC or AECL and others that apply to both CNSC and AECL. A list of the reference documents used in preparing the report is provided as Attachment 1. A complete list of recommendations is tabulated in Attachment 2.

The Talisman Team's Charters are included in this report as Appendix A. The Talisman Team was requested to focus on lessons learned, particularly process or procedure improvements, not on individual personnel shortcomings. The Talisman Team has extensive nuclear regulatory and industry experience. A biographical background of the Talisman Team members is provided in Appendix B.

The Talisman Team conducted its assessment by reviewing CNSC and AECL documents and interviewing current and former CNSC and AECL staff and managers. The Talisman Team reviewed NRU reactor licensing and inspection correspondence, records related to the recent extended outage at NRU, and regulatory decisions made during licence renewal proceedings. The focus of the review was on the interactions between the CNSC and AECL related to the Emergency Power Supply (EPS) upgrade and its lack of connection to two of the reactor's main cooling pumps - referred to as Main Heavy Water Pumps (MHWPs). The acronyms used in this report are listed in Appendix C. A timeline of events, associated with the major observations, is provided in Appendix D. The list of personnel interviewed by the Talisman Team is provided in Appendix E.

This report is structured to first highlight the factual information identified by the Talisman Team, based on the document reviews and the interviews, then to identify the important observations based on those facts, and finally to present the recommendations that the Talisman Team made to address those observations. Some areas of the report overlap, since the factual information that supported the observations was the same. Whenever that occurs, the material is repeated in that section for the sake of completeness. However, if an earlier recommendation already covers the observation, then the report only references the earlier recommendation.

This report represents the views of the Talisman Team, and does not necessarily represent the views of the CNSC or AECL. The Talisman Team received full cooperation from both organizations, and independently decided which documents to review and whom to interview.

## II. Background

The NRU reactor is a 135 MWt heavy water reactor operated by AECL at the Chalk River Laboratories (CRL) site. The NRU reactor has multiple purposes, which include the production of medical isotopes, testing of various fuel types, and other irradiation services. It began operation in 1957, and is currently continuing operation with a licence renewed by the CNSC in July 2006, and which expires in October 2011. The licence was issued by the CNSC Commission with the understanding that seven safety upgrades had been installed and were fully functional. The seven safety system upgrades, which had been declared fully operational, were the following:

- an independent second reactor trip system,
- a qualified emergency response center,
- a new emergency core cooling system,
- a qualified emergency water system,
- main pump flood protection,
- liquid and gaseous confinement boundary, and
- a new emergency power system.

The main issue in this report is related to the new Emergency Power System, which provided a hazard-qualified power supply to the six other upgraded safety systems, while also intended to provide a hazard-qualified power supply to two MHWPs, P-104 and P-105. These latter connections were not made at the time of licence renewal. A general description of the NRU reactor and the safety upgrades is provided in Appendix F.

On November 5, 2007, the CNSC CRL site inspector discovered a statement in an operating manual that the EPS was not connected to the MHWPs. AECL confirmed that to be the case in writing, on November 7, 2007 [1]. CNSC expressed concern that the NRU physical plant was not consistent with the licensing and safety basis. On November 14, 2007, NRU completed a technical operability evaluation (TOE) which concluded that there was no loss of function and that there was reasonable assurance of adequate margins of safety. CNSC was informed of the results of the TOE on November 16, 2007. The NRU reactor was shut down for a four-day scheduled maintenance outage on November 18, 2007. CNSC informed AECL of its concerns regarding the depth and conclusions of the TOE, advised AECL that it was working on a letter stating its concerns, and recommended that AECL not restart the reactor, but no such letter was ever sent.

After much discussion with the CNSC staff, centred on the concern that restarting the reactor was outside of the licensing basis, on November 22, 2007 [2], AECL informed the CNSC that the NRU reactor would not be restarted that day (as originally planned), in order to complete installation and testing of new seismically-qualified direct current (DC) Motor Starters and EPS supplied power for MHWPs P-104 and P-105.

NRU management believed that they had two paths available to resolve the issue. One was to complete the EPS connection to both pumps; the other was to submit and obtain approval of a

safety case for one-pump operation. From mid-November to mid-December, the projected end dates for these paths were changing, as progress was made and understanding was gained. NRU shifted its primary success path according to the way in which one path's end date moved ahead of the other.

On November 29, 2007 [3], AECL formally submitted a safety case to support restart with the upgraded EPS connected to one pump (P-105). Both AECL and CNSC staffs recognized that it was unlikely that a prompt resolution would be reached. AECL notified the CNSC on December 2, 2007 [4], that it was not continuing with that option, and that the reactor would only be restarted after both DC motor starters for MHWPs P-104 and P-105 were connected to the EPS. On December 7, 2007 [5], AECL requested regulatory approval for a modification to the Facility Authorization (FA), in order to permit the "one pump" operation for a limited period of time,. CNSC staff informed AECL, in letters dated December 7, 2007 [6], and December 10, 2007 [7], that a complete safety case and request for licence amendment was required of AECL before the matter could be referred to the CNSC Commission. Subsequently, the Minister of Natural Resources Canada and the Minister of Health Canada wrote to the Presidents of the CNSC and AECL on December 10, 2007 [8, 9], and urged them to work together to restart the reactor safely with due regard for those reliant on the medical isotopes produced by NRU. The reactor remained shut down. On December 11 and 12, 2007, the House of Commons and the Senate respectively passed a law [10] which gave AECL the authorization for operation of the NRU reactor for 120 days, with certain conditions. The reactor was restarted on December 16, 2007, and medical isotope production resumed within days.

## III. Implementation of NRU Reactor "Upgrades"

### III. A. Early Plans

On December 7, 1992, AECL informed the Atomic Energy Control Board (AECB) [11] of its intent to upgrade NRU reactor safety with modifications needed to achieve off-site dose and safety assessment goals. The seven safety system upgrades included an independent second trip system, a qualified emergency response center, a new emergency core cooling system, a qualified emergency water system, main pump flood protection, liquid and gaseous confinement boundary, and a new emergency power system.

The safety improvements expected from the NRU safety upgrades were described in a January 1993 Concept Safety Assessment [12]. "*The EPS will provide power for the NECC (See Section 7.3), other upgraded safety systems and improve the reliability of power supplies to heavy water pumps P-104 and P-105 […] In the case of failure of the NRU Class 1 supply, this 130VDC supply will be used to supply heavy water pumps P-104 and P-105.*" A Core Damage Frequency improvement, due to the EPS, was tabulated. "*Improvement in Core Damage Frequency when Proposed Emergency Power Supply Installed"* listed four sequences: (1) Loss of Class 3 for more than 2 hours with partial loss of Class 4 was $3 \times 10^{-3}$ and will be $5 \times 10^{-5}$ ; (2) Loss of Class 3 for more than 2 hours caused by loss of Class 4 with failure of diesels was $3 \times 10^{-3}$ and will be $5 \times 10^{-5}$ ; (3) Loss of Class 3 for more 2 hours with Class 4 available was $2 \times 10^{-3}$ and will be $3 \times 10^{-5}$ ; and (4) Loss of Class 4 with Class 1 batteries unavailable was $1 \times 10^{-2}$ and will be $2 \times 10^{-5}$.

The revised frequency on the expectation that the core can survive for at least 30 minutes without forced cooling flow was $4 \times 10^{-4}$ and will be $8 \times 10^{-7}$. The safety goals were not formally incorporated into the NRU OL, either directly or indirectly - through the FA or Final Safety Analysis Report (FSAR). The proposed safety upgrades were scheduled for completion in 1995/1996, pending approval of the AECL Board of Directors.

In a 1994 Board Member Document (BMD) [13], the AECB staff informed the Board of AECL plans *"to upgrade the NRU reactor with a package of seven improvements it considers important to permit the reactor to operate safely until about the turn of the century."* The BMD indicated that improvements to the EPS would be installed by 1997. The AECB staff said it agreed *"that these improvements are desirable"*, and proposed *"to authorize these on a case-by-case basis"*. According to the document, *"The upgrades would be authorized by licence amendments."* AECB staff said in the BMD that it was *"not yet in a position to assess whether the proposed set of upgrades is sufficient to allow the reactor to operate safely for the remainder of the planned life-time."*

In 1997, the *Nuclear Safety and Control Act* (NSCA) established the CNSC, replacing the AECB as the independent regulatory body with the responsibility for the regulation of Canadian nuclear facilities.

Throughout the mid 1990s, multiple communications were held between the CNSC and AECL regarding the details of, and schedules for, the safety upgrades. In a 1995 Licensing Plan [14], AECL described the package of seven proposed upgrades including EPS which *"provides a hazards qualified source of Class 1 power for the main heavy-water pumps No. 4 and 5 in the event of a loss of coolant accident."*

The Talisman Team considers that these early plans clearly included the connection of a hazards-qualified EPS backup power to the MHWPs, as a part of the planned upgrades.

## IV. CNSC Regulatory Process for Incorporating the EPS Upgrade into the NRU "Licensing Basis"

### IV. A. Conceptual Design of the EPS Upgrade

In the March 1995, Licensing Plan [14], AECL stated that it would implement the NRU safety upgrades under the change control process in the FA. In November 1996, AECL issued "Project Implementation Plan - NRU Research Reactor Upgrade Project" [15]. The implementation plan stated, *"The base scope of work was generated from Conceptual Design Documents of the seven proposed upgrades determined from assessment phase. Design Requirements Documents and Detailed Design Descriptions including Option Studies, where applicable, will be produced to form the basis for seeking approval to proceed from the appropriate governing bodies. Project Procedure NRU-180-02600-0001 "Change Control Procedure" defines the requirements for controlling changes to approved documentation, processes and procedures applicable to the NRU Research Reactor Upgrade Project during all phases of the project."*

In November 1998, in accordance with the change control process in the FA, AECL issued the First Safety Note for the EPS [16]. The Safety Note stated: *"The emergency power supply upgrade is an essential part of the overall safety improvements that are currently being implemented in NRU. The EPS is designed as a fully redundant, independent and separated multi-class power supply. The EPS will provide a hazards-qualified source of electrical power for the operation of other safety upgrades, and for the main heavy water pumps that provide both NECC cooling following LOCA and shutdown core cooling […] EPS equipment, as well as equipment for the new safety systems, will be qualified to withstand hazard events including fire external to the EPS room, and design basis earthquakes in an assessment basis earthquake environment."* According to the Safety Note Implementation Plan, AECL was to issue an Installation Plan by December 1998, issue an EPS Commissioning Plan by May 2000, and issue an EPS Training Plan by June 2000.

### IV. B. Safety Upgrades First Incorporated into the NRU Operating Licence[1]

The revised OL for NRU, issued by CNSC in 1998 [17], included licence conditions 27a and 27b, specifying the seven upgrades described in section 4.5 of AECL-MISC-300-97, dated March 1998, "NRU Reactor Annual Safety Review 1997" [18] to be implemented by October 31, 2000. Section 4.5.6 of AECL-MISC-300-97 stated *"A seismically qualified EPS is required to provide continuity of electrical power to the upgrades in the event of Class 4 power failures. The EPS will provide power for the NECC and other safety-related systems, and improved reliability of the DC power supplies for P-104 and P-105 motors."*

### IV. C. Subsequent Operating Licence Revisions

Subsequent OL revisions removed this condition and replaced it with other conditions, as follows:

- 10/2000 licence condition regarding the seven upgrades was not included;
- 05/2003 shutdown by December 31, 2005 unless authorized by the CNSC;
- 06/2004 shutdown by December 31, 2005 unless authorized by the CNSC;
- 12/2004 shutdown by December 31, 2005 unless authorized by the CNSC;
- 11/2005 demonstrate all seven upgrades fully operational by December 31, 2005; the licence expired in July 2006.

License Condition 13.1, contained in the November 2005 licence, required all seven upgrades to be made fully operational by December 31, 2005, and was specifically included in the 2005 OL, at the request of the CNSC staff, as the basis for permitting operations beyond December 31, 2005. The licence did not define what is meant by "*upgrades*" or "*fully operational*". The latter term was separately defined and agreed upon in written correspondence between AECL and CNSC staff. (See Section V.A. for additional discussion concerning the clarity of this license condition.)

[1] The actual AECL OL covers 14 different facilities at the CRL site and, as a result, has many referenced documents that become part of the site OL. For ease of discussion, this Report uses the term NRU OL to cover those portions of the actual AECL OL that regulate the operations of the NRU reactor.

**IV. D. Current Operating Licence, July 2006**

The current NRU OL, NRTEOL-01.00/2011, dated July 28, 2006 [19], also does not specifically identify the scope of the seven safety upgrades. Among other requirements, the licence contains Condition 19.1: "*The licensee shall comply with the requirements set out in the document entitled Licensing Strategy for the NRU Licensability Extension Project*." However, there is no specific document reference number or document date given in Condition 19.1 and therefore, it is not clear to which document this Condition refers as part of the OL.

Based on interviews, it was understood by both AECL and the CNSC staffs that the document referred to in Licence Condition 19.1 is an attachment [20] to a February 28, 2006 letter from the CNSC Director to the Vice President of AECL's CRL site [21]. This letter states that its purpose is to communicate CNSC staff's strategy for the regulatory oversight activities associated with the NRU Licensability Extension (NRU LE) project. *"The attached document outlines the licensing prerequisites in a prioritized manner from now into the future."* The letter further states that *"the expectation is that this document will form the basis for future submissions and activities by AECL and reviews and approvals by the CNSC."* The attachment entitled "Licensing Strategy for the NRU Licensability Extension Project" (Licensing Strategy document) attempted to set expectations for items to be completed, along with a schedule for completion, in order for the NRU reactor licence to be renewed. The CNSC's original intent for this document was to get agreement on a proposed licensing plan, partially because there were a large number of open items which had to be addressed to the CNSC's satisfaction for the longer term licence being proposed. By invoking the Licensing Strategy document in a licence condition, the CNSC intended to impose specific requirements. However, the Licensing Strategy document did not use the term "requirements" in describing any of these planned actions.

Regarding the safety upgrades, the Licensing Strategy document stated: *"Acceptance Criteria - AECL must demonstrate that the seven safety system upgrades are fully operational (as of January 2006) […] CNSC to perform a full scope audit of the EPS upgrades […] All seven upgrades are currently installed."* The Licensing Strategy document discussed the seven safety upgrades as if they had already been implemented and declared "fully operational". As of February 28, 2006 (the date of the letter), the OL in effect included Condition 13.1, which specified that these seven upgrades had to be fully operational by December 31, 2005. The CNSC noted in the Licensing Strategy document that it planned to perform an audit of the Liquid Confinement, Vented Confinement (LCVC) and EPS upgrades, after AECL had declared them fully operational.

The Licensing Strategy document goes on to include eleven short-term AECL actions to be implemented before July 2006, addressing known non-compliances with requirements and safety concerns and midterm actions by July 2007. However, these actions and the criteria to be met refer to several studies and programs which are also not well specified by concise regulatory language.

## IV. E. Facility Authorization - FA

The FA is the primary document used to provide operators with limiting conditions for operations (LCOs) and action requirements. Contrary to the change control process [23] required by the OL, the FA was not revised to include the EPS (hazards qualified) upgrades after they were declared "fully operational" in December 2005 [22]. The currently approved FA is AECL-FA-01, Revision 4, August, 2000 [24], providing detailed NRU reactor operating limits for various operating modes. It is referenced in Appendix B of the current OL as the applicable document for the NRU Reactor Facility, but does not include the LCOs for all the upgrades. The FA is based, in part, on the FSAR. As discussed below, CNSC had not approved updated versions of the FSAR submitted by AECL, and therefore AECL did not update the FA. Pending CNSC approval, AECL issued Instructions to Supervisors (ITS) in lieu of LCOs for these upgrades.

## IV. F. Final Safety Analysis Report - FSAR

The FSAR is the comprehensive safety analysis of the reactor. The FSAR was not updated to reflect an assessment or safety analysis of the upgrades' implementation, as they were declared operational and placed in service. The CNSC, in a November 21, 2005 letter to AECL [25], indicated that it "expects" the FSAR and the FA (AECL-FA-01) to be updated before site licence renewal. This was not done.

The February 28, 2006, Licensing Strategy document had discussed the 2000 FSAR and stated that the 2000 version was still not approved. The Licensing Strategy document goes on to discuss several deficiencies and implies a requirement for AECL to "make a commitment" to submit a program to update the FSAR. This letter makes reference to AECL-MISC-300, Revision 0, NRU Research Reactor-Safety Analysis Report, Volume 2, 2000 [26].

AECL had previously submitted AECL-MISC-300 on October 31, 2000 [27]. However, on December 1, 2000 [28], CNSC provided comments to AECL and asked for a work plan and schedule for addressing all outstanding issues and the submission of supporting documentation and information at the RSEP review meeting on December 6, 2000. CNSC did not address the FSAR again until October 26, 2006 [29], six years later. FSAR versions which describe the upgrades were submitted in October 2000 and March 2007, but neither was approved by the CNSC. Since these later versions of the FSAR have not been approved by CNSC, the FSAR invoked by the OL continues to be the original outdated 1964 (emphasis added) version [30] [Schedule 1: Reference Documents, item (1) IOI-260, *A Safety and Hazards Review of the NRU Reactor*, March 1964, (or as superseded by the most up-to-date revision of the document that has been approved in writing by the SRC and CNSC)]. This 1964 document is supplemented by numerous addenda that are also listed in the FA. At the time of the review of the CNSC documents, the current OL did not incorporate, by reference, the updated FA, the LCOs for the upgrade equipment, or the updated FSAR reflecting the detailed basis for the upgrades.

**Observation (1) – Operating Licence (OL)**
The Talisman Team concluded that the current OL does not explicitly contain clear requirements for implementation of the safety system upgrade modifications. This is based on the fact that

Licence Condition 19.1 is vaguely worded and does not use clear, enforceable and understandable regulatory language necessary to impose specific requirements (exactly "what" and "when") in an OL. The Licensing Strategy document referred to by Licence Condition 19.1 did not use the term "requirements" at all. The Licensing Strategy document apparently referred to, includes opinions, expectations and requests, but does not include clear and specific requirements. The Talisman Team also concluded that the renewed 2006 licence incorporates out-of-date information (such as the original 1964 version of the FSAR), does not include essential information, such as the LCOs and their bases, and is very cumbersome. The reader must refer to several attachments and reference documents in order to attempt to understand the OL requirements. The Licensing Strategy document is very long and is very imprecise as to what is required. For example, the OL Condition that required the safety upgrades was not clear as to the description of exactly what EPS upgrades were required and when.

The licence renewal process involves a combined effort, and the facility (CRL) licence contains information prepared by both the licensee (AECL) and the regulator (CNSC) staff. Nevertheless, the current NRU OL is cumbersome and unclear. Based on the Talisman Team review of the information presented to the team members, the following recommendations are made. This format will be used for all other recommendations that follow the observations.

**Recommendations**[2]

**C-OL-1:** CNSC should clarify current OL requirements, particularly the requirements invoked by the Licensing Strategy document.

***CNSC Management Response***

At the end of May, the CNSC conducted a follow-up audit to review the status of the seven upgrades identified in the Licensing Strategy document. The CNSC is currently reviewing all the findings and will issue a set of directives and actions to AECL which will need to be completed. The final report should be issued within the next 60 business days. CNSC will work with AECL to review any remaining commitments specified in the Licensing Strategy document, to ensure they are clear, that they adequately address the licensing requirements and that both CNSC and AECL are clear on the necessary actions and timelines to meet the commitment. These will be reviewed by legal counsel for clarity and enforceability. This will be completed by October 31, 2008.

**C-OL-2:** CNSC should use precise regulatory language, to ensure that future CRL OL and licence conditions for the NRU reactor, and other licensed facilities, are clear. The CNSC staff should ensure that, before a licence condition is approved and issued, both the licensee and the regulator can understand what actions will be needed to fully implement the requirements, and that it is clear enough that the CNSC staff can enforce specific details. Use specific (enforceable) regulatory terms and references, as opposed to "implement the seven upgrades."

[2] Recommendations are numbered as follows: X - XX - #: The first letter designates who the recommendation is being made to; J is for recommendations made to both AECL and CNSC; A is for AECL; and C is for CNSC. The second series of letters designates the process or function addressed by the recommendation (e.g., PM is for project management). The number at the end uniquely identifies the recommendations in each category.

***CNSC Management Response***

The CNSC will review the current license for NRU to improve the structure, content and clarity of the license, license conditions, limiting conditions of operations and any reference documents. The review will be completed by October 31, 2008. The CNSC will work with AECL to agree on a timeline for completing any necessary changes to the license and any reference documents. The plan and timeline for implementing the changes will be presented to the Commission in February, 2009. The CNSC will improve its review process for licensing documents, including reviews by legal counsel, to ensure more precise regulatory language. As part of establishing licence conditions and the development of the Commission Member Documents, CNSC staff will:
(a) ensure the required actions and timelines to fulfill the condition are understood by both the licensee and staff;
(b) ensure the compliance plan for verifying, enforcing and reporting compliance on the license condition are understood by both AECL and CNSC staff.

**C-OL-3:** CNSC management should require that all the regulatory documents that CNSC staff plan to use or rely on (when establishing requirements or providing authorizations) would be reviewed for enforceability by CNSC counsel before issuance.

***CNSC Management Response***

Legal counsel reviews draft licences including licence conditions. CNSC will review the structure of licences and reference documents to simplify and facilitate legal counsel reviews. This will be completed while addressing recommendations C-OL-2, J-OL-1, J-OL-2 and J-PSA-1.

**C-OL-4:** CNSC should adopt a standard to test the clarity of regulatory language, so that both a nuclear plant control room operator and a regulatory inspector would be able to read a document and agree on "what" is required, the means or details of "how", and "by when".

***CNSC Management Response***

This will be partially addressed by addressing recommendations C-OL-1, C-OL-2. In addition, CNSC will include a validation step in the review process for key regulatory documents, to ensure that both CNSC inspectors and AECL workers have a common understanding of the license conditions, regulatory expectations and regulatory processes.

**C-OL-5:** CNSC should obtain authorization to hire its own in-house counsel. Legal support services should be more effectively used for review of key regulatory documents, to ensure clarity and enforceability.

***CNSC Management Response***

Complete. The CNSC acquired its own independent legal counsel as of May 16, 2008.

**Observation (2) – Operating Licence (OL) - Reference Documents**

At the time of the Talisman Team's review, the OL references an obsolete FA and an obsolete FSAR. AECL has submitted later versions of the FSAR, but CNSC has not approved them. There is no requirement for CNSC to complete its review of the FSAR or FA before recommending the CNSC Commission to issue a new OL, and the CNSC staff has not conducted a timely review of the current NRU FSAR.

**Recommendations**

**J-OL-1:** CNSC and AECL should achieve approval of up-to-date FA and FSAR, and incorporate them into the OL as soon as practical.

***CNSC Management Response***

The CNSC will coordinate with AECL the review and approval of the FA and the FSAR and incorporate them into the operating licence. In line with responding to recommendation C-OL-2, the CNSC will work with AECL to agree on a timeline for completing any revisions, reviews and approvals of these reference documents. The plan and timeline for completing this work will be established by September 30, 2008.

***AECL Management Response***

AECL will work with CNSC staff to ensure an approved FA for NRU, supported by an acceptable FSAR, is expeditiously incorporated into the licence (see overall recommendation 13).

**J-OL-2:** AECL should update - and CNSC should promptly approve, and incorporate into the OL - , the updated FA, including LCOs for any new required structure, system, or component that is added in a new OL or in a new OL amendment.

***CNSC Management Response***

The CNSC will coordinate with AECL the review and approval of any future nuclear facility modifications and the updated FA LCO. These will be incorporated into the operating licence.

***AECL Management Response***

For future nuclear facility modifications (new structures, systems or components), AECL will ensure the associated Facility Authorization is promptly updated to include new or modified Limiting Conditions of Operation (as appropriate) and submitted for CNSC approval, prior to inclusion in a revised licence (see overall recommendation 13).

## V. Licence Condition - NRU Upgrades to be "Fully Operational" by December 31, 2005

### V.A. Clarity of Licence Condition 13.1

In November 2005, the CNSC Commission renewed the CRL OL for several months with an expiration of July 31, 2006 [31]. The new OL included condition 13.1, *"Licensee shall demonstrate that all 7 NRU upgrades are fully operational by December 31, 2005."* The licence condition offered no further explanation of the seven NRU upgrades.

The AECL Licence Application for Removal of Clause 13.1 Pertaining to NRU Reactor Operation [32] stated that EPS is "*to be installed and commissioned but not yet fully operational and ready for connection to the other NRU safety upgrades […] These safety upgrades were placed in service as noted above. The Emergency Power Supply system has been commissioned and an application has been made to the Safety Review Committee and CNSC to place it in service, at which time it will be fully operational and ready for connection of Emergency Power Supply power to the other NRU safety upgrade […] All the safety upgrades are seismically and environmentally qualified. They are all designed to modern codes and standards".* The licence application stated that "*additional information on these safety upgrades is provided in"* an AECL Interim Report on the Plant Life Management Program for the NRU Reactor" [33]. The Interim Report stated *"The last two upgrades (NECC and EPS) are now installed, commissioned, and ready for connection of EPS to the other NRU Safety Upgrades […] The only remaining Upgrades work of significance is the replacement of the DC Motor Starters for Main Heavy Water Pumps #4 and #5 with seismically qualified units. One of these starter units is currently installed (2005 April) and is undergoing in-service testing on Main Heavy Water Pump #1."*

During the hearing process [34] for approving the new OL, a CNSC Commission Member questioned whether the safety upgrades were clearly understood, and whether the expectations regarding the OL condition were specific enough that, in the future, the CNSC Commission would be able to conclude that they were met. AECL and CNSC staff indicated to the CNSC Commission Members that they both understood and agreed on the short term actions. AECL stated: "*No, Madam Chair, in fact we believe the two lists are pretty well aligned."* CNSC stated: *"From a historical perspective, that terminology, "seven upgrades" has been recognized through streams of numerous licensing correspondence and Commission documentation. So from my perspective it's explicitly clear."*

As indicated by the timeline in Appendix D of this report, there were many documents that discussed the NRU upgrades, in general, and the EPS tie-in to the MHWPs, in particular. In addition to letters of correspondence (2/96 & 12/04), there were transmittals of Annual Safety Reviews (3/98 & 3/05), EPS First Safety Notes (4/97, 11/98), EPS Final Safety Notes (9/02 3/05, & 7/05), Design Requirements (3/05) and Design Descriptions (8/00 & 4/05). AECL documents beginning with the AECL Project Upgrades Plan in April, 1993 [35] through Revision 2 of the EPS Final Safety Note in July, 2005 [36], consistently stated that hazards-qualified back-up power was to be supplied to the MHWPs from the EPS Upgrade.

### V.B. Installation of NRU Safety Upgrades Delayed Many Times

The NRU upgrades, including the EPS tie-in to the MHWPs were originally planned for completion in 1997. In April, 1997, AECL's First Safety Note [37] stated that EPS will provide hazards-qualified power for the MHWPs essential for core cooling in 1998. In May, 1998, AECL apprised CNSC in a meeting [38] that the EPS upgrade was scheduled for installation in September 2000. In October 1998, the NRU OL included Licence Condition 27a that the NRU upgrades described in the 1997 NRU Annual Safety Review [18] were to be completed by October 31, 2000. In July 2000, the CNSC Commission was apprised in a CMD [39] that EPS

would not be implemented by October 31, 2000, and NRU would not be in conformance with Licence Condition 27a of the then current OL.

In August 2004, AECL stated in a letter to CNSC [40] that the NRU upgrades would be completed by the end of the fiscal year. In April 2005, CNSC, in a letter to AECL [41], acknowledged AECL's agreement that EPS and NECC were to have been completed by March 2005 and that the deadline had not been achieved. AECL apprised CNSC that the EPS and NECC upgrades would be in service in April/May 2005 and September 2005 respectively. In June 2005, AECL, in a letter to CNSC [42], expressed its understanding that, when the EPS was tied into the Emergency Response Center cabinets, and the tie-ins to the other formally requested upgrades had been made, the commitment to complete the EPS was met. The EPS tie-in to the MHWPs had not been requested and, at that time, was considered by NRU management to no longer be part of the required upgrade.

### V.C. Reasons why AECL did not make EPS connections to MHWPs per Licence Condition 13.1

While AECL actions to comply with Licence Condition 13.1 of the November 2005 OL and make the seven upgrades fully operational by December 31, 2005 were substantial, they were not completely effective, for the following reasons:

1) The NRU reactor OL conditions issued in 2005 and 2006 were not clear, and did not specify in detail exactly which NRU safety upgrades were to be installed. Installation of safety upgrades was part of the information relied on by the CNSC Commission in making its decision to renew the CRL OL in 2006, and was a licensee commitment even though it was not a specific licence condition.
2) The connection of the MHWPs to the EPS required the installation of seismically-qualified DC Motor Starters, but these had not yet been installed because NRU reactor management did not believe there was a licensing requirement to install them.
3) The NRU commitment tracking system was not effective in tracking and monitoring the EPS connections to the MHWPs. Despite the fact that these connections were part of the EPS safety upgrades that were planned by AECL, by 2007, this safety upgrade was not being tracked in the NRU commitment tracking system.
4) Similar to the CNSC regulatory oversight program, AECL NRU upgrades were managed more from an "expert based" approach than a "process oriented" one. AECL, in its internal root cause analysis, found that the NRU staff had made a decision to track the EPS connections to DC motors for MHWPs P-104 and P-105 as a separate work package, outside the scope of the EPS upgrade. The Talisman Team found that the mindset to consider the EPS connections to the MHWPs as being outside the planned upgrades was shared by key project and plant personnel, even though the decision was not formally incorporated into the project plan, the facility modification, the design change package, or communicated to either the AECL Safety Review Committee (SRC) (who had been providing high-level oversight of the upgrades) or to the CNSC. In fact, the Talisman Team found no written document which provided the basis or rationale for this position. In 2005, when NRU management separated the planned connection of the EPS to the MHWP from the EPS safety upgrade activities, some CNSC staff members became

aware of the change, but CNSC management was not informed by CNSC staff or AECL and did not have the opportunity to challenge this decision. CNSC management continued to believe, based on earlier documentation, that the planned safety upgrades included the hazards-qualified EPS provided to MHWPs.

5) The original approach for connecting EPS to the MHWPs involved qualifying the existing, installed DC motor starters. The project was not able to qualify the existing motor starters, and the search for a supplier and qualification of new motor starters took considerable time and effort.
6) When the new motor starters were installed in the plant and connected to the non-essential MHWP for testing, a problem was discovered with starting current. The motor starter manufacturer did not develop a technical solution, so the burden fell on the NRU electrical design engineers, who already had a very heavy workload. While the NRU engineers did come up with a remedy, this took considerable time and delayed the months-long proof test of the motor starters on non-essential pumps. The NRU operations staff wanted these tests performed, in order to demonstrate reliable operation prior to making the connections to MHWPs P-104 and P-105.
7) The NRU operations and facility managers did not share the safety significance of the tie-in of EPS to the MHWP. The safety benefit of implementing the modification to connect the MHWPs to the EPS was not agreed upon, or well understood, by NRU site management. The operators had a lot of confidence in the existing configuration, which included powering the MHWP from the off-site power grid, normal Class IV power, normal Class III diesels, and Class I batteries. They perceived the upgrade as potentially introducing new failure modes while addressing a very improbable external event (design basis earthquake). The operators and plant managers were reluctant to change the power supply configuration and did not drive completion of the EPS tie-in.
8) The AECL SRC was a supporter of the upgrades and considered the tie-in of the EPS to the MHWP to be of high safety significance. However, the SRC was not successful in convincing the NRU staff of its benefits, or influencing its expedited installation.
9) As reported during the interviews, there was a recurring problem implementing long-term projects. Frequently, the projects were said to be adequately funded and provided with sufficient dedicated project resources, but the NRU staff necessary to execute or support key project activities was unable to do so because of its normal day-to-day plant duties, emergent issues, maintenance outage work and other responsibilities.

When AECL informed the AECB of its intent to provide Class 1 power to the MHWP, in December 1992, completion was expected in 1995 or 1996, but an integrated resource loaded plan and schedule had not been prepared to ensure that the targeted completion date could be met. A project was authorized and initiated, and the connection of EPS to the MHWP through hazards-qualified equipment was included in the NRU Upgrades Project Plan. However, the scope was not identified as being a CNSC commitment. The subsequent implementation documents (plant modification package, drawings and procedures etc.) also had no reference to a CNSC commitment. The upgrades were incorporated into the OL as part of Licence Condition 13.1 in November 2005, but at that time the NRU Managers did not view the installation of seismically-qualified DC Motor Starters as part of the “original” NRU Upgrades; yet the DC motor starters were required to tie-in the EPS to the MHWPs.

The action tracking system in use at the CRL is known as the Action Item Management System (AIMS). This system has been used CRL-wide for tracking a myriad of issues, including regulatory issues. Although CRL staff has a handbook available from the software vendor, which provides instructions on how to make entries, AECL staff does not have procedural controls for its use. AIMS entry number 1998-NRUU-UPGR-5 was entered in January 1998, and indicated "fully operational" on October 13, 2005. The installation of the new DC motor starters was entered into AIMS in September 2004, as a non-regulatory item in the Environmental Program plan (EnvA-66), with a target date of March 2005. This effectively removed the tracking of this item from close oversight.

The EPS upgrade was commissioned in late 2005, and a letter was written to the CNSC on December 23, 2005 [22], stating that the upgrades were "fully operational." The basis for that determination or position was that EPS was connected to all the other upgrades, and it was the apparent collective mindset of several NRU managers and key project personnel that the DC motor starters and connection of EPS to the MHWPs were an "enhancement", not part of the upgrades. While there were internal AECL emails that clearly reflected this belief, the AECL project description documents reviewed by the Talisman Team, governing the planned scope of the upgrade project and the design changes for EPS, did not reflect that change. The Talisman Team has identified no project description or project control documents that supported that position.

**Observation (3) – Operating Licence (OL)**

The Talisman Team concluded that the November 2005 OL was not clear, in that it did not define the seven NRU upgrades required to be operational by December 31, 2005.

**Recommendation**

Recommendations C-OL-1 through C-OL-5, as discussed above, address this observation.

**Observation (4) – Project Management (PM)**

The NRU upgrades project management process did not have sufficient controls, and the existing controls it had were not always effectively implemented. The NRU Upgrades Project Plan included connecting EPS to the MHWPs in its scope description; however, the scope was not identified as a licence commitment. Senior AECL managers took the position that the replacement of the DC motor starters, an essential part of the new hazard-qualified EPS connection to the MHWP DC motors, was outside the scope of the NRU safety upgrades and represented an enhancement. This decision was not consistent with the Project Plan, and AECL submittals to the CNSC, including the EPS First Safety Note, the EPS Final Safety Note, the Design Requirement, and the Design Description. A project procedure required a licensing review of scope changes. The decision to exclude the DC motor starters from the rest of the safety upgrades was not considered to be a scope change, and was not reviewed by licensing. The Talisman Team reviewed the guidance provided to the project managers at the time the NRU Upgrades Project was initiated (mid-1990s), as well as the current guidance. The Talisman Team concluded that the earlier guidance, which is based largely on Project Management Institute guidance, is superior. For example, in 1994, an engineering projects procedure

appropriately assigned responsibility for compliance with AECB requirements to the project manager.

**Recommendations**

AECL should consider the following improvements to the project management process:

**A-PM-1:** AECL should ensure its project management guidance is based on the Project Management Institute guidance for project management.

***AECL Management Response***

Since the formation of a consolidated project delivery organization in April 2005, AECL has implemented a project quality program and associated project management procedures that are based on Project Management Institute guidelines (Project Management Book of Knowledge). These project management processes continue to be strengthened based on self-assessments and the auditing process. AECL will review existing procedures and incorporate previous procedures as necessary (see overall recommendation 14).

**A-PM-2:** AECL should ensure that the responsibility for compliance with commitments is assigned to Project Managers.

***AECL Management Response***

Accountability statements and position descriptions for project managers will be reviewed and revised if necessary to ensure responsibilities include meeting regulatory commitments (see overall recommendation 14).

**A-PM-3**: AECL should require Project Managers, by procedure, to include licence commitment references in their project plans, schedules and implementing documents.

***AECL Management Response***

AECL will ensure that its project management procedures include requirements for Project Managers to include regulatory commitments in project plans, schedules and documents. Existing procedures will be reviewed and revised as necessary to ensure regulatory commitments are incorporated into project planning documents (see overall recommendation 14).

**Observation (5) – Modification Management (MM)**

AECL commissioned a facility modification to the EPS, which was not completely installed and tested as required. The back-up EPS power supply to the MHWPs was included in the scope of a plant modification that was commissioned in October 2005, but it was not installed. Completion Assurance Certificates were signed without exception, even though the back-up power to the MHWPs, which was part of the modification, was not installed. The completion assurance process required reviews and sign-offs by all the appropriate functional groups, but completion was signed-off either without verifying all the work was done, or without documenting what work had not been completed in the open items/exceptions list.

The modification was commissioned, and the plant was started up in a configuration other than the one specifically analyzed by the modification package. The current process allows a plant modification to be commissioned with open items, but there is no control over the significance of

the open items. In this case, the tie-in of EPS to the MHWPs was not made. The drawings and procedures at that time showed the system as if the entire modification was complete. In addition, the Talisman Team could find no evidence that the operators were trained on the interim configuration, or that there was a safety case that reflected the interim configuration.

The Project Procedure on Commissioning Completion Assurance (RC-2000-109, CWP-27) provides only for completion assurance of the entire modification, and does not allow for commissioning only part of a modification, as was done for the EPS Upgrade. The Procedure does not adequately address activities not completed at the time of commissioning. For those, it requires the activities to be listed as deficiencies, but it does not provide direction regarding the completion of these activities. The Conduct of Operations Procedure [23] requires closure of the modification after ensuring that all deliverables (document revisions) have been completed.

The current modification process also allows construction to make changes without engineering approval, and submit them to engineering to be incorporated into as-built drawings. Until recently, engineering was considered to be a service organization, and was not accountable for configuration management. Recently, engineering was given more of a leadership role in the process.

**Recommendations**

AECL should consider the following changes to its plant modification procedure and commissioning procedures:

**A-MM-1**: AECL should ensure the Engineering Change Control procedure requires that, when only part of a modification is commissioned and placed in service, the actual configuration has been reflected in drawings and procedures, that operators have been trained, and the specific configuration being placed in service has been analyzed in a safety evaluation (safety case); it should also require a new stand-alone modification be issued, covering installation and commissioning of the remainder of the modification.

***AECL Management Response***

AECL's process for commissioning a system and declaring it in-service requires that drawings, procedures, training programs, and safety cases are up-to-date before the declaration is made. AECL's recently-issued engineering change control (ECC) procedure, 145-508120-PRO-001, provides a structured and controlled process for implementing modifications in a staged fashion. Any deviations to the original engineering change package such as partial implementation would invoke the field change process and a subsequent re-evaluation (including a safety evaluation) and re-assessment of the modifications to the original change package. Any significant deviations (such as changes to design intent, requirements, performance, safety case, hazards assessment or pressure boundary) would result in a rejection of the field change and would require a revision to the original change package. A second change package would then have to be issued to complete any outstanding work. The current ECC procedure will be reviewed and revised accordingly to address partial implementation of modifications at the next revision stage (see overall recommendation 14).

**A-MM-2:** AECL should ensure the Engineering Change Control procedure requires that the as-installed configuration be consistent with the engineering change package.

***AECL Management Response***

AECL's recently-issued engineering change control procedure, 145-508120-PRO-001, requires that the as-installed configuration be consistent with the engineering change package. Currently the process requires a "fully-operational" declaration (meets the change request requirements) and a "close-out" declaration (all documents are updated and there are no outstanding issues) (see overall recommendation 14).

**A-MM-3:** AECL should ensure the Engineering Change Control procedure requires that any non-trivial change must have prior Engineering approval.

***AECL Management Response***

AECL's recently-issued engineering change control procedure, 145-508120-PRO-001, requires Engineering approval for all non-trivial changes. In addition, the field change control procedure (145-508120-PRO-002), currently under revision, describes the requirements to capture changes to approved change packages during implementation (see overall recommendation 14).

**A-MM-4:** AECL should ensure the Engineering Change Control procedure requires that an independent verification of the physical installation be performed prior to completion acceptance.

***AECL Management Response***

AECL's recently-issued engineering change control procedure, 145-508120-PRO-001, requires verification of the physical installation prior to completion. Post-installation field walk-downs are included as part of construction completion assurance. In addition AECL will review its current detailed work plan ("route" sheet) process to ensure adequate inspection, verification, "hold" and "witness" points are properly identified during implementation (see overall recommendation 14).

**A-MM-5:** AECL should ensure the Engineering Change Control procedure requires that for plant modifications done to meet CNSC commitments, a reference to the commitment be included in the applicable documents (drawings, specifications, procedures, etc.).

***AECL Management Response***

See response to A-CM-5. In addition, all change requests include the type of regulatory commitment (REG-C, M or I) and the CNSC commitment date.

**A-MM-6:** AECL should ensure the Engineering Change Control procedure requires specific LCOs, with their detailed bases, to be in effect when modifications are approved and required to be functional by the CNSC.

***AECL Management Response***

AECL will ensure that LCOs are available in the form of a revised FA when seeking approval to operate a new or revised system (see J-OL-2).

**Observation (6) – Work Management (WM)**

AECL did not implement a facility modification which was part of the planned safety upgrades and viewed as a significant improvement to safety in a timely manner, since the installation was still not completed in November 2007.

**Recommendations**

AECL should strengthen its Work Management Process as follows:

**A-WM-1:** AECL should strengthen the long-term planning process (including programs and processes for budgeting and resource allocation, work prioritization, and work planning and control) such that it is aligned with the nuclear industry's best practices. Long-term plans should include resource-loaded schedules for major projects, which reflect the amount of support required and availability of the plant staff. Ensure that all functional departments understand the scope, priority and schedule for regulatory projects. The commitment date and project schedule should be based on plant staff resource requirements and availability, plant operating and shutdown schedules, and safety significance.

***AECL Management Response***

AECL is implementing improvement work management practises that are based on industry best practises. A 13-week rolling schedule has been implemented, and work is underway on a 52-week rolling schedule. Included in the work management process is the identification of regulatory commitments to ensure they are accorded appropriate oversight and priority (see overall recommendations 10 and 14).

**A-WM-2:** AECL should include long-term project work in the recently implemented cyclic work planning process, so that is given appropriate priority and can be completed on schedule. Long-term project work can be planned and staged in advance with routine plant work, such that it can be smoothly executed during a "work week".

***AECL Management Response***

The next stage of AECL's work management improvements that is underway is the rollout a 52-week schedule that includes project work.

**Observation (7) – Modification Management (MM) and Work Management (WM)**

The Talisman Team identified several AECL NRU processes that appeared to have been "overridden" (or not followed) because of the mindset of the NRU management and upgrade experts. Had any one of these processes been sufficiently robust and implemented properly, it should have challenged or prevented the mindset that the installation of the seismically-qualified motor starters and connecting them to EPS was not part of the planned safety upgrade project. The Talisman Team reviewed the applicable AECL processes and their implementation, and identified areas that needed to be further assessed in order to identify specific enhancements. At Talisman's request, AECL formed a team to support the Talisman Team. The AECL Team reviewed Configuration Controls, including Modification Management, Work Control, and Quality Control processes and procedures.

**Recommendations**

**A-MM-7:** AECL should continue its self-assessment of the NRU Configuration Control Processes, including Modification Management processes and procedures.

***AECL Management Response***

AECL will complete the assessment of NRU processes as part of an upcoming PINO (Performance Improvement and Nuclear Oversight) performance-based audit (see A-RC-1).

**A-WM-3:** AECL should continue its self-assessment of the NRU Configuration Control Processes, including Work Control and Quality Control processes and procedures.

***AECL Management Response***

AECL will complete the assessment of NRU processes as part of an upcoming PINO performance-based audit (see A-RC-1).

**Observation (8) – Commitment Management (CM)**

AECL's commitment management process was not effective in ensuring that the commitment made to CNSC to install hazards-qualified back-up EPS Class 1 power to the DC motors of MHWPs was completed by December 31, 2005. If a formal licensing tracking system and the inspection tracking system had been in place, it should have clearly included entries that indicated that the EPS hazard qualified connections had not been completed. This would also have helped to highlight outstanding issues during routine inspections as well as during licensing briefings to the Commission.

**Recommendations**

**J-CM-1**: AECL and CNSC should identify all of the open regulatory commitments, and reach an agreement that these open items will adequately cover the licensing requirements.

***CNSC Management Response***

CNSC will work with AECL to review all open regulatory commitments, including any remaining commitments specified in the Licensing Strategy document, to ensure they are clear, that they adequately address the licensing requirements and that both CNSC and AECL are clear on the necessary actions and timelines to meet the commitment. These will be reviewed by legal counsel for clarity and enforceability. This will be completed by October 31, 2008.

***AECL Management Response***

AECL has started a process to identify open regulatory commitments (see overall recommendations 2 and 13), and will work with CNSC staff to achieve agreement on the set of commitments that adequately cover licensing requirements.

**J-CM-2:** AECL and CNSC should develop and implement a formal tracking system to clearly identify those licensee commitments and statements, as well as track any open inspection or audit findings. As new items are identified by AECL or CNSC, those new items should be entered into the AECL and CNSC commitment action tracking system.

***CNSC Management Response***

CNSC will work with AECL to review and update the AECL's existing commitment tracking system to identify licensing and compliance commitments that are considered of greater risk significance and higher priority. AECL will carry out an effectiveness review of this system by September 30, 2008. In addition, the CNSC will introduce its own simplified tracking system for licensing and compliance commitments that are considered of greater risk significance and higher priority. This tracking system will be developed and implemented by September 30, 2008.

***AECL Management Response***

AECL will work with CNSC staff to agree on a tracking system for licensing and regulatory obligations, for inspection and audit findings, and for licensee commitments (see overall recommendation 2).

AECL needs to strengthen its commitment management process as follows:

**A-CM-1:** AECL should require by procedure that commitments only be made by authorized individuals, in writing, with a clear description of scope and schedule. Prior to making the commitment, a resource loaded plan and schedule must be developed, to ensure that the commitment can be met.

***AECL Management Response***

AECL's regulatory commitment procedure, CW-508760-PRO-246, requires that commitments can only be made by authorized staff, and that schedules and resources are agreed to by line management before the commitment is made. AECL is undertaking an effectiveness review for the commitment procedure to ensure there are no impediments to proper implementation (see overall recommendation 2).

**A-CM-2:** AECL should prioritize existing and future regulatory commitments and initiatives by safety significance, cost, schedule, and plant availability.

***AECL Management Response***

AECL will include in its commitment tracking system a prioritization scheme based on safety, cost and business impact (see overall recommendations 2 and 11). In addition, initiatives will be prioritized on the basis of risk benefit as determined with risk assessment tools (see overall recommendation 6).

**A-CM-3:** AECL should track all commitments in a central database, managed by the licensing group, and reference the licensing commitment number in the implementation plans and execution documents, in order to ensure that no scope or schedule changes are made without a licensing assessment.

***AECL Management Response***

AECL has a database for commitments, and is in the process of making improvements (see overall recommendation 2). Also, commitments are referenced in project management

documentation to ensure changes are only made after a proper assessment (see overall recommendation 14).

**A-CM-4:** AECL should include in the Commitment Management Procedure a step that once a committed action has been completed and verified, the commitment may be closed and CNSC informed in writing.

***AECL Management Response***

AECL will ensure that closure of commitments is addressed in its commitment management procedure (see overall recommendation 2).

**A-CM-5:** AECL should reflect reference to the commitment in implementation documents such as drawings and procedures, to ensure that the commitment is not inadvertently "undone" at a later date.

***AECL Management Response***

AECL will include references to commitments and obligations in licensing bases documents to ensure they are not superseded (see overall recommendation 13, and A-OL-1 and A-CM-3).

**Observation (9) – CNSC Commitment Management (CM)**

CNSC does not have an effective formal system for tracking inspection and licensing issues. The lack of a formal commitment tracking system for both licensing and inspection issues hinders management oversight to ensure proper resolution and closure. Throughout the last 15 years, during which the NRU upgrades were being proposed, implemented, and added to the OL, CNSC experienced considerable staff turnover and established a resident inspector office. The CNSC staff does not have a formal tracking system, to ensure follow-up to commitments and inspection findings when staff changes are made. Outstanding inspection issues, as well as outstanding licensing issues, were not clear to the new CNSC staff during and after turnover of responsibilities.

**Recommendations**

**C-CM-1:** CNSC should develop a formal CNSC tracking system, and use it to monitor outstanding licensing and inspection issues. CNSC should share this with the licensee, to help ensure that both CNSC management and the AECL management have a current understanding of the outstanding regulatory issues. The tracking system should include licensing issues, inspection findings, licensee commitments and action items. This should be used to provide continuity as regulator and licensee staff change over time. It should also be used to assist any new project managers - or inspectors - in knowing the current licence commitments and inspection follow-up status.

***CNSC Management Response***

CNSC will work with AECL to review and update the AECL's existing commitment tracking system to identify licensing and compliance commitments that are considered of greater risk significance and higher priority. AECL will carry out an effectiveness review of this system by September 30, 2008. In addition, the CNSC will introduce its own simplified tracking system for licensing and compliance commitments that are considered of greater risk

significance and higher priority. This tracking system will be developed and implemented by September 30, 2008 (same as J-CM-2).

## VI. CNSC Enforcement

### VI. A. Enforcement of NRU Upgrades Licence Conditions

The CNSC staff conducted a compliance inspection of NRU upgrades and sent the results to AECL in an April 20, 2006 letter [43]. During the inspection, the inspection team identified that the commissioning tests of the EPS seismic upgrades were not completed. The Compliance Inspection Report Summary [43] cited Licence Condition 13.1 "*The licensee shall by December 31, 2005, demonstrate that all seven NRU Reactor safety system upgrades are fully operational.*" There were a number of findings listed under "*Commissioning Adequacy*", one of them was Finding 4.9.1.8, "*The commissioning tests of the new DC Motor Starters and ATS-3 & 4* [Automatic Transfer Switch] *on P-104 and P-105 are not complete.*" The findings under commissioning were analyzed and a Directive OMSD-AECL-2006-T1743-QA-02-D9 was issued: "*Functional, performance, control, and safety requirements for the upgrades were not demonstrated by commissioning in accordance with CSA N286.4 Clauses 2 & 4.1.1, […] AECL shall ensure that the functional, performance, control, and safety requirements for all seven upgrades are demonstrated by commissioning […] For the functional, performance, control, and safety requirements of each upgrade system, AECL shall produce a document that identifies the corresponding commissioning tests.*" The CNSC procedure for performing Type 1 inspections [44] specified that "*If a serious non-compliance or unsafe practice is uncovered during the course of the inspection, it shall be brought to the attention of the team leader immediately for onward communication to the licensing Director or project officer. These situations are dealt with in the appropriate manner and may require use of regulatory tools such as issuance of orders if the situation warrants it.*" Although some of the CNSC staff knew that the connections to the two pumps had not been completed, the inspectors did not identify the EPS commissioning finding, by itself, as a serious non-compliance or unsafe practice.

The Inspection Procedure also required that, prior to the completion or termination of the on-site inspection, the team leader would conduct a final team meeting, to summarize the inspection findings with the help of the team members. The team should also come to a preliminary judgment on whether the deficiencies should be the subject of an Action Notice or Directive, using a flow chart to help decide on classifying their findings as Action Notices or Directives. A Directive is the most serious finding, and is defined in the Inspection Procedure as: "*A written request that the licensee take action to correct a non-compliance with governing regulations, licence conditions, codes, standards, or a general or sustained failure to adhere to approved documents, policies procedures, instructions, programs, or processes that the licensee has established to meet licensing requirements.*" The CNSC Compliance Inspection Report does not include the EPS connection to the MHWP issue as a specific Directive and the Inspection Team did not document whether or not this finding was considered to be in violation of the OL Licence Condition 13.1. The inspectors did not, as a team, classify findings using the flow chart in the Inspection Procedure. The uncompleted commissioning tests of the new DC Motor Starters and ATS-3&4 on P-104 and P-105 became one of eighty-five findings, and since it was not identified

by the CNSC as a licence violation, a Directive or even an Action Notice, it was not perceived by AECL to be a significant problem.

In a June 15, 2006 letter to CNSC [45], AECL responded to the Directives, Action Notices, Recommendations and Findings in the audit report. In this letter, AECL apprised the CNSC that the connection had not been completed. The CNSC staff did not take any enforcement action, and did not provide any feedback to AECL that the lack of the EPS connection was an issue that needed to be addressed promptly.

AECL again informed the CNSC that the connections were not completed, in the Final Safety Note of July 2006 [46]. The Final Safety Note stated that the emergency power supplies are "now being connected" to the DC motors of P-104 and P-105. The Talisman Team could not determine why CNSC did not promptly follow-up on this indication that the EPS was not connected to the MHWPs before the licence was renewed, or at least verify that it had been fully completed, especially since other AECL documents indicated that the EPS was "fully operational".

### VI. B. CNSC Inspector Training

CNSC staff stated in interviews that, except for the on-site CNSC CRL inspectors, the training program for inspectors is fairly brief and not very comprehensive. While the Talisman Team did not conduct (nor was it requested to conduct) a rigorous review of the CNSC Technical Training Program, it appears that a more thorough and formal training in the CNSC regulatory process (including the inspection and enforcement roles and responsibilities) is warranted. From various interviews, it was not clear whether CNSC staff understood who is responsible for documenting licence violations or non-conformances, or how to document known or observed violations of CNSC regulatory requirements in formal inspections, or enforcement documents.

The Talisman Team was told that, during this period of time, there were CNSC management changes in the CRL Compliance and Licensing Division, a change in the CNSC Single Point of Contact (SPOC) for the NRU reactor, reassignment of key CNSC staff away from oversight of the upgrades to other CRL licence renewal issues; a high priority was placed on getting the NRU licence renewal document prepared. This high priority was necessary because the NRU licence was scheduled to expire in July 2006, which would presumably have forced the NRU reactor to shutdown.

### Observation (10) – Enforcement (E) – Characterization of Findings

The Talisman Team concluded that the inspection team did not follow the CNSC Inspection Procedure as it relates to identification of licence violations and, as a result, they did not fully understand whether a violation of Licence Condition 13.1 had occurred or not. The issue was not effectively raised to the CNSC management, or to the CNSC counsel, for assistance in determining whether there was a licence violation, or whether enforcement action should be taken. If the CNSC Type I Compliance Inspection had highlighted the potential licence violations due to the lack of EPS upgrade components, appropriate corrective action could have

been taken much earlier, or agreement may have been reached that the connections could be made on a different schedule, as had been the case for earlier dates for upgrade implementation.

**Recommendations**

**C-E-1:** CNSC senior management should clearly promulgate their expectations regarding procedural adherence by CNSC staff. This should include clearly documenting in every audit or inspection report whether any OL violations were identified or not, as well as the safety significance, as it is understood at that time.

***CNSC Management Response***

The CNSC management will immediately remind CNSC staff of expectations for procedural adherence. This will include re-enforcing the expectation to clearly document and communicate any identified license violation and their relative safety significance.

**C-E-2:** CNSC senior management should provide training for all CNSC staff that conducts inspections, to ensure that CNSC staff understands how to identify and document OL or regulation violations, and encourage the inspectors to get advice from CNSC counsel if there are any questions concerning a possible OL violation.

***CNSC Management Response***

In 2006, the CNSC approved the development of courses for inspectors: a 2 day course for inspection and a 3 day course for investigation. More than 75 inspectors have been trained. The next course is scheduled for October 2008. The CNSC will ensure that all current inspectors at the CRL site attend existing training courses on inspections and investigations. As the compliance process and procedures are revised or formalized, CNSC will update its training program and ensure all compliance staff receive the necessary training.

**Observation (11) – Enforcement (E) Assessment of Penalties**

The enforcement of the CNSC expectations and requirements for the NRU upgrades has not been effective. The Talisman Team observed that CNSC staff had identified multiple examples of non-compliance with CNSC requirements and expectation. The CNSC staff response has only been to request that AECL respond with plans and schedules for correction and upgrades (also see report Section IV.D above and the discussion regarding the Licensing Strategy document that needed to address "known non-compliances with regulatory requirements and safety concerns"). Thus, it appears that there is really no "penalty" imposed by CNSC for failure to meet a regulatory requirement in most instances. AECL is simply requested to respond to the issue. While the CNSC can order the reactor to be shutdown or propose a potential monetary fine, it can only do so by requesting the Canadian Department of Justice to go to court. This latter enforcement action appears to require much more effort from the CNSC staff and it is very seldom used.

**Recommendation**

**C-E-3:** CNSC senior management should adopt an Enforcement Policy which includes the ability to levy monetary fines. If necessary, the CNSC should request civil penalty authority. This should be an inherent authority of CNSC, not subject to support from other government agencies. This provides the regulator with a more efficient and effective way to identify those violations that warrant elevated enforcement action, and enables the regulator to be more effective in ensuring regulatory requirements are met.

***CNSC Management Response***

This is currently under review and will be further examined for possible application. The implementation of this proposal would require changes of the *Nuclear Safety and Control Act*, legal reviews and the establishment of qualified staff and supporting tools to ensure its effective execution. The CNSC will review this option with its Legal Counsel and provide a recommendation to the Commission by November 2008 that will include a proposed timeline for bringing the necessary changes for parliamentary approval and executing the implementation pending the approval.

## VII. Communications between CNSC and AECL on NRU Safety Upgrades Requirements and Progress of Work to Support Licence Renewal.

### VII. A.Mutual Understanding - Agreement between CNSC and AECL for EPS Tie-in Implementation

The Talisman Team was asked to assess whether there was a clear mutual understanding of the design details for the NRU upgrades which would be installed by AECL, on what schedule, and which specific aspects of those upgrades would be required as a condition of the license.

In written correspondence from AECL, the upgrades were frequently discussed in general terms (such as "*the Upgrades are fully operational*") without specifying to any detail exactly which upgrades were being discussed. Formal written correspondence between the licensee and regulator does not always reference a controlled design description document which could be understood by both the licensee's design and construction staff and the CNSC inspection and technical review staff. The Facility Authorization (FA) offers a process for implementing modifications [23] that, if followed, would result in detailed descriptions of modifications at the conceptual and final stages. AECL appears to have followed the process by submitting First Safety Notes and Final Safety Notes, which described the EPS Upgrades in sufficient detail to achieve mutual understanding that the hazard-qualified Class 1 power supply to the MHWPs P-104 and P-105 was a key part of the upgrade.

However, on several occasions after December 31, 2005, AECL maintained in other correspondence that the NRU upgrades, including EPS, were fully operational, while noting that the EPS connection to the MHWPs had not been completed. Neither AECL nor the CNSC staff acted to resolve the apparent inconsistency. As discussed earlier, in the October 2005 CNSC Licence Renewal Hearing, one of the CNSC Commission Members questioned whether CNSC staff and AECL agreed on the details of the seven upgrades, and the Commission Members were assured by both the CNSC staff and AECL that they agreed. CNSC staff stated that, from a historical perspective, the "seven upgrades" terminology has been recognized through numerous licensing correspondence and CNSC Commission documentation.

The Talisman Team believes that the inconsistency between AECL and the CNSC senior management positions' understanding on the status of the upgrades becomes evident in reviewing the correspondence sent to CNSC after the Hearings. On December 23, 2005, AECL reported [22] that *"all seven NRU upgrades are fully operational."* On May 31, 2006, in a letter

to the CNSC [47], AECL reiterated that *"the current upgrades are fully operational"* even when NRU management knew that the EPS connection to the MHWPs had not been implemented. This management understanding difference between AECL and the CNSC continued until November 2007.

**VII. B. Effectiveness of CNSC and AECL Communications**

Multiple AECL documents, provided to the CNSC from April 2005 through June 2006, indicated that the EPS upgrades, including the seismic qualification, have been fully operational, completed, or are ready for tie-in. On the other hand, multiple AECL documents also indicated that the DC motor upgrades were not connected.

Documents indicating that the EPS upgrades are operational, completed or ready for tie-in include:

- April 13, 2005, AECL, R. K. Kumar Letter to CNSC A. Alwani, "*fully functional for 2 years*", ready for tie in. [48]
- December 23, 2005, AECL, W. R. Shorter, Director NRU Facility Authority, letter to C. Nache, Project Officer, CNSC written confirmation that seven mandated safety upgrades were fully operational. [22]
- March, 2006, CRL-00521-LP-002, "*remaining two systems that complete the installation have been made fully operational (2005 December). […] The seven seismically and environmentally qualified upgrades identified in earlier engineering and safety reviews have been completed."* [49]
- May 31, 2006, letter from AECL to CNSC stated *"I would like to reiterate that AECL is convinced the current NRU upgrades are fully operational and that they will meet their functional and performance requirements if called upon to operate."* [47]
- June 23, 2006, NRU-150113-021-000, NRU Action Plans, response to CNSC Licensing Strategy, the EPS is *"Fully Operational [...] As of January 2006, all Safety Upgrades meet these conditions and have been declared "fully operational."* [50]
- March, 2007, AECL Safety Analysis Report, NRU Safety Analysis Report, NRU Licensability Extension Project, NRU-01320-SAR-001 AECL MISC-300, Rev. 1, A set of seven major upgrades, designed to enhance the safety of the NRU Reactor, have been installed. *"As part of the upgrades package, MHWP DC Motors 4 and 5 have been equipped with seismically-qualified starters that incorporate transfer switches."* [51]

Following the December 2005 deadline for having all seven upgrades fully operational, AECL provided information to the CNSC that the EPS was not connected to the MHWPs. CNSC staff did not question or challenge AECL, and did not raise this issue to CNSC management as a potential licensing requirement that was not being met.

- March 17, 2006, preliminary response to the CNSC audit states that the EPS upgrades are connected with the exception of the DC motors for P 104 and 105. [52]
- June 15, 2006, AECL, W. R. Shorter, Letter to C. Nache, CNSC, "*Type I Compliance Inspection Report OMSD-AECL-2006-T1743-QA-02 NRU Upgrades QA Audit*", *"All*

*upgrades are now connected to the EPS, except for MHWP #4 & #5 DC motors. B-20-004 will be the full functional test for the EPS."* [45]

- July, 2006, AECL Nuclear Safety Note "Final Safety Note on the Emergency Power Supply (EPS) Upgrade of NRU", *"EPS power supplies are now being connected to the dc motors P-104 and P-105 […] When commissioning installation of the new DC motor starters for main heavy water pumps P-104 and P-105 is completed a full functional test of EPS system will be repeated."* [46]
- July 6, 2006, AECL, Shorter, Letter to CNSC, Nache, *"...the DC starters are being replaced by hazards qualified units."* [53]
- August 31, 2006, AECL, W. R. Shorter letter to CNSC, L. Lang, "Type 1 Compliance Inspection Report OMSD-AECL-2006-T1743-QA-02 NRU Upgrades Audit, File Number 26-1-54-3-12" AECL response to Finding 4.9.1.4 "*Commissioning Procedure B-20-004 will test the system under actual load conditions, when the new DC motor starters are connected up."* Finding 4.9.1.5 *"All upgrades are now connected to the EPS, except for MHWP #4 & 5 DC motors." Finding 4.9.1.7 "Correct. Testing of the new DC motor starters is still in progress."* [54]
- December, 2006, AECL "Emergency Power Supply Commissioning Verification", NRU-152006-REPT-002, Revision 0. The Commissioning Verification Report for EPS was prepared in response to CNSC Directive OMSD-AECL-2006-T1743-QA-02-D9 to review the adequacy and completeness of the commissioning program applied to EPS. The verification report states *"In October 2005, with approval of the SRC and the CNSC, the final connections of EPS power to the other safety upgrades were completed and the system was brought to the 'fully operational' […] Replacement of these starters was an addition to the original project scope resulting from the NRU safety reanalysis. It will provide enhanced protection against Loss of Flow especially after a seismic event. […] The final commissioning report shows that there were 72 commissioning procedures completed for the testing of individual components/equipment during the inactive phase of commissioning. There were seven additional procedures identified for the active commissioning phase. Five of these have been completed to establish that the system functions as designed and its acceptance criteria are met; the remaining two procedures are related to the new qualified DC motor starters and will be completed after the new starters are installed."* [55]
- March, 2007, Annual Safety Review, *"As part of the NRU upgrades new seismically qualified direct current (dc) motor starters were purchased. Installation and testing of these starters for the Main Heavy Water Pumps 4 and 5 will continue in 2007."* [56]
- July 31, 2007, NRU Life Extension Final Report, *"A subsequent design addition to the Upgrades work of significance has been the replacement of the DC Motor Starters for Main Heavy Water Pumps #4 and #5 with seismically qualified units. One of these starter units was installed in a test circuit #1, 2005 April, and underwent a few months of in-service testing on Main Heavy Water Pump #1. Starter unit testing was completed, some recommended modifications to the DC motor starter were made and retesting was completed. Results of the retesting are being evaluated prior to tie-in."* [57]

There were multiple AECL and CNSC staff meetings on the actions needed to respond to the NRU upgrade audit findings. However, when asked about these meetings during interviews by the Talisman Team, the staff had no recollection of any discussion about the EPS connections

being made or not being made. As noted earlier, there was no formal commitment tracking system, at either AECL or the CNSC, that prioritized the remaining work to be completed according to its safety significance. As a result, AECL staff focused on the CNSC Compliance Inspection Directives and Actions items as the highest priority issues to be addressed for licensing, along with other actions that the CNSC staff had identified in the Licensing Strategy document.

**Observation (12) Communications (CC)**

Given the number of opportunities that the CNSC management had to request information from the CNSC staff, and the number of opportunities that the CNSC staff had to identify the issue and inform CNSC management of potential issues which were not resolved, there is a need to improve CNSC internal communications and engagement of managers with the staff. Based on the Talisman Team review of the information presented to the team members, the following recommendation is made:

**Recommendation**

**C-CC-1:** CNSC management should communicate an expectation of "no surprises" to the CNSC staff, and foster a culture that encourages the staff to feel free to bring safety issues or potential problems to the attention of management.

***CNSC Management Response***

CNSC management is working to improve communications with its staff by encouraging open communications, insisting on a "no surprises approach" and supporting staff that brings problems to the attention of management.

## VII. C.Information on which the CNSC Commission Members Based their 2006 NRU Reactor Licence Renewal Decision

The July 2006 record of proceedings, including reasons for decision [58], delineates the information relied on by CNSC Commission Members in deciding to renew the NRU reactor operating licence through 2011. The CNSC Commission Members based their decision on, among other things, the AECL licence renewal application [59], the CNSC and AECL prepared CMDs, and the CNSC staff and AECL presentations and statements made at the CNSC Commission meeting.

The CNSC Commission decision stated "*AECL's SAR indicated that the present NRU design, including the recently completed safety upgrades, provided adequate protection. ...The upgraded NRU would not pose an unacceptable risk to the public …*"

A review of the licence application, CMDs and briefing testimony indicated that the CNSC Commission was apprised of significant staff concerns with the implementation of the safety upgrades; but the CNSC Commission was not specifically informed that the EPS was not connected to the MHWPs.

In its CMD supporting the AECL licence application [59], the CNSC staff referred to the current licence condition requiring AECL to demonstrate that all seven NRU upgrades are fully

operational by December 31, 2005, and noted that, following AECL's declaration of the operational status of the upgrades, the CNSC staff had conducted an audit. The CNSC staff summarized the audit findings in Appendix E of the CMD, and noted: "*Preliminary results from the audit indicate there are significant deficiencies ... As a result there is lack of assurance that the safety upgrades possess the physical functional and performance characteristics to meet their design objectives with high reliability."* The staff stated *"At the time of writing this CMD CNSC staff is in the process of considering the implications of these deficiencies to the extent that* [they] *will provide the level of assurance that the upgrades possess the physical, functional and performance characteristics to meet their design objectives with high reliability. […] CNSC staff will be in a position to provide more details on these regulatory requests or actions for Hearing Day 2.*" CNSC staff stated in CMD-06-H9.B [61], "*CNSC's staff review of the NRU Upgrades concluded that, although they possess the physical, functional and performance characteristics to meet their design objectives, there is a lack of assurance that they will perform their functions with high reliability*." [60]

In its CMD 06-H9.1 [49], AECL stated "*The seven seismically and environmentally qualified safety upgrades identified in earlier engineering and safety reviews have been completed."* AECL did not clarify to the CNSC Commission that the EPS tie-ins to the two pumps were now considered an enhancement, and no longer part of the EPS safety upgrade.

As noted in the information provided to the CNSC Commission Members, the Type I Compliance Inspection Report of April 20, 2006 [43] described many deficiencies in the two (LCVC and EPS) safety upgrades selected for audit. This inspection report appeared to be a very thorough and detailed inspection of the safety upgrades, except for the EPS connections to the MHWPs P-104 and P-105. In fact, the report concluded that AECL had not ensured that LCVC and EPS designs met all the design requirements. *"These deficiencies are due to a number of quality processes not being applied during the upgrades project from design to commissioning. As a result, there is a lack of assurance that the safety upgrades possess the physical, functional, and performance characteristics to meet their design objectives with high reliability."* The uncompleted commissioning tests of the new DC Motor Starters and ATS were just one of eighty-five findings documented in the Compliance Inspection Report.

In a March 17, 2006 preliminary response to the inspection [52], AECL stated that the EPS upgrades were connected, with the exception of the MHWPs P-104 and P-105 DC motors. AECL made briefings to the CNSC Commission Members on April 26 and June 28, 2006. As noted above, since AECL management did not consider it to be part of the upgrades, they did not apprise the CNSC Commission Members that the EPS was not connected to the MHWPs as originally planned.

The June 28, 2006 CNSC staff presentation to the CNSC Commission Members (CMD 06-H9.B) [60] did not fully reflect the CNSC inspection findings because the incomplete commissioning of the DC motor starter upgrades was not mentioned. The fact that the motor starters were not connected was known to some of the CNSC staff, as indicated by interviews of both organizations. Since the briefing materials provided to the CNSC Commission primarily described the deficiencies identified by the inspection as "quality assurance" issues, they did not focus on the incomplete EPS installation. There was no evidence of CNSC management reaction

to the audit team findings on the motor starter connection to the EPS connections, other than to address the audit status in the CNSC Commission hearing.

### VII. D. NRU Licence Renewed without Up-To-Date Reference Documents and Clearly Specified Technical Requirements

The CNSC Commission Members renewed the NRU reactor OL, despite the fact that the NRU licence did not have LCOs or a FA that reflected the actual plant configuration for the EPS, or an approved FSAR that was up-to-date. This was not unprecedented. The CNSC Commission had approved NRU licence renewals without a CNSC staff's formal approval of similar documents, in the past. CNSC managers had not previously required the CNSC staff to complete their reviews of the AECL submittals in a timely fashion. The backlog of documents to review and approve, so as to support the CNSC Commission hearing before the licence expired was a very challenging amount of work for the existing CNSC staff.

The CNSC Commission Members approved a licence condition that referred to a "Licensing Strategy" document which did not clearly specify the requirements to be met. The Licensing Strategy document was based in large part on what was yet to be done to achieve compliance with "modern standards." There was no clear definition of what "modern standards" were to be met.

There was a sense of urgency to prepare the licence renewal documentation, which was necessary in order for the CNSC Commission to issue a new AECL licence, which would permit the continued operation of the NRU reactor and the entire CRL site.

### VII. E. Focus of CNSC Activities

The Talisman Team concluded that the licence was renewed although the EPS upgrade had been audited and found not to have been properly installed (in the opinion of some CNSC staff). The Talisman Team learned that a significant effort was undertaken by the CNSC staff and management, to support various OLs by reviewing and approving revisions to OLs. This resulted in CNSC staff not reviewing other AECL submittals in detail, and not having enough time to formally document their review of AECL documents that had been submitted for review and approval. Any licence renewal requires substantial CNSC staff and licensee effort, to support the CNSC Commission Hearing. The very short licence duration for the November 2005 licence renewal, coupled with the fact that it was not acceptable to be without an approved OL, created a situation of constant "churning" of activity related to revising and updating OLs. CNSC staff and AECL staff were preparing for - or participating in - CNSC Commission meetings at the rate of one per month, between mid-2005 to mid-2006. Appendix G lists the types of licensee and CNSC staff interactions that occurred during this period, each of which required preparation for and participation in the CNSC Commission meetings.

The existing CNSC licence renewal practice allows for licence renewal applications having short-lead times, and for short licence extension periods. The licence renewal process is labor-intensive, and can distract CNSC staff and AECL personnel from operational issues. CNSC staff indicated during the interviews that they spent more time on licence renewal than on oversight of

plant operations. The NRU licence renewal process strained CNSC resources and this, in turn, appeared to affect the timeliness, thoroughness and rigor of the NRU licence reviews.

**Observation (13) – Operating Licence (OL)**

The CNSC Commission based its licensing decision on an FSAR that was not approved or referenced in the OL.

**Recommendation**

Recommendation J-OL-2 addresses this observation.

**Observation (14) – Communications (CC)**

From a review of the above documents, the Talisman Team concluded that AECL and CNSC staffs did not effectively or clearly communicate with each other, on multiple occasions. The NRU process for communicating with the CNSC was ineffective. When certain NRU project staff first embraced the belief that the EPS tie-in to the MHWPs was not part of the safety upgrades, the licensing and commitment management process should have flagged the need to ensure that their understanding was shared by the CNSC. Communications between CNSC and AECL did not result in a common view of system requirements and facility equipment status at the senior management level.

Between December 2005 and July 2007, AECL provided inconsistent statements regarding the status of the safety upgrades. They were *"operational"*, but the motor starters were *"not installed"*; however, this was not challenged by the CNSC staff. There are multiple written documents from AECL which indicated that the EPS upgrades (including hazards qualification) were fully operational or ready for tie-in. In a May 31, 2006 letter to CNSC, AECL stated that the *"current upgrades are fully operational"*, at a time when AECL knew some CNSC staff were aware that the upgraded DC motor starters were not in service. AECL's notifications were either missed or not acted upon by CNSC staff. According to an internal AECL root cause analysis [62], sometime between April 2005 and June 2005, NRU senior managers decided to track EPS to the DC motor starters separately from the other safety upgrades. However, the Talisman Team could not find a written request for a modification of the scope of the EPS safety upgrades from AECL, following the spring of 2005 decision.

Although it is apparent, from a review of correspondence, that there was an attempt to agree on certain actions, it is not exactly clear what specific terms used meant in a regulatory or operational sense. Terms used include, for example, "7 upgrades", "declared fully operational", and "declared in service." These terms were not defined in the OL - and had they been, there would have been a basis for the reactor operators to use them in daily licence verifications and required actions.

Regulatory language used by the CNSC includes terms such as "expectations", and "we are asking AECL…" It is not clear that either the licensee or the regulator understood precisely and consistently what was required, when it was required, the actions specified and consequences, if not met.

The Talisman Team was informed that formal CNSC licensing documents, which are approved by the CNSC Commission, are reviewed by counsel to ensure they are consistent with the requirements of the *Nuclear Safety and Control Act*. However, unless requested by the CNSC staff, their legal review does not normally include all the documents referenced by the licence, or key documents that are incorporated by the documents referenced in the license. There also appears to be no general policy to have other regulatory documents and decisions routinely reviewed and concurred in by counsel, so as to ensure that the requirements are clear, inspectable, and are clearly enforceable. Counsel is available to advise the staff on potential licence violations. However, the staff is involved in many regulatory licensing reviews, and a legal review of potential violations is discretionary unless Commission involvement is required, such as the issuance of an order, or the referral of a violation to the Department of Justice for a proposed civil penalty.

**Recommendations**

**J-CC-1:** CNSC and AECL should strengthen the quality and timeliness of internal and external communications, including a process to elevate issues of differing views to higher levels of management for resolution when needed.

***CNSC Management Response***

The CNSC and AECL have recently developed a protocol for communications at the working level. CNSC and AECL will extend that protocol to ensure it promotes effective (timely and high-quality) communications, to include a process for escalating issues to senior management for resolution (where required), and to include senior- and executive-level meetings. An agreed schedule for senior and executive level meetings between AECL and the CNSC will be completed by June 30, 2008. The formalized communications and problem resolution process will be developed, documented and implemented by December 31, 2008.

***AECL Management Response***

AECL will work with CNSC staff to strengthen existing communication channels at working and senior levels, including ensuring that regular meetings at all levels, including senior and executive management, continue (see overall recommendation 5).

**A-CC-1:** AECL should improve its communications with CNSC at all levels, including site licensing interactions, site senior management meetings, and corporate visits to the CNSC senior executives. AECL should implement formal communication plans and procedures, conduct training on their use and conduct an effectiveness review, at least annually. AECL should include, as a matter of routine, expectations that their managers periodically meet with regulatory organizations, to make sure that communications are effective.

***AECL Management Response***

As discussed under J-CC-1 and overall recommendation 5, AECL will be working with the CNSC to improve communications channels at all levels and will be developing a Regulatory Communications Protocol. In addition, AECL will incorporate an annual effectiveness review of regulatory communications in the self-assessment program for Licensing.

**C-CC-2:** To ensure that the CNSC regulatory position is clear and understandable, CNSC should adopt a practice of issuing a Safety Evaluation Report (SER) that summarizes the basis for the CNSC review and acceptance of a design change or licence amendment. These CNSC SERs should be issued as timely as possible, and the CNSC managers should establish a planned review completion schedule for each major licensing document.

***CNSC Management Response***

The CNSC has recently developed a process for conducting technical assessments for life extension projects for Nuclear Power Plants. The CNSC will immediately adopt this process for use with NRU reviews.

**C-CC-3:** CNSC should not normally request reports and analyses that they do not intend to review. CNSC should document its approval, approval with conditions, or disapproval in written correspondence to the licensee.

***CNSC Management Response***

Reports and analyses are required from licensees to document licensee performance and demonstrate compliance with requirements and to confirm to both the licensee and the CNSC that the facility can and is being or will be operated safely. The CNSC applies a risk informed approach when establishing the level of review of reports and analyses. Effective immediately, the CNSC will ensure that licensees are informed within 5 business days to confirm receipt of any reports and analyses. The CNSC will ensure the licensee is informed of the CNSC review plans. CNSC acceptance, approvals, approval with conditions or disapproval will be communicated in writing. Refer to C-CC-2 with regards to documenting the decision following the review.

**Observation (15) – Communications (CC)**

The Talisman Team reviewed a joint pilot procedure, Communications Protocol for CNSC staff and AECL CRL Licensee, dated April 24, 2007, which had been approved for a 3-month trial use. The purpose of this procedure was to ensure that the communication process - the interface between CNSC staff and AECL-CRL licensee - is well coordinated, effectively managed, and responsive to the needs of the staff and licensee. Although the Talisman Team understands that this procedure was coordinated by both CNSC and AECL staff to improve communications, AECL needs to have its own communication protocol procedure.

**Recommendation**

**A-CC-2:** AECL should issue its own communication protocol, and reemphasize or implement a policy of "no surprises" and 3-way communication with CNSC staff on regulatory issues and the status of regulatory commitments.

***AECL Management Response***

AECL will issue a Regulatory Communications Protocol addressing these suggestions and provide training (see A-CC-1 and overall recommendation 5).

**Observation (16) – Operating Licence (OL)**

General legal services are an essential element in nuclear regulation and licensing. This is not only important in official licensing, inspection, and enforcement activities, but also in the normal course of day-to-day internal business. This would include efforts to approve regulatory documents specifying requirements in the preparation and issuance of OLs and permits. From the terms used in several written communications between the CNSC and AECL, it is evident that a much higher level of clarity could have been achieved.

**Recommendations**

Recommendations C-OL-3 and C-OL-5 address this observation.

**Observation (17) – Enforcement Discretion – (E)**

It is noted that some of the decisions made by the CNSC staff in this instance appear to reflect elements of "enforcement discretion" without the supporting regulatory framework and documentation. A formal Enforcement Policy would address the process for evaluation of potential licence violations, establish the steps needed to evaluate the safety significance of a violation, and address the actions to be taken, such as compensatory measures to be implemented by the licensee. The Talisman Team notes that if the safety upgrades were required to be in service by a licence condition, or at least made a clear condition of the licence with the appropriate LCOs (placed into the FA), the reactor operators would have known which equipment was required to be operational in order to operate the NRU reactor.

**Recommendation**

**C-E-4:** CNSC should develop and implement an Enforcement Policy that includes guidance for the CNSC staff to exercise enforcement discretion under certain conditions. This needs to be fully coordinated with CNSC in-house counsel in both the development of the policy and the oversight of its implementation to ensure consistency among inspectors. Should CNSC obtain the authority and ability to issue civil penalties as recommended above, this should also be covered in the new Enforcement Policy.

***CNSC Management Response***

The CNSC recognizes the need to ensure clarity on the range of enforcement tools to be applied commensurate with the severity of non-compliance and the overall safety significance. The CNSC will complete a review and ensure clarity on the range of existing enforcement tools and their application by September 30, 2008. The CNSC will also document the process for graduated enforcement including guidance for assessing the risk significance of temporary conditions on NRU safety systems and identifying appropriate regulatory actions. This will be communicated to both licensees and staff. This will be completed by November 15, 2008.

**Observation (18) – Licence Renewal – (LR)**

The NRU licence was renewed without the formal approval of key documents such as the FA and FSAR, which are key documents to understanding ongoing compliance. The CRL OL was renewed based in part on completion of the seven NRU upgrades, but as noted earlier, the Talisman Team found that there was not always a clear mutual understanding of the design details for the NRU upgrades which would be installed by AECL, on what schedule, and which

specific aspects of those upgrades would be required as a condition of the license. The practice of requiring CNSC Commission approval of every licence amendment adds an additional burden on the CNSC and AECL staffs. The information provided by both the CNSC staff and AECL staff to the CNSC Commission Members was incomplete, in that neither staff apprised the CNSC Commission Members that the EPS to the MHWPs was not connected, even though this had always been part of the EPS upgrade safety function.

The Talisman Team judged that this situation contributed directly to a "CNSC culture" with a priority to process a licence application on a fast-track schedule, as opposed to having ample time and resources to thoroughly review and evaluate proposed safety cases and safety analyses, develop regulations and regulatory guidance, and verify the implementation of existing licenses. The lack of a "Timely Renewal" process contributed to this workload demand for both organizations.

**Recommendations**

**J-LR-1:** AECL and CNSC should strengthen the licence renewal process to require more complete and accurate information to be provided to the CNSC Commission Members, especially if, in the view of the CNSC staff, the information involves a key safety issue or a potential licence violation. Both organizations need to be prepared to bring the most up-to-date and detailed information to the CNSC Commission Members.

***CNSC Management Response***

As part of documenting the licensing process, the CNSC will review the format and content of CMDs and supporting documents to ensure more complete and accurate dissemination of information to the Commission. The plan and timeline for completing this work will be established by September 30, 2008.

***AECL Management Response***

AECL agrees, and will provide guidance for ensuring open and complete communications to Commission Members in its Regulatory Communications Protocol (see overall recommendation 5).

**C-LR-1:** CNSC should review the current statutory authority for licensing and, if the ability to delegate the authority for issuing licence amendments to the CNSC staff exists, authorize the Executive Vice-President or the Directors General for Licensing to approve licence amendments. If that authority does not exist, the CNSC should request it from Parliament.

***CNSC Management Response***

In alignment with the *Nuclear Safety and Control Act*, CNSC will review and seek Commission approval to further delegate authority from the Commission to Designated Officers including the Executive Vice-President and the Director Generals or seek to further streamline of the Commission decision making process to approve license amendments in abbreviated time periods. The two options will be reviewed by October 31, 2008 and presented to the Commission in November 2008 with implementation to follow pending Commission approval.

**C-LR-2:** CNSC should adopt a "Timely Renewal" licensing process. This would allow an existing licence to remain in effect until CNSC had completed its full licensing review. This would be based on the receipt of the application at least one year prior to the licence expiration date. The existing OL remains in effect until CNSC decides to issue or not the new licence. If there is a significant safety issue during the timely renewal period, CNSC can issue an order to the licensee to take the actions necessary to ensure protection of the public health and safety, the workers, or the environment. Under "Timely Renewal", CNSC retains the option for a periodic safety review, while at the same time having the flexibility for additional or more in depth licensing evaluations or to address unforeseen operational issues.

***CNSC Management Response***

CNSC already extends licenses as appropriate through license amendments. The CNSC further explored opportunities to further utilize license amendments to extended licenses as appropriate. This was completed on June 30, 2008. In addition, the CNSC is currently reviewing the use of Periodic Safety Reviews for Nuclear Power Plants and NRU to support a more systematic and timely approach to safety review that could lead to extended licence durations. This in turn will facilitate the timely submission and review of license renewal applications. The CNSC will bring forward a proposal to the Commission by December 31, 2008.

**C-LR-3:** CNSC should consider requiring that licence applications be submitted under oath or affirmation. This would emphasize the importance of providing accurate information to the CNSC to make its licensing decisions.

***CNSC Management Response***

Paragraph 48(*d*) of the *Nuclear Safety and Control Act* states that "Every person commits an offence who
(*d)* knowingly makes a false or misleading written or oral statement to the Commission, a designated officer or an inspector;"

Section 51(3) further states that every person who commits such an offence
"(*a*) is guilty of an indictable offence and liable to a fine not exceeding $1,000,000 or to imprisonment for a term not exceeding five years or to both; or
(*b*) is guilty of an offence punishable on summary conviction and liable to a fine not exceeding $500,000 or to imprisonment for a term not exceeding eighteen months or to both."

The CNSC will review for the possible use of oaths and affirmation to further promote compliance. As part of its compliance process, CNSC will review its enforcement process including investigation and possible prosecution in the event of submittal of false or misleading written or oral information. A schedule for completing this work will be established by September 30, 2008.

**Observation (19) – Licence Renewal (LR)**

Licence renewal is a very labor intensive effort, and has challenged CNSC staff resources during periods of high turnover and reduced staffing levels.

**Recommendation**

CNSC should implement the following improvements to the licence renewal process:

**C-LR-4:** CNSC should shift to a more process-based system, where regulatory requirements and expectations are specified in writing and in guidance documents.

***CNSC Management Response***

This is currently underway, as the implementation of the CNSC Management System and associated improvement initiatives are delivering this.

**C-LR-5:** CNSC should issue a Standard Format and Content guide for use by licensees in preparing licence applications.

***CNSC Management Response***

Similar documents are already under development to support the application for New Reactor Builds. As part of documenting the licensing process CNSC will capitalize on this work, and document standard formats, guides and review plans for all major facilities with NRU as a high priority. A schedule for completing this work will be established by September 30, 2008.

**C-LR-6:** CNSC should issue a Standard Review Plan for use by the CNSC staff in conducting their safety reviews.

***CNSC Management Response***

The development of "review guides" is currently being undertaken for the review of applications for new facilities. The CNSC will review these guides to establish simplified templates for producing "standard review plans" for all licensed major operating facilities starting with NRU. A schedule for completing this work will be established by September 30, 2008.

**Observation (20) - Licence Renewal (LR)**

CNSC staff specifies the standards approved for use and required to be implemented by AECL. CNSC encourages its licensees to periodically upgrade to modern standards. Frequently, the term "modern standards" is used without definition.

**Recommendation**

Regarding the practice of upgrading to modern standards, CNSC should consider:

**C-LR-7:** CNSC should not, unless there is a safety justification, change the standards that were in effect when the reactor was licensed. Those standards should remain unchanged for the duration of the licence, to provide for regulatory predictability and stability. If CNSC desires to revise these standards during periodic safety upgrades, it should specify this and provide the basis so that licensees become aware of the expectations to be met.

***CNSC Management Response***

In documenting the process for conducting technical assessments, the CNSC will document the standards to be used. These and any subsequent changes and the basis for them will be communicated to the licensee. A schedule for completing this work will be established by September 30, 2008.

## VIII. Untimely Installation of the EPS Connections to the Main Heavy Water Pumps P-104 and P-105

AECL specifically requested the Talisman Team to review the reasons why the connection of EPS to MHWPs P-104 and P-105 had not been made as of November 2007. The Talisman Team interviewed most of the individuals who were involved in the NRU safety upgrade program, and reviewed the program documents related to the EPS upgrade - as noted in the sections above. The Talisman Team concluded that the fundamental reason for the long installation time was the AECL site management's beliefs that the connections were not an AECL licence requirement. As a result of those beliefs, the AECL resources available to the safety upgrade program in early 2006 were diverted to responding to the Directives and Actions identified in the CNSC QA audit report, which had to be addressed to support the AECL licence renewal hearings before the CNSC Commission.

The lack of any apparent CNSC concern regarding the missing connections appears to have reinforced the belief that these connections were not considered very important from a safety aspect. Prior to the CNSC Compliance Inspection, and prior to the Licence Condition that required the safety upgrades to be fully operational by the end of December 2005, AECL management was tracking the activities to make these connections as a "Non-REG" item in the AIMS tracking system in the section that was part of the Environmental Program. The initial entry that documented this status was made in the AIMS tracking system in September 2004. It continued to be tracked in the AIMS system until March 2007, when it was removed and was no longer included in any major AECL tracking system, and oversight was transferred to the "environmental panel."

The Talisman Team reviewed the NRU Licence Extension Project Report for July 7, 2006 and the NRU Licence Extension Project meeting minutes for March 2007, to see if the DC Motor Starter connection status was being tracked. It was not identified as an action item being tracked in either system. As a consequence, the connections were being implemented in a non-priority manner. In interviews with key individuals involved, the Talisman Team was informed that the reactor operations group wanted to proceed cautiously with any changes to the power supply of MHWPs P-104 and P-105, since those two pumps were key components of the emergency safety cooling system. The operators viewed the current power supply configuration to the MHWPs as robust and highly reliable and, as a result, they had high confidence in the existing configuration. Consequently, there was no sense of urgency, from any part of the NRU operating organization, to complete the tie-in. The only group that expressed a sense of importance and urgency to the connections was the SRC. In early 2006, when the SRC became aware that the connections were not made as part of the EPS upgrade, it requested the NRU staff to prepare a schedule for

implementation. The SRC was unsuccessful in convincing the NRU staff of the safety benefit of the EPS to the MHWPs. As noted above, although plans were developed to connect the pumps, this was never raised as an important safety improvement that had any schedule priority.

The AECL staff had recognized the need for a formal process for managing regulatory commitments, and issued for use procedure CW-508760-PRO-246, *Managing Canadian Nuclear Safety Commission Correspondence and Regulatory Commitments*, in June 2006. This procedure included many essential components of a good regulatory commitment management and tracking process, but it was not required to be used. Commitments and other actions were still being entered into the AIMS database, and were not always being entered into the "TRAK" system, as required by PRO-246.

**Observation (21) Enforcement (E)**

The CNSC audit inspection of the safety upgrades, which included the EPS upgrades, did not classify the missing connections as a licence violation, or an issue that warranted being identified as a Directive or Action Item. This was not highlighted, even though members of the audit team were aware that the connections were not made. This further supported the NRU site management's belief that the EPS connections to the MHWPs were not a CNSC regulatory requirement. As a result, the NRU reactor staff refocused essentially all available safety upgrade resources to address other significant items that had been identified in the CNSC audit report in order to support the licence renewal.

**Recommendation**

Recommendation C-E-1 addresses this observation.

**Observation (22) – Commitment Management (CM)**

The Talisman Team concluded that both the CNSC and AECL staffs were focused primarily on the responses to the ten Directives, five Action Notices and two recommendations, with less attention being given to the eighty-five findings, which appeared to be treated as less important inspection findings. Without a formal commitment tracking system, individuals used their own judgment as to how to track work activities. As of April 1, 2008, AECL made a decision to use a single tracking procedure for managing all AECL responses to CNSC correspondence and regulatory commitments, which, if properly implemented, should significantly improve the management attention to these action items (see CW-508760-PRO-246). This system is also intended to track activities internal to AECL, such as responses to internal safety audits, emergency drills, and AECL inspections. These items are tracked as Non-REG items.

**Recommendation**

**A-CM-6:** AECL should revise procedure CW-508760-PRO-246 to include a safety significance evaluation for any Non-REG entry into the system. For those that are considered to be significant from a health and safety perspective, a level of schedule control similar to the one used for regulatory [REG-C, REG-M and REG-I] actions should be adopted and used.

*AECL Management Response*

AECL's ImpAct process identifies all events, regulatory and non-regulatory, and tracks the requisite corrective actions. Events are rated according to their safety and programmatic significance, and actions to address the more significant events are subjected to increased schedule control.

**Observation (23) – Commitment Management (CM)**

The NRU commitment tracking system was not effective in tracking and monitoring the EPS connections to the MHWPs. Despite the fact that these connections were part of the EPS safety upgrade planned by AECL, by 2007 this safety upgrade was not tracked in the NRU commitment tracking system at all.

**Recommendation**

Recommendation A-CM-3 addresses this observation.

**Observation (24) – Regulatory Compliance (RC)**

During the CNSC Type I Inspection audit of two of the "completed" NRU safety upgrades, the inspectors identified that the commissioning tests of the DC motor starters were not documented. AECL responded to the inspection on two occasions, stating that the starters were not connected, but AECL did not identify the fact that the EPS upgrade modification was commissioned without having been fully implemented, and that the "stream of correspondence" regarding the upgrades was in conflict with the mindset of key NRU project staff, who believed that the tie-in was an enhancement and not part of the original seven upgrades.

**Recommendation**

**A-RC-1:** AECL should assess the effectiveness of NRU's regulatory compliance process.

*AECL Management Response*

AECL will conduct an effectiveness review of regulatory compliance in NRU as part of an upcoming PINO performance-based audit.

**Observation (25) – Oversight (O) – Safety Review Committee**

The AECL SRC supported the safety upgrades and considered the EPS tie-in to the MHWPs as an important safety upgrade. However, when it became aware that the tie-in had not been made, the SRC was ineffective in ensuring that senior AECL management clearly understood the safety and regulatory significance that the tie-in be made expeditiously. The safety benefit of implementing the modification to connect the MHWPs to EPS was not acknowledged by NRU site management following review by the SRC, and was not elevated to AECL Corporate Management for resolution.

**Recommendations:**

**A-O-1:** AECL should include non-AECL safety experts as members of the SRC, to strengthen its independence and objectivity.

***AECL Management Response***

As part of the mandate revision for the SRC, representation by independent external experts is being sought (see overall recommendation 15).

**A-O-2**: AECL SRC reports to management should highlight important safety issues as the first part of their quarterly reports.

***AECL Management Response***

AECL will ensure that guidance on SRC reporting to executive management is included in the revised mandate, including briefings to the executive following SRC meetings (see overall recommendation 15).

**A-O-3:** AECL management should communicate an expectation that the SRC should be more assertive in requesting and obtaining responses from the line organizations.

***AECL Management Response***

The SRC mandate revision will ensure that SRC safety concerns are better identified and acted upon (see overall recommendation 15).

## IX. Reasons for the Extended Outage following the NRU Reactor Shutdown in November 2007

On November 5, 2007, the CNSC resident inspector at CRL discovered a statement in the NRU electrical system operating manual that MHWPs P-104 and P-105 were not connected to the EPS. The inspector expressed surprise. On November 7, 2007, AECL confirmed in writing [1] that the MHWPs were not connected to the EPS. In a CNSC-AECL monthly meeting on November 8, 2007, AECL again confirmed that the MHWPs were not connected to the EPS. CNSC staff expressed concern that the physical plant did not agree with the licensing and safety basis. On November 14, 2007, AECL made a verbal report to CNSC that (1) there was a difference between the 2007 FSAR and the physical plant, and (2) that it would use a TOE process from a Canadian power reactor licensee for an assessment, and a root cause analysis would be completed.

The NRU reactor tripped on November 16, 2007. AECL informed CNSC of the results of its TOE evaluation, indicating that NRU was operating within its safety envelope, and that NRU would restart later that day. The NRU reactor was restarted November 16, 2007, when it was known that the EPS was not connected to the two MHWPs, and when that condition was considered to be outside the licensing basis and safety case by the CNSC staff[3]. While NRU had performed a TOE prior to restart [63], it had used a process not developed or formally approved for use at the NRU reactor, although the Talisman Team was informed that the procedure was approved by the CRL Chief Engineer prior to use, in November 2007.

[3] It is noted that current NRTEOL Operating licence condition General 1.1 states that the Commission or a person authorized by the Commission is the sole authority to interpret the conditions of this license.

On November 19, 2007, the NRU reactor was shut down for a 4-day regularly scheduled maintenance outage. CNSC informed AECL of CNSC staff's concerns as to the depth and conclusions of the TOE, and advised AECL that CNSC was working on a strong letter, which stated its position and concerns, and recommended that AECL should not restart the reactor (scheduled for Thursday night, November 22). AECL then informed the CNSC in writing [2] that the reactor would not be restarted, and would remain in extended shutdown, to continue installation of qualified motor starters for P-104 and P-105, and to complete the TOE process; CNSC did not send the letter. AECL said it would provide daily updates and would consult with CNSC prior to restarting the reactor.

NRU pursued two parallel paths to resolve the issue: (1) connect EPS to both MHWPs, and (2) submit and obtain approval of a safety case for one-pump operation. From mid-November to mid-December, the projected end dates for these paths kept changing, while progress was made and more understanding was gained. NRU shifted its primary success path whenever one path's end date moved ahead of the other.

On November 29, 2007 [3], AECL formally submitted a safety case to allow restart with the upgraded EPS connected to one pump (P-105). Both AECL and CNSC staffs recognized that it was unlikely that a prompt resolution would be reached. AECL notified CNSC on December 2, 2007 [4], that it was not continuing with that option, and that the reactor would only be restarted after both DC motor starters for MHWP P-104 & P-105 were connected to the EPS. On December 7, 2007 [5], AECL requested regulatory approval for a modification to the FA, to permit operation with one pump connected to EPS for a limited period of time. CNSC staff apprised AECL, in letters dated December 7, 2007 [6] and December 10, 2007 [7], that a complete safety case and request for licence amendment was required of AECL before the matter could be referred to the CNSC Commission. Subsequently, the Minister of Natural Resources Canada and the Minister of Health Canada wrote to the Presidents of CNSC and AECL on December 10, 2007 [8, 9], and urged them to work together to restart the reactor safely, with due regard for those reliant on the medical isotopes produced by NRU. The reactor remained shut down. On December 11 and 12, 2007, the House of Commons and the Senate, respectively, passed a law [10] which gave authorization to AECL to operate the NRU reactor for 120 days, with certain conditions. The reactor was restarted on December 16, 2007, and medical isotope production resumed within days.

The Talisman Team concluded that another key reason for the extended outage of the NRU reactor that began in November, 2007, was the fact that the CNSC senior managers considered NRU to be operating outside its licensing basis because the EPS tie-in had not been made, and that a licence amendment was needed to approve operation for a different plant configuration. Since the CNSC staff did not have the authority to issue a licence amendment, they needed to prepare the background material and safety case for submission to the CNSC Commission for a licence amendment review and approval. Therefore, they requested AECL to submit a safety case and a licence amendment for CNSC staff review and analysis, prior to requesting a CNSC Commission meeting to consider the new operating configuration. The preparation of this required safety information, and its review by the CNSC staff, clearly added additional time to the duration of the shutdown.

**Observation (26) Enforcement (E) and Training**

The CRL resident inspector identified a potential problem and successfully brought it to the attention of senior CNSC and NRU management.

**Recommendation**

The example set by the CRL resident inspector should be used in the enforcement training noted in recommendation **C-E-2.**

**Observation (27) – Operating Licence – (OL)**

There is no CNSC definition of "licensing basis" in the CNSC regulations, regulatory policies, regulatory standards, or regulatory guidance documents. Interviews of CNSC staff and managers did not yield a uniform definition of the term "licensing basis", but it was commonly understood to be:

> Licensing basis = (1) The CNSC-issued OL requirements and conditions, (2) including those requirements and conditions described in documents referenced in the OL, and (3) the information (Commission Member Documents, presentation material and testimonies) provided to the CNSC Commission Members and upon which they based their decision to grant the OL.

The information provided to the CNSC Commission, although relied upon when granting an OL, is not addressed by regulations if it is not incorporated into the OL or documents referenced in the OL. There is no regulatory process for resolving deviations from the information relied on by the CNSC Commission Members in making their decisions, if the information had not been included in the OL itself. CNSC staff considered the EPS tie-in to the MHWPs to be part of the "licensing basis", but there is no CNSC documented regulatory definition of the term. Regulatory oversight is complicated by the fact that CNSC does not have a formal definition of the "licensing basis", and the implications when a licensee is identified as operating outside of its licensing basis. There is no common understanding between AECL and the CNSC staff of what constitutes the licensing basis for the NRU reactor and what must be reflected in the OL.

**Recommendation**

**C-OL-6:** CNSC should publish a definition of the term "licensing basis", which includes those commitments and statements that the CNSC Commission Members relied upon as a basis for the CNSC Commission decision to approve the OL. CNSC should also define other commonly used terms - besides "licensing basis" - in a regulatory guidance document.

***CNSC Management Response***

The CNSC will review the definition of "licensing basis" as documented in an existing Regulatory Document RD-360 and develop any additional guidance document to clarify its applicability to existing facilities. This will be completed by September 30, 2008. The Reasons for Decisions will be used to capture the basis for the Commission decision.

**A-OL-1:** AECL should clearly define the licensing bases (e.g., licence applications must include the current FA, the FSAR and the applicable LCOs and their bases) OL for the NRU reactor, to ensure future licensing bases are clear.

***AECL Management Response***

AECL agrees that the licensing bases for NRU (and other Nuclear Facilities) should be clearly established and is embarking on a major initiative to ensure the licensing bases are properly captured in facility and program documentation (see overall recommendation 13).

**Observation (28) – Process to promptly Assess Interim Operation (AIO)**

AECL was unable to promptly assess and justify the safety of continued NRU reactor operation to the satisfaction of the CNSC staff, when it was learned that the EPS was not connected to the MHWPs.

A special process for urgently requested temporary amendments or enforcement discretion would enable CNSC to promptly assess the health and safety of the public for interim operation with additional compensatory measures. CNSC staff does not have an effective formal process which could be used to address this type of situation. The process for Class I licence amendments or enforcement discretion is "ad hoc" and does not appear to support urgent requests.

**Recommendations**

**C-AIO-1:** CNSC should implement a formal process for reviewing urgent requests for temporary licence amendments and for exercising enforcement discretion to allow continued operation in special situations. Special situations include severe weather, missed surveillance tests, lack of spare parts, degraded electrical grid situations etc. Operating reactors face these situations from time to time, and this would allow them to request approval for continued operation. Frequently, this approval is based on the temporary use of compensatory measures or other appropriate means to assure safety, while not meeting certain specific conditions.

***CNSC Management Response***

As part of documenting the licensing process, the CNSC will document a sub-process for the review of all license amendments including temporary amendments. A schedule for completing this work will be finalized by September 2008. Refer to C-AIO-2 for information on reviews and approvals (see response to recommendation C-E-4 with regards to enforcement discretion).

**C-AIO-2:** CNSC should issue guidance to the industry for making requests for continued operation under off-normal conditions, including what information is to be submitted to CNSC by the licensee.

***CNSC Management Response***

AECL is adapting and adopting a process referred to as Technical Operability Evaluation (TOE) currently used at operating Nuclear Power Plants. The CNSC will provide guidance and regulatory oversight to AECL to ensure the process is effective in identifying and assessing off-normal conditions and for identifying and implementing any necessary mitigative measures to ensure continued safe operation under those conditions. The CNSC will formalize and document the CNSC's internal processes where CNSC reviews and approvals are required to allow for continued NRU reactor operation. The process will

include a clear identification of roles, responsibilities, authorities and accountabilities for CNSC staff, management and the Commission to ensure for the timely review and disposition of any requests for continued NRU reactor operation during off-normal conditions. An interim process will be established by September 30, 2008 and fully documented by January 31, 2009.

**A-AIO-1:** AECL, pending issuance of the CNSC guidance recommended above, should review, approve and implement a TOE process that is aligned with the nuclear industry's best practices in this area. The process can be similar to that used in November 2007, but should be specifically designed and issued for use at the NRU reactor for the assessment of such off-normal conditions. It should include specific actions, assessments and acceptance criteria related to regulatory requirements, design basis, safety function, and safety analysis. AECL should share this procedure with CNSC.

***AECL Management Response***

AECL is developing a Technical Operability Evaluation procedure for application to discovery issues with facility operations. The procedure will ensure that safe operation is not compromised, and that regulatory requirements continue to be met. This procedure will be shared with CNSC staff (see overall recommendation 4).

**A-AIO-2:** AECL should strengthen its risk management assessment (including use of probabilistic safety analysis tools) programs, to support their use in the safety assessment process.

***AECL Management Response***

AECL will be using the NRU PSA to strengthen risk management assessment (see overall recommendation 6).

**Observation (29) – Corrective Action Program (CAP)**

After it was first discovered that the EPS tie-in to the MHWPs was not made, it was reported and processed by AECL using the CAP (IMPACT). The Talisman Team reviewed the NRU operability and reportability determinations. In this case, since the operating licence was not clear, facility management, licensing and engineering should have more thoroughly researched the reported condition, the OL and the licensing basis, and consulted with CNSC to properly characterize the problem.

In addition, the NRU CAP procedure, Improvement Action (IMPACT) Process, CW-514300-PRO-392, does not provide sufficient details of how and when to determine or assess the operability of degraded systems and components or how to evaluate the reportability thereof.

**Recommendation**

**A-CAP-1:** AECL should assess the adequacy of the reportability evaluations performed as part of the CAP.

***AECL Management Response***

AECL will include an effectiveness review of reportability evaluations in its self-assessment plan for Licensing.

**Observation (30) – Enforcement (E)**

The NRU reactor was restarted on November 16, 2007, when it was known that the EPS was not connected to the MHWPs and that this may have been in violation of the licensing basis. The CNSC staff did not initiate enforcement action, and allowed the plant to restart.

**Recommendation**

Recommendations C-E-1 and C-E-2 above will address this observation.

**Observation (31) – Corrective Action Program (CAP)**

Several examples of weak CAP performance were identified by the Talisman Team. A few examples are:

AECL performed a TOE using a process not developed and formally approved for use at the NRU reactor, and did not recognize that it was an activity important to safety, which should have been conducted in accordance with an approved procedure. The TOE process was used without following the process for issuing procedures.

The root cause analysis performed for the EPS tie-in to the MHWPs did not thoroughly evaluate the deviation. There were no corrective action documents generated for many of the programmatic problems discussed above. The fact that there was an apparent OL violation - from January 1, 2006 through the current OL - was not captured and dispositioned in a corrective action document.

A June 2006 AECL Internal Analysis Report, *Chalk River Laboratories Regulatory Issues Assessment Report*, Regulatory Assessment Team Report [64] concluded:

1. AECL had not consistently recognized or effectively dealt with those issues identified as significant by the regulator, in a timely manner. Subsequent AECL self-assessments reinforced CNSC concerns and led to corrective actions.
2. High-level ownership of regulatory issues within AECL was not always established or clear. The administrative process for prioritizing and tracking regulatory issues was not sufficiently effective.
3. The importance of timely and full compliance with regulatory requirements was not consistently reflected in AECL priorities and actions taken. Traceability of regulatory requirements to AECL governing and operating documents needs improvement.
4. AECL was not sufficiently proactive in seeking clarification when CNSC requirements and expectations were not clear, nor did AECL proactively follow-up on CNSC submissions, so as to ensure CNSC staff concerns had been adequately addressed.

This was a missed opportunity, as the self-assessment identified similar problems as the Talisman Team has. The self-assessment did not generate a corrective action program document for the conclusions. Had a corrective action program deficiency report been generated, and the extent of condition been investigated, the NRU safety upgrades issue may have been identified by AECL earlier.

In August 2005, the EPS Operating Manual indicated the EPS connection to MHWPs is available, but when the manual was issued the connection had not been done. This was a discrepancy that should have been documented and dispositioned in the CAP on an IMPACT.

**Recommendations**

**A-CAP-2:** AECL should assess the effectiveness of its CAP.

***AECL Management Response***

AECL has an effectiveness review of its ImpAct process in the self-assessment plan for Performance Improvement and Nuclear Oversight (PINO). In addition, the Nuclear Oversight independent assessment plan for 08/09 includes an audit of the OPEX program, including ImpAct (see overall recommendation 15).

**A-CAP-3:** AECL should continue to strengthen the root cause analysis capability of the NRU staff, and conduct training on root cause analysis techniques.

***AECL Management Response***

AECL will provide additional training in root cause analysis methodology as follows: a week long RCA training session for September 2008 to be delivered and attended by industry peers, participation in the COG Corrective Action Working Group, key role in the development of an RCA practitioners working group whereby industry peers can exchange ideas/methods, and focussed RCA training to be delivered in October 2008 by a third party expert (see overall recommendation 15).

**Observation (32) - Probabilistic Safety Analysis (PSA)**

CNSC and AECL were unable to quickly estimate the incremental risk of interim operation with degraded conditions. AECL and CNSC had not incorporated the NRU safety goals associated with the upgrades, either directly into the OL, or indirectly via the FA or FSAR, and neither the latest, nor the previous AECL PSA had been approved by CNSC. Accordingly, when CNSC and AECL attempted to evaluate the incremental difference in risk associated with the incomplete tie-in of EPS to the MHWPs, they could not readily agree. The use of risk, either qualitative or quantitative (i.e., Probabilistic Safety Analysis), could be used as one input to assess the effect of a temporary condition. The licensee could be required to submit an evaluation of the proposed temporary condition, including its calculation of the incremental risk, and the CNSC staff could perform an independent calculation or assessment for verification, including the improved safety of compensatory measures. Compensatory measures could be identified and taken, along with other actions and considerations, to justify safe, interim operation.

**Recommendations**

**J-PSA-1:** AECL and CNSC should both develop their own methodology to assess risks of specific plant configurations of the NRU reactor.

***CNSC Management Response***

In line with responding to recommendation- C-OL-2, CNSC will work with AECL to jointly establish a schedule for the timely review, issue resolution and approval of the NRU PSA and proceed with execution. The plan and timeline for completing this work will be established by September 30, 2008.

***AECL Management Response***

AECL will work with CNSC staff to achieve an approved PSA for NRU to support risk assessments (see overall recommendations 4 and 6).

**J-PSA-2:** AECL and CNSC should establish safety goals for the NRU reactor.

***CNSC Management Response***

CNSC will work with AECL to review and ensure clarity in the safety goals for NRU. The plan and timeline for completing this work will be established by September 30, 2008.

***AECL Management Response***

AECL will work with CNSC to establish safety goals for NRU (see overall recommendation 4).

## X. Performance Improvement and Oversight

The current regulatory system is primarily "expert-based" vs. "process-based", and can be characterized as "the licensee proposes and the regulator disposes."

**Observation (33) – Self-Assessment (SA) and Oversight (O)**

AECL oversight and self-assessments did not identify the existence of the programmatic weaknesses discussed above. While it would be expected that the above processes and implementation by the line organization should have caught the deviation from the project plan and EPS design change package, other lines of defense, self-assessment and oversight by Quality Assurance (QA), should have also identified the deviation. Programmatic weaknesses of the nature that allowed the EPS modification to be closed without the connection to MHWPs are significant, and should have been identified by an effective Self-Assessment Program and QA Program.

**Recommendations**

**A-O-4:** AECL should continue to increase and strengthen its QA Program and its implementation.

***AECL Management Response***

AECL is in the process of improving its QA program (governing programs and standards), and will include lessons learned from this event in the planned improvements.

**A-O-5:** AECL should assess the effectiveness of Quality Control and QA.

***AECL Management Response***

AECL will conduct a focussed causal assessment on why QC and QA staff did not identify the deviation.

**A-SA-1:** AECL should continue to increase and strengthen its self-assessment programs.

***AECL Management Response***

AECL is focussing on improvements to its self-assessment program. In 08/09, these improvements will be driven by a performance-based audit of the self-assessment program (see overall recommendation 15).

**A-SA-2:** AECL should arrange and conduct a peer review of the CRL self-assessment program.

***AECL Management Response***

AECL will include industry peers on the performance-based audit mentioned in the response to A-SA-1 (see overall recommendation 15).

## XI. Summary and Conclusions

The Talisman Team concluded that the overarching root cause of the AECL NRU reactor's extended outage in late 2007 was due to a CNSC and AECL set of processes which were "expert based" and not "process based." This culture of informality was considered a significant and fundamental flaw in both organizations' methods of operation, and contributed to a series of misunderstandings regarding reactor plant safety system upgrade status, AECL licensing commitments, and CNSC regulatory requirements and licence conditions.

These misunderstandings and ineffective communications contributed to a condition where the AECL licensee staff at the CRL site had not installed part of an electrical safety system upgrade which the CNSC had expected to be installed, tested, and made functional. The CNSC Commissioners, in part, based their decision to renew the NRU reactor license in July 2006, for an additional five years on the understanding that all the safety upgrades had been completed.

In late 2007, once it became well known amongst senior AECL and CNSC management that the complete extent of the upgrades was not in place and functioning, the timely resolution of the situation by the AECL and CNSC staff was hampered; they had no pre-established and effective processes with which to resolve the issues from both organizations' standpoints, while taking into account the needs of the licensee (production of medical isotope) and the regulator (protection of the public from unwarranted risks).

Throughout the review process, the Talisman Team sought to determine why these misunderstandings - which ultimately resulted in the extended outage - took place, and what actions would be appropriate to prevent recurrence. It became clear that there were several basic processes which were flawed, within both AECL and CNSC. These have been discussed in detail in the previous sections.

To address the conclusions discussed above and the factors that contributed to their existence, the Talisman Team has identified recommendations for specific short-term and long-term process and procedure improvements, for both CNSC and AECL. The specific recommendations are provided in the attached report. They have been combined and summarized below:

Short-Term

- CNSC should clarify current OL requirements, particularly regarding the Licence Strategy document referred to in Licence Condition 19.1 of the current OL. CNSC should reach agreement with AECL on open regulatory commitments, and concur that the open items adequately address the licensing requirements.
- CNSC and AECL should implement a licensing commitment management system to control the initiation, prioritization, implementation, tracking, close-out and maintenance of licensing commitments.
- CNSC should delegate sufficient authority to the Directors General, so that they are authorized to issue licence amendments.
- CNSC and AECL should develop a formal process to promptly determine whether, and under what conditions, continued NRU reactor operation may be justified during off-normal conditions.
- AECL should strengthen its risk management assessment (including use of probabilistic safety analyses tools) program, to support its use in the safety assessment process.
- CNSC and AECL should strengthen the quality and timeliness of internal and external communications, including a process to elevate issues of differing views to higher levels of management, for resolution, when needed.

Long-Term:

- CNSC should improve the clarity of future NRU OL conditions, by using specific regulatory terms and references, and enforceable language. Safety requirements, such as the limiting conditions for operations, should be included in the OL. CNSC counsel should review licence terms and conditions language for enforceability.
- AECL should clearly define the licensing bases (e.g., license applications must include the current FA, the FSAR and the applicable LCOs and their bases) in the future OL for the NRU reactor, to ensure future licensing bases are clear.
- CNSC should develop and issue guidance to the CNSC staff and industry, aimed at preparing and evaluating a request for the exercise of enforcement discretion for temporary conditions of low safety significance.
- CNSC should strengthen its enforcement capability, by requesting the authority to issue civil penalties without referral to the Justice Department.
- In a generic sense, CNSC should adopt the concept of "timely renewal", in order to eliminate any perceived need for a "rush" to avoid the pending termination of an OL. This should be coupled with a requirement for licence renewal applications to be filed early enough to allow for a reasonable period for licence renewal application reviews, while retaining the ability to take the additional time needed to finish a licence review and to reach a clear understanding (by both the licensee and the CNSC staff) as to the licence details.
- AECL should strengthen its long-term planning process, to ensure that all functional departments understand the scope, priority, and schedule for regulatory projects. The

commitment date and project schedule should be based on safety significance, plant staff resource requirements and availability, plant operations, and shutdown schedules.

- AECL should strengthen its work execution and configuration management processes, to ensure that safety significant improvements are promptly implemented and properly closed-out. Specific improvements are recommended in project management, modification management, and work management.
- The CNSC should define the term "licensing basis" in a regulatory guidance document.
- AECL should continue to strengthen its ability to self-identify and affect performance improvements. Specific recommendations have been made to improve the Corrective Action and Self-Assessment Processes and independent oversight functions, such as the Safety Review Committee.

In summary, the Talisman Team believes that improved communications, clear licence conditions, and a mutual understanding of plant status and outstanding licensing and inspection issues, along with improved inspector training and enforcement and in-house legal staff, would help prevent the misunderstandings which led to the extended outage in late 2007.

**Attachment 1**

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**Attachment 2**

## RECOMMENDATIONS

| Number[4] | Priority[5] | RECOMMENDATION |
|---|---|---|
| **Operating Licence (OL)** | | |
| **J-OL-1** | **L1** | CNSC and AECL should achieve approval of up-to-date FA and FSAR, and incorporate them into the OL as soon as practical. |
| **J-OL-2** | **L1** | AECL should update - and both AECL and CNSC should promptly approve, and incorporate into the OL - , an updated FA, including LCOs for any new required structure, system, or component that is added in a new OL or in a new OL amendment. |
| **C-OL-1** | **S1** | CNSC should clarify current OL requirements, particularly the requirements invoked by the Licensing Strategy document. |
| **C-OL-2** | **L1** | CNSC should use precise regulatory language, to ensure that future CRL OL and licence conditions for the NRU reactor, and other licensed facilities, are clear. The CNSC staff should ensure that, before a licence condition is approved and issued, both the licensee and the regulator can understand what actions will be needed to fully implement the requirements, and that it is clear enough that the CNSC staff can enforce specific details. Use specific (enforceable) regulatory terms and references, as opposed to "implement the seven upgrades." |
| **C-OL-3** | **S1** | CNSC management should require that all the regulatory documents that CNSC staff plan to use or rely on (when establishing requirements or providing authorizations) would be reviewed for enforceability by CNSC counsel before issuance. |
| **C-OL-4** | **L1** | CNSC should adopt a standard to test the clarity of regulatory language, so that both a nuclear plant control room operator and a regulatory inspector would be able to read a document and agree on "what" is required, the means or details of "how", and "by when". |
| **C-OL-5** | **L2** | CNSC should obtain authorization to hire its own in-house counsel. Legal support services should be more effectively used for review of key regulatory documents, to ensure clarity and enforceability. |
| **C-OL-6** | **L2** | CNSC should publish a definition of the term "licensing basis" which includes those commitments and statements that the CNSC Commission Members relied upon as a basis for the CNSC Commission decision to approve the OL. CNSC should also define commonly used terms - besides "licensing basis" - in a regulatory guidance document. |
| **A-OL-1** | **S1** | AECL should clearly define the licensing bases (e.g., licence applications must include the current FA, the FSAR and the applicable LCOs and their bases) OL for the NRU reactor, to ensure future licensing bases are clear. |
| **Commitment Management (CM)** | | |
| **J-CM-1** | **S1** | AECL and CNSC should identify all of the open regulatory commitments, and reach an agreement that these open items will adequately cover the licensing requirements. |
| **J-CM-2** | **S1** | AECL and CNSC should develop and implement a formal tracking system to clearly identify those licensee commitments and statements, as well as track any open inspection or audit findings. As new items are identified by AECL or CNSC, |

[4] J = Joint applies to Both CNSC and AECL, C = applies to CNSC, A = Applies to AECL,
[5] S1 = Short Term Priority 1, S2 = Short Term Priority 2, L1 = Long Term Priority 1, L2 = Long Term Priority 2

| Number[4] | Priority[5] | RECOMMENDATION |
|---|---|---|
| | | those new items should be entered into the AECL and CNSC commitment action tracking system. |
| **C-CM-1** | **S1** | CNSC should develop a formal CNSC tracking system, and use it to monitor outstanding licensing and inspection issues. CNSC should share this with the licensee, to help ensure that both CNSC management and the AECL management have a current understanding of the outstanding regulatory issues. The tracking system should include licensing issues, inspection findings, licensee commitments and action items. This should be used to provide continuity as regulator and licensee staff change over time. It should also be used to assist any new project managers - or inspectors - in knowing the current licence commitments and inspection follow-up status. |
| **A-CM-1** | **L1** | AECL should require by procedure that commitments only be made by authorized individuals, in writing, with a clear description of scope and schedule. Prior to making the commitment, a resource loaded plan and schedule must be developed, to ensure that the commitment can be met. |
| **A-CM-2** | **S1** | AECL should prioritize existing and future regulatory commitments and initiatives by safety significance, cost, schedule, and plant availability. |
| **A-CM-3** | **L1** | AECL should track all commitments in a central database, managed by the licensing group, and reference the licensing commitment number in the implementation plans and execution documents, in order to ensure that no scope or schedule changes are made without a licensing assessment. |
| **A-CM-4** | **L1** | AECL should include in the Commitment Management Procedure a step that once a committed action has been completed and verified, the commitment may be closed and CNSC informed in writing. |
| **A-CM-5** | **L1** | AECL should reflect reference to the commitment in implementation documents such as drawings and procedures, to ensure that the commitment is not inadvertently "undone" at a later date. |
| **A-CM-6** | **L1** | AECL should revise procedure CW-508760-PRO-246 to include a safety significance evaluation for any Non-REG entry into the system. For those that are considered to be significant from a health and safety perspective, a level of schedule control similar to the one used for regulatory [REG-C, REG-M and REG-I] actions should be adopted and used. |
| **Communications (CC)** | | |
| **J-CC-1** | **L1** | CNSC and AECL should strengthen the quality and timeliness of internal and external communications, including a process to elevate issues of differing views to higher levels of management for resolution when needed. |
| **C-CC-1** | **S1** | CNSC management should communicate an expectation of "no surprises" to the CNSC staff, and foster a culture that encourages the staff to feel free to bring safety issues or potential problems to the attention of management. |
| **C-CC-2** | **L2** | To ensure that the CNSC regulatory position is clear and understandable, CNSC should adopt a practice of issuing a Safety Evaluation Report (SER) that summarizes the basis for the CNSC review and acceptance of a design change or licence amendment. These CNSC SERs should be issued as timely as possible, and the CNSC managers should establish a planned review completion schedule for each major licensing document. |
| **C-CC-3** | **S2** | CNSC should not normally request reports and analyses that they do not intend to review. CNSC should document its approval, approval with conditions, or disapproval in written correspondence to the licensee. |
| **A-CC-1** | **L1** | AECL should improve its communications with CNSC at all levels, including site |

| Number[4] | Priority[5] | RECOMMENDATION |
|---|---|---|
| | | licensing interactions, site senior management meetings, and corporate visits to the CNSC senior executives. AECL should implement formal communication plans and procedures, conduct training on their use and conduct an effectiveness review, at least annually. AECL should include, as a matter of routine, expectations that their managers periodically meet with regulatory organizations, to make sure that communications are effective. |
| **A-CC-2** | **S2** | AECL should issue its own communication protocol, and reemphasize or implement a policy of "no surprises" and 3-way communication with CNSC staff on regulatory issues and the status of regulatory commitments. |
| **Licence Renewal (LR)** | | |
| **J-LR-1** | **S2** | AECL and CNSC should strengthen the licence renewal process to require more complete and accurate information to be provided to the CNSC Commission Members, especially if, in the view of the CNSC staff, the information involves a key safety issue or a potential licence violation. Both organizations need to be prepared to bring the most up-to-date and detailed information to the CNSC Commission Members. |
| **C-LR-1** | **S1** | CNSC should review the current statutory authority for licensing and, if the ability to delegate the authority for issuing licence amendments to the CNSC staff exists, authorize the Executive Vice-President or the Directors General for Licensing to approve licence amendments. If that authority does not exist, the CNSC should request it from Parliament. |
| **C-LR-2** | **L1** | CNSC should adopt a "Timely Renewal" licensing process. This would allow an existing licence to remain in effect until CNSC had completed its full licensing review. This would be based on the receipt of the application at least one year prior to the licence expiration date. The existing OL remains in effect until CNSC decides to issue or not the new licence. If there is a significant safety issue during the timely renewal period, CNSC can issue an order to the licensee to take the actions necessary to ensure protection of the public health and safety, the workers, or the environment. Under "Timely Renewal", CNSC retains the option for a periodic safety review, while at the same time having the flexibility for additional or more in depth licensing evaluations or to address unforeseen operational issues. |
| **C-LR-3** | **L1** | CNSC should consider requiring that licence applications be submitted under oath or affirmation. This would emphasize the importance of providing accurate information to the CNSC to make its licensing decisions. |
| **C-LR-4** | **L1** | CNSC should shift to a more process-based system, where regulatory requirements and expectations are specified in writing and in guidance documents. |
| **C-LR-5** | **L1** | CNSC should issue a Standard Format and Content guide for use by licensees in preparing licence applications. |
| **C-LR-6** | **L1** | CNSC should issue a Standard Review Plan for use by the CNSC staff in conducting their safety reviews. |
| **C-LR-7** | **S1** | CNSC should not, unless there is a safety justification, change the standards that were in effect when the reactor was licensed. Those standards should remain unchanged for the duration of the licence, to provide for regulatory predictability and stability. If CNSC desires to revise these standards during periodic safety upgrades, it should specify this and provide the basis for it, so that licensees become aware of the expectations to be met. |
| **Assess Interim Operation (AIO)** | | |
| **C-AIO-1** | **L1** | CNSC should implement a formal process for reviewing urgent requests for |

| Number[4] | Priority[5] | RECOMMENDATION |
|---|---|---|
| | | temporary licence amendments and for exercising enforcement discretion to allow continued operation in special situations. Special situations include severe weather, missed surveillance tests, lack of spare parts, degraded electrical grid situations etc. Operating reactors face these situations from time to time, and this would allow them to request approval for continued operation. Frequently, this approval is based on the temporary use of compensatory measures, or other appropriate means, to assure safety while not meeting certain specific conditions |
| **C-AIO-2** | **L1** | CNSC should issue guidance to the industry for making requests for continued operation under off-normal conditions, including what information is to be submitted to CNSC by the licensee. |
| **A-AIO-1** | **S1** | AECL, pending issuance of the CNSC guidance recommended above, should review, approve and implement a TOE process that is aligned with the nuclear industry's best practices in this area. The process can be similar to that used in November 2007, but should be specifically designed and issued for use at the NRU reactor for the assessment of such off-normal conditions. It should include specific actions, assessments and acceptance criteria related to regulatory requirements, design basis, safety function, and safety analysis. AECL should share this procedure with CNSC. |
| **A-AIO-2** | **L1** | AECL should strengthen its risk management assessment (including use of probabilistic safety analysis tools) programs, to support their use in the safety assessment process**.** |
| **Probabilistic Safety Assessment (PSA)** | | |
| **J-PSA-1** | **S1** | AECL and CNSC should both develop their own methodology to assess risks of specific plant configurations of the NRU reactor**.** |
| **J-PSA-2** | **S1** | AECL and CNSC should establish safety goals for the NRU reactor. |
| **Enforcement (E)** | | |
| **C-E-1** | **S1** | CNSC senior management should clearly promulgate their expectations regarding procedural adherence by CNSC staff. This should include clearly documenting, in every audit or inspection report, whether any OL violations were identified or not, as well as their safety significance, as it is understood at that time. |
| **C-E-2** | **L1** | CNSC senior management should provide training for all CNSC staff that conducts inspections, to ensure that CNSC staff understands how to identify and document OL or regulation violations, and encourage the inspectors to get advice from CNSC counsel if there are any questions concerning a possible OL violation. |
| **C-E-3** | **L2** | CNSC senior management should adopt an Enforcement Policy which includes the ability to levy monetary fines. If necessary, the CNSC should request civil penalty authority. This should be an inherent authority of CNSC, not subject to support from other government agencies. This provides the regulator with a more efficient and effective way to identify those violations that warrant elevated enforcement action, and enables CNSC to be more effective in ensuring regulatory requirements are met. |
| **C-E-4** | **L1** | CNSC should develop and implement an Enforcement Policy that includes guidance for the CNSC staff to exercise enforcement discretion under certain conditions. This needs to be fully coordinated with CNSC in-house counsel in both the development of the policy and the oversight of its implementation to ensure consistency among inspectors. Should CNSC obtain the authority and ability to issue civil penalties as recommended above, this should also be covered in the new Enforcement Policy. |
| **Regulatory Compliance** | | |

| Number[4] | Priority[5] | RECOMMENDATION |
|---|---|---|
| **A-RC-1** | **L1** | AECL should assess the effectiveness of NRU's regulatory compliance process. |
| **Modification Management (MM)** | | |
| **A-MM-1** | **L1** | AECL should ensure the Engineering Change Control procedure requires that, when only part of a modification is commissioned and placed in service, the actual configuration has been reflected in drawings and procedures, that operators have been trained, and the specific configuration being placed in service has been analyzed in a safety evaluation (safety case); it should also require a new stand-alone modification be issued, covering installation and commissioning of the remainder of the modification. |
| **A-MM-2** | **L1** | AECL should ensure the Engineering Change Control procedure requires that the as-installed configuration be consistent with the engineering change package. |
| **A-MM-3** | **S1** | AECL should ensure the Engineering Change Control procedure requires that any non-trivial change obtain prior Engineering approval. |
| **A-MM-4** | **S1** | AECL should ensure the Engineering Change Control procedure requires that an independent verification of the physical installation be performed prior to completion acceptance. |
| **A-MM-5** | **L1** | AECL should ensure the Engineering Change Control procedure requires that for plant modifications done to meet CNSC commitments, a reference to the commitment be included in the applicable documents (drawings, specifications, procedures, etc.) |
| **A-MM-6** | **L1** | AECL should ensure the Engineering Change Control procedure requires specific LCOs, with their detailed bases, to be in effect when modifications are approved and required to be functional by the CNSC. |
| **A-MM-7** | **L2** | AECL should **c**ontinue its self-assessment of the NRU Configuration Control Processes, including Modification Management processes and procedures. |
| **Project Management (PM)** | | |
| **A-PM-1** | **L2** | AECL should ensure its project management guidance is based on the Project Management Institute guidance for project management. |
| **A-PM-2** | **L2** | AECL should ensure the responsibility for compliance with commitments is assigned to Project Managers. |
| **A-PM-3** | **L2** | AECL should require Project Managers, by procedure, to include licence commitment references in their project plans, schedules and implementing documents. |
| **Work Management (WM)** | | |
| **A-WM-1** | **L1** | AECL should strengthen the long-term planning process (including programs and processes for budgeting and resource allocation, work prioritization, and work planning and control) such that it is aligned with the nuclear industry's best practices. Long-term plans should include resource-loaded schedules for major projects, which reflect the amount of support required and availability of the plant staff. Ensure that all functional departments understand the scope, priority and schedule for regulatory projects. The commitment date and project schedule should be based on plant staff resource requirements and availability, plant operating and shutdown schedules, and safety significance. |
| **A-WM-2** | **L1** | AECL should include long-term project work in the recently implemented cyclic work planning process, so that is given appropriate priority and can be completed on schedule. Long-term project work can be planned and staged in advance with routine plant work, such that it can be smoothly executed during a "work week". |

| Number[4] | Priority[5] | RECOMMENDATION |
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| **A-WM-3** | **L2** | AECL should continue its self-assessment of the NRU Configuration Control Processes, including Work Control and Quality Control processes and procedures. |
| **Corrective Action Program (CAP)** | | |
| **A-CAP-1** | **L2** | AECL should assess the adequacy of the reportability evaluations performed as part of the CAP. |
| **A-CAP-2** | **L1** | AECL should assess the effectiveness of its CAP. |
| **A-CAP-3** | **L2** | AECL should continue to strengthen the root cause analysis capability of the NRU staff, and conduct training on root cause analysis techniques. |
| **Self-Assessment (SA)** | | |
| **A-SA-1** | **L2** | AECL should continue to increase and strengthen its self-assessment programs. |
| **A-SA-2** | **L2** | AECL should arrange and conduct a peer review of the CRL self-assessment program. |
| **Oversight (O)** | | |
| **A-O-1** | **L2** | AECL should include non-AECL safety experts as members of the SRC, to strengthen its independence and objectivity. |
| **A-O-2** | **L2** | AECL SRC reports to management should highlight important safety issues as the first part of their quarterly reports. |
| **A-O-3** | **S2** | AECL management should communicate an expectation that the SRC should be more assertive in requesting and obtaining responses from the line organizations. |
| **A-O-4** | **L2** | AECL should continue to increase and strengthen its QA Program and its implementation. |
| **A-O-5** | **L2** | AECL should assess the effectiveness of Quality Control and QA |

## Appendix A- Independent Review Team Charters

## CNSC: Independent Review Team Charter; Statement of Work

### 1.0 Background

The Canadian Nuclear Safety Commission (CNSC) has adopted a continuous improvement culture that includes transparent reporting of results and performance evaluations based on lessons learned.

The CNSC will undertake a review of lessons learned stemming from the Atomic Energy of Canada Limited (AECL) decision to shut down the National Research Universal (NRU) reactor in order to complete safety upgrades. This review will aim to develop a concise overview of key findings, and was committed to by Mr. Barclay Howden, Director General of the CNSC Nuclear Cycle and Facilities Regulation Directorate during the December 6, 2007 meeting of the CNSC Tribunal.

### 2.0 Objectives

The purpose of this review is to:

Examine the performance of CNSC staff over the period leading up to and pursuant to the Commission Tribunal decision to renew the NRU licence (thus allowing the NRU to remain operational), as well as the subsequent period leading up to AECL's decision to shut down the NRU; and identify recommendations for improvements in CNSC performance.

### 3.0 Scope of Work

- Clearly identify the current regulatory basis for licensing the NRU, CNSC staff recommendations to the Commission, and the approved safety case as it relates to the two-pump backup configuration. This review should include how the licensing basis was determined;
- Review elements of the 2006 NRU licence renewal: Commission Member Documents and supporting information (including safety system upgrade documentation), transcripts, minutes and Records of Decision, and other applicable documentation;
- Investigate how compliance was enforced with regards to the emergency power supply and other safety system upgrades;

- Identify the nature, frequency and quality of communication among CNSC staff, AECL, and any other stakeholders on NRU safety upgrade requirements, and progress of work from 2005 and beyond; and
- Ascertain the nature and extent of consultations between AECL and CNSC staff on the work plan (including timelines) to carry out these upgrades, with emphasis on the emergency power system.

## 4.0 Tasks to be performed

A team of 3 Talisman consultants will perform the work identified in this scope. They will be supported by CNSC staff as needed. The CNSC core support team will include a project coordinator and a technical writer.

The consultants shall review all pertinent background documents, including, but not limited to:

- Technical documents related to NRU licensing matters, including licence amendments allowing for extended NRU operations, and CNSC staff follow-up on required AECL actions;
- Information submitted in support of the licence application as issued August 2006, including safety cases submitted by AECL and the results of CNSC staff reviews of this material;
- Commission hearing transcripts, Records of Decision and Commission Member Documents;
- Meeting notes or correspondence, specifically with respect to the requirement and planning for connection/commissioning of the two main heavy water pumps to the NRU's emergency power system; and
- Information and compliance findings in support of NRU reactor continued operation.

Interviews of CNSC staff members involved in the NRU file and in activities proceeding and subsequent to the 2006 licence renewal shall be conducted. Subjects will include project officers and managers in the Chalk River Licensing Division; the facility site supervisor and inspectors; members of the CNSC Legal Services Unit; and members of the CNSC Executive.

External interviews with industry members and academia may be required and will be determined at a later date.

## Appendix A (Continued)

## AECL: Independent Review Team Charter; Statement of Work

### 1.0 Background

Atomic Energy of Canada Limited (AECL) has adopted a continuous improvement culture that includes transparent reporting of results and performance evaluations based on lessons learned.

AECL will undertake a review of lessons learned stemming from the extended outage of AECL's National Research Universal (NRU) reactor in November and December of 2007. This review will aim to develop a concise overview of key findings, and was committed to by Mr. Brian McGee, Senior Vice-President and AECL's Chief Nuclear Officer, during the December 6, 2007 meeting of the Canadian Nuclear Safety Commission (CNSC) Tribunal, and reinforced at the January 9, 2008 meeting of the CNSC Tribunal.

The CNSC had previously engaged Talisman to carry out a review focused on the CNSC. AECL and the CNSC have now agreed that the Talisman review will cover both organizations, and will result in a single final report that will include recommendations for improvement for both parties.

### 2.0 Objectives

The purpose of this review is to:

Examine the performance of AECL staff over the period leading up to and pursuant to the Commission Tribunal decisions to amend the Chalk River licence in late 2005 (thus allowing the NRU to remain operational) and to renew the Chalk River site licence in 2006, as well as the subsequent period leading up to the extended outage of NRU in late 2007; and identify recommendations for improvements in performance.

### 3.0 Scope of Work

- Clearly identify the current regulatory basis for licensing the NRU, CNSC staff recommendations to the Commission, and the approved safety case, as it relates to the two-pump backup configuration. This review should include how the licensing basis was determined;
- Review elements of the 2006 NRU licence renewal: Commission Member Documents and supporting information (including safety system upgrade documentation), transcripts, minutes and Records of Decision, and other applicable documentation;
- Investigate how compliance was enforced regarding the emergency power supply and other safety system upgrades;
- Identify the nature, frequency and quality of communication among CNSC staff, AECL, and any other stakeholders on NRU safety upgrade requirements and progress of work from 2005 and beyond;
- Ascertain the nature and extent of consultations between AECL and CNSC staff on the work plan (including timelines) to carry out these upgrades, with emphasis on the emergency power system and connection of the two pumps to EPS;

- Review the clarity provided to AECL in licensing requirements, with respect to the scope and breadth of the upgrades, and make recommendations for improved clarity in licensing requirements;
- Review AECL's management of the safety upgrades, with specific focus on the Emergency Power System and the two pumps in question (MHWP's 104 and 105), during the period prior to December 31, 2005, relative to the licence condition to have the upgrades fully operational by that date, and subsequent to that date - up to the start of the extended outage in late 2007;
- Determine whether there were viable options available to AECL and the CNSC, in November and December 2007, which could have avoided or shortened the unplanned extended outage of NRU.

## 4.0 Tasks to be Performed

A team of 3 Talisman consultants will perform the work identified in this scope. They will be supported by AECL staff as needed. AECL's senior single point of contact for this work is Mr. G. H. Archinoff, Vice-President, Compliance, Corporate Oversight and Regulatory Affairs. Talisman's senior single point of contact will be Mr. H. Thompson.

The consultants shall review all pertinent background documents including, but not limited to:

- Documents related to NRU licensing matters, including licence amendments allowing for extended NRU operations, and CNSC staff follow-up on required AECL actions;
- Information submitted in support of the licence application, as issued in August 2006, including safety cases submitted by AECL and the results of CNSC staff reviews of this material;
- Commission hearing transcripts, Records of Decision and Commission Member Documents;
- Meeting notes, correspondence and AECL internal documentation specifically, with respect to the requirement and planning for connection/commissioning of the two main heavy water pumps to the NRU's emergency power system; and
- Information and compliance findings in support of the NRU's continued operation.

Interviews of AECL staff members involved in the NRU file and in activities preceding and subsequent to the 2006 licence renewal shall be conducted. Subjects will include past and present members of the NRU management team, members of the Chalk River Leadership Team, CRL licensing staff, and other AECL staff with relevant knowledge, to be identified by the AECL contact. Talisman should also interview individuals outside of AECL, including CNSC staff, as necessary to meet the objectives of this work.

# Appendix B

## Independent Review Team Member Resumés

# Hugh L. Thompson, Jr.
## Vice President

### Summary

Mr. Thompson is a Vice President at Talisman. Before joining Talisman, he was a Senior Nuclear Regulatory Advisor in SCIENTECH's litigation assistance practice. He has more than 33 years of nuclear safety experience, including senior level management positions at the U.S. Nuclear Regulatory Commission. Prior to joining SCIENTECH in 1999, Mr. Thompson was the Deputy Executive Director for Regulatory Programs at the NRC. In that position, he directed the licensing, inspection, and rulemaking activities for all NRC licensed nuclear reactors, the oversight of DOE's high-level radioactive waste program, the decontamination and decommissioning of contaminated sites, and the material licensees regulated by both the 29 Agreement States and the NRC. Mr. Thompson has also held the positions of Director of the Office of Nuclear Material Safety and Safeguards, Director of the Division of Licensing, and Director of the Division of Human Factors Safety for the Office of Nuclear Reactor Regulation.

Mr. Thompson has testified before congressional committees and the NRC Commission on issues such as safety issues at nuclear facilities, NRC's HLW program, potential NRC oversight of DOE facilities, and Y2K safety concerns. Mr. Thompson has been an expert witness in several litigations involving NRC licensees.

Mr. Thompson has provided litigation assistance and expert testimony on cases involving NRC regulatory actions. He also chaired an Independent Technical Review Panel evaluating safety concerns of a planned DOE remediation at a low-level radioactive waste burial site, provided oversight for the search for lost fuel rods at Millstone Unit 1, and supported the restart activities at Honeywell Metropolis Plant.

### Education

J.D., George Washington University, 1978
M.S., Nuclear Engineering, Georgia Institute of Technology, 1972
B.S., Naval Science, U.S. Naval Academy, 1965

### Qualifications

**Executive Services and Litigation Support.** Assisted in investigations and an arbitration concerning the prudence of actions taken during the operation of a three-unit nuclear power station in response to a proceeding initiated by minority owners. Analyzed testimonies and reports presented by opposing witnesses and assisted client attorneys in preparing interrogatories and discovery requests about these testimonies. Assisted client attorneys during depositions and cross-examination of opposing technical experts. Provided expert testimony concerning the regulatory requirements and other factors that would have been involved in the licensing of a

very low-level waste disposal site in a NRC Agreement State. Provided expert consultation on the licensing requirements for a project being considered to process depleted uranium, the management and disposal of radioactive waste, and the license termination requirements for the West Valley Demonstration Project. Mr. Thompson has provided oversight of the Northeast Utilities search for the lost fuel rods, participated in two due diligence reviews related to nuclear utility mergers, and has provided extensive expert support for the DOE Licensing Support Network for DOE's Yucca Mountain project. Mr. Thompson has also supported several independent reviews of allegations at NRC licensed facilities, including operating nuclear power plants and fuel cycle facilities.

**Management -** Twenty years of program management experience with U.S. government organizations ranging from 10 – 1,500 persons. Ten years experience as Deputy Executive Director for Operations. During the last two years in that position, he directed all NRC regulatory programs, including the four NRC Regional Offices.

**Nuclear Waste and Nuclear Material Regulatory Management** - As Director of NRC's Office of Nuclear Material Safety and Safeguards, he directed the licensing, inspection, and environmental reviews of the following activities regulated by the NRC:

- Uranium recovery and nuclear fuel fabrication and development
- Medical, industrial, academic, and commercial uses of radioisotopes
- Safeguard activities
- Transportation and storage of spent nuclear fuel and other radioactive materials
- High- and low-level radioactive waste management and disposal
- Uranium Mill tailings cleanup and stabilization

**Low-level Waste** - Managed the development of Site Acceptance Methodology for low-level waste disposal. Directed and contributed to the regulatory framework for packaging, shipping, and disposing of low-level waste. Developed the guidance and managed the NRC review of state and compact implementation plans for low-level waste disposal. After leaving the NRC, chaired the Independent Technical Review Panel chartered by DOE to evaluate safety concerns raised about the planned characterization of Pit 9 at the Idaho National Engineering and Environmental Laboratory.

**High-level Waste** - Managed and directed the NRC's program for decommissioning, and was responsible for developing the supporting data and analysis for promulgation of NRC regulations for decommissioning. Led the NRC oversight of DOE efforts to characterize the Yucca Mountain site. Directed and directly participated in numerous interactions with DOE, EPA OSTP, and OMB over cleanup standards. In 2001-2002, provided oversight to Northeast Nuclear Utilities in their efforts to locate two spent fuel rods at the Millstone Unit 1 station.

**Nuclear Reactor Safety Management** - Directed and implemented nuclear reactor regulation programs including licensing, inspection, enforcement, and rulemaking. Also directed and implemented the NRC regulatory program for training and licensing reactor operators. Positions held included the following:

- Deputy Executive Director for Regulatory Programs

- Division Director in Reactor Regulation for Licensing all reactor designs
- Division Director in Reactor Regulation for Westinghouse reactor licensing, reactor system safety and radiological safety
- Division Director in Reactor Regulation for Human Factors Safety
- Environmental project manager for a number of light water reactors for the construction and for operations.

**Operational Readiness Review -** Led NRC operational readiness team reviews as part of licensing reviews following TMI-2 accident. Focus included not only plant physical condition, but also licensed operators' training and readiness. Conducted an Independent Safety Review of an operating nuclear fuel facility. Was a team member of a DOE contractor's self-assessment of Integrated Safety Management effectiveness.

**Security -** Developed and implemented security standards for U.S. commercial nuclear industry, including both powers reactor and major fuel cycle facilities.

**Emergency Preparedness -** Directed NRC's reactor safety and protective measures teams in headquarters emergency response organization. Led and participated in NRC emergency response exercises for commercial nuclear facilities, both reactor and non-reactor facilities. Developed NRC emergency preparedness regulations and directed their implementation.

**Human Factors Safety** - Directed the development and implementation of the human factors requirements that followed the accident at TMI 2. This included the redesign of reactor control rooms, the revisions to the emergency operating procedures, the training and qualification of the licensed reactor operators, the qualification and experience of the senior reactor operators, and the requirements for plant-specific simulators for both training and testing. Directed and implemented the initial NRC re-qualification of licensed reactors operators. Lead NRC review that endorsed the INPO National Academy for Nuclear Training program.

**IT and Y2K -** Directed NRC's internal IT program from 1990-1995. Developed and implemented the regulatory response for NRC's oversight of the nuclear industry Y2K response. Represented NRC on the President's Y2K Conversion Council 1997 and 1998.

**Employment**

**TALISMAN International, LLC,** Vice President, 2001- present

**SCIENTECH, Inc.** Senior Nuclear Regulatory Advisor, 1999-2001

**U.S. Nuclear Regulatory Commission**, 1975-1999
Deputy Executive Director for Regulatory Programs, 01/97-12/98
Deputy Executive Director for Nuclear Materials Safety Safeguards Administration and Operations Support, 02/89-01/97
Director of the Office of Nuclear Material Safety and Safeguards, 02/87-02/89
Director, Divisions of Licensing and PWR Licensing, NRR, 03/85-02/87
Director, Division of Human Factors Safety, NRR, 12/81-03/85

Director, Planning and Program Analysis Staff, NRR, 09/80-12/81 and
Senior Technical Advisor, various assignments, 09/75-09/80

**U.S. Atomic Energy Commission**, 1972-1975
Environmental Project Manager

**Alabama Power Company**, 1970-1972
Nuclear licensing engineer

**U.S. Nuclear Navy**, 1965-1970
Nuclear Submarine Program

## HONORS

NRC Distinguished Service Award, 1991
Distinguished Senior Executive Award, 1991
Meritorious Senior Executive Award, 1987 and 1996
President's Council on Y2K Conversion – Outstanding Service, 1998
DOE Certificate of Appreciation – Pit 9 Project, 1999

## Security Clearance

NRC Q Clearance (inactive)

Millstone Nuclear Power Station Security Access (inactive)

Department of Justice Public Trust Clearance (active)

## Publications and Litigation Support:

Authored numerous NRC documents including Environmental Impact Statements, expert testimony in licensing hearings, NRC Testimony before Congressional Committees or Subcommittees including DOE's High Level Waste Program, NRC Oversight of DOE, and Y2K Readiness of Operating Nuclear Power Reactors, (1973-1998).

Thompson, Hugh L., Deposition in Support of Plaintiff, Nuclear Fuel Services v. Envirocare of Utah, Inc. and Khorow B. Semnani, Utah State Court, Salt Lake City, Utah, July 1999, Record Sealed.

Thompson, H.L. et al., Independent Technical Review of Proposed Drilling Activities for Operable Unit 7-10 Staged Interim Action (Alternate Pit 9 Project), for the U.S. Department of Energy, October 1999.

Hugh L. Thompson, Jr. et al., Independent Review Team Memorandum to Frank Rothen, IRT Oversight of the Millstone Unit One Fuel Rod Accountability Project (FRAP) and Approval of Final FRAP Report, October 9, 2001.

H. L. Thompson, Letter Termination Report to J. A. Van Vliet, Termination of the Implementation of an Increased Facility Radioactive Source Inventory Limit and Shipping Port Fuel Removal, Flour Hanford Operational Readiness Review, March 8, 2002.

Dominion Nuclear Connecticut, Inc. Docket No. 50-423-LA-3, Affidavit of Dominion Nuclear Connecticut Outside Expert Panel, H. L. Thompson, Jr. et al., March 18, 2002.

Hugh Thompson, et al., Review Team Report of Potential Chilling Effect in Designated Organizations At Indian Point Energy Center, January 17, 2007.

# Jon R. Johnson
## Senior Nuclear Safety Consultant

**Summary**

Jon Johnson is a Senior Nuclear Safety Consultant with Talisman International. He has over 30 years of experience in the nuclear regulatory industry, with expertise in the areas of nuclear safety, reactor safety licensing, inspection policy, engineering and technical reviews, and nuclear oversight. He has advised national and international nuclear utilities and governmental executives regarding nuclear safety and regulatory policy. As a member of the Safety Review Board for two nuclear stations, he reviewed all aspects of quality assurance activities and non-conformance reports as well as all self assessments of safety related activities. He has provided advice to license applicants on effective implementation of NRC and industry (ASME NQA-1) QA standards.

While at the Nuclear Regulatory Commission (NRC), Mr. Johnson directed licensing and inspection activities as part of the Reactor Oversight Program at all nuclear power reactor facilities in the United States. He was also responsible for leadership of NRC renewal of operating licenses, licensing of advanced nuclear reactors and risk-informed regulations as Deputy Director of NRC's Office of Nuclear Reactor Regulation. Mr. Johnson received the Presidential Meritorious Rank Award from the President of the United States for sustained superior achievement in managing programs in the Senior Executive Service.

As Deputy Regional Administrator for Region II, he was directly responsible for administering licensing, inspection, enforcement, budgeting, travel, human resource, legal, public affairs, state liaison, training, and emergency preparedness programs for one of NRC's largest regional offices.

**Education**

M. Eng., Nuclear Engineering, University of Virginia
B.S., Physics (with distinction), U.S. Naval Academy

**Qualifications**

**Management** – As Deputy Director of NRC's Office of Nuclear Reactor Regulation (NRR), assisted the Director in managing a staff of 600 personnel and responsible for the following areas: engineering and technical reviews, licensing and license renewal, inspection and oversight programs (ROP), assessment, event response, security, and maintenance rule implementation for all NRC-operating reactors in the U.S. Other responsibilities included certification and licensing of advanced reactors and the renewal of current power reactor operating licenses. During this position also served as the NRC's Chairman of the License Renewal Steering Committee. Provided NRC oversight of the technical staff's safety evaluation and environmental reviews as well as the budgeting and management of resources to implement Commission policy. As

Deputy Regional Administrator for Region II, directly responsible for administering licensing, inspection, enforcement, budgeting, travel, human resource, legal, public affairs, state liaison, training, and emergency preparedness programs for one of NRC's largest regional offices. This included reactor safety as well as radioactive materials safety (medical and industrial) and fuel facility safety programs.

**Reactor Safety Licensing and Inspection Policy** – While a Senior Nuclear Safety and Engineering Consultant, provided advice to national and international nuclear utilities and governmental managers regarding nuclear reactor licensing and inspection policy. Also provided advice to the nuclear industry regarding advanced reactor policy. As Deputy Director of the Office of NRR developed risk-informed regulations, operator licensing, advanced reactor licensing, and generic Technical Specification development. In this position also provided expert advice on policy matters to the NRC Commissioners, Congress, and the White House. Served as the NRC principle spokesman along with the Industry Steering Committee Chairman during periodic open public meetings to discuss high priority issues needing regulatory decisions and supervised Regional inspections of aging management programs.

**Engineering and Technical Reviews** - As a Consultant to a major nuclear utility, reviewed self assessments of engineering processes and designed controls including safety design margins for critical components and systems. As Deputy Director of NRR, responsible for NRC policy on engineering and technical reviews including regulations and industry standards endorsed for implementation, NRC reviewer qualifications, and the preparation of safety evaluations of license applications. As Deputy Regional Administrator, was responsible for oversight of all inspections of design and engineering activities at all power and research reactors and fuel facilities in the Southeastern US. As a Senior NRC Executive in charge of the NRC MC 0350 process for oversight and performance improvement of the Brunswick and Browns Ferry stations, managed all regulatory reviews of engineering design and construction activities. As NRC Manager in Region I, led the Team that determined Seabrook Station was constructed in substantial conformance with the engineering processes and design as described in the FSAR. This ended up being a major factor in the operating license issuance.

**Quality Assurance Programs** - As a member of the Safety Review Board for two nuclear stations, reviewed all aspects of quality assurance activities and non-conformance reports as well as all self assessments of safety related activities. Provided advice to license applicants on effective implementation of NRC and industry (ASME NQA-1) QA standards. As an NRC Inspector and Manager, reviewed detailed implementation of NRC requirements in 10 CFR 50, Appendix B, including design controls, procurement, testing, and corrective action programs. Led Team assessments of Corrective Action Programs at nuclear reactors with performance issues under close scrutiny of NRC.

**Spent Fuel Repository Reviews** - As the Chairman of the Executive Assessment Board and a Member of the Executive Team, evaluated a major DOE effort to prepare a license application to the NRC for the world's first deep geological spent fuel repository. This required regulatory advice and licensing guidance. As a Consultant, reviewed the management and Quality Assurance effectiveness of proposed repository programs.

**Security** – As a Senior Consultant, provided advice on security requirements for advanced reactor sites. Served as Special Senior Safety and Security Advisor to the NRC's Office of the Executive Director for Operations. In this position, managed twelve teams to assess safety and security strategy at all power plants in the U.S. As the Associate Director for Inspection and Programs and, later, Deputy Director for the Office of Nuclear Reactor Regulation, responsible for physical security inspection and licensing programs as well as security regulation development at all U.S. civilian reactors. Following 9-11, served on NRC's Executive Task Force to establish strategic plan for NRC's comprehensive re-evaluation of security effectiveness and establish interim requirements.

**Diagnostic Evaluations and Self Assessments** - As an NRC Manager and Inspector, served on numerous inspection teams evaluating licensees self assessment program effectiveness. Served as NRC's SES manager and chairman of the Brunswick and Browns Ferry MC0350 oversight panels to monitor and lead the recovery actions from prior poor performance. Both facilities subsequently completed world records for safe operating periods.

**Nuclear Oversight** - Served as Member and Chairman of Nuclear Oversight Boards for a major U.S. utility and a major DOE contractor. As a Senior Nuclear Safety Consultant provided advice to Chief Nuclear Officers and the DOE M&O contractor site President on matters involving nuclear safety, operations excellence, and licensing strategies. As Deputy Director of NRR directly managed implementation of NRC's Reactor Oversight Process (ROP), which also involved engineering and technical review, inspection, assessment, enforcement, security, and emergency response functions for all NRC-operating reactors in the northeast (Region I) and southeast (Region II).

**Training and Qualification Programs** - As Associate Director and Deputy Director of NRR, was directly responsible for NRC's inspector training and qualification programs as well as oversight of civilian reactor operator licensing and training programs. Directly monitored revision of NRC's inspector training and qualification program and served as chairman of certification boards. While serving in the U.S. Navy worked as Division Director and responsible for development of course instruction for 15 instructors and 800 students that related reactor physics to a naval nuclear power plant.

As a Nuclear Safety Consultant, developed and presented a unique course on risk-informed regulatory approaches and inspection techniques to Eastern European regulators and utility managers. Invited to be principal expert speaker at workshops in Europe for the IAEA on nuclear regulatory strategies in a deregulated electricity market as well as the use of technical support organizations by the regulator. Provided nuclear operator and regulator training advice to foreign regulatory agency.

**Research Effectiveness** - As Associate Director for Inspection and Programs, served as NRC's representative to the NRC Research Effectiveness Review Board. Reviewed planning and budgeting priorities as well as evaluated the process for coordination between licensing and research for those who user the results of nuclear safety research.

**Public Communications** - While an Executive in NRC Headquarters and at two Regional offices, represented the NRC to the White House, Congress, state and local officials, the public, and news media. Chaired NRC steering committees, public meetings, workshops, licensee performance reviews and enforcement conferences. Also served as NRC's chief spokesman during emergency exercises.

**Reactor Operations and Operational Readiness** – As a Senior Nuclear Safety Consultant, provided reactor operations and nuclear safety advice to nuclear utility managers. As NRC Executive at NRC Headquarters and in two Regional offices, was responsible for the safety oversight (ROP) of 103 operating power reactors and 36 research reactors in the US. While an NRC Senior Resident Inspector, conducted daily reactor plant operations and maintenance inspections and regulatory oversight. As an NRC Inspector and Regional Manager, directly responsible for construction completion, operational readiness inspections, and regulatory oversight for power reactors in the licensing stage. As Region II Executive, chaired NRC's licensing and inspection MC 0350 panels to assess the readiness of Progress Energy's Brunswick site and TVA's Browns Ferry reactor to restart after extended shutdown periods. .During period as U.S. Naval Officer, directed dual–reactor plant operations at sea and during refueling overhaul in this position. Also conducted readiness assessments prior to U.S. naval reactor plant restarts.

**Emergency Preparedness**- While Deputy Director of NRR and a Regional Executive was responsible for reactor safety incident response functions at NRC's Headquarters and two Regional offices. Served as a Member of NRC's Executive Team in NRC Headquarters Incident Response Center during both the Indian Point 2 steam generator tube rupture and response to the 9-11 attack on the World Trade Center. Also participated in various crisis exercises as well as directed NRC's emergency response to reactor events while in RC Headquarters. Completed training and qualification as NRC Team Leader for Incident Investigation Teams.

**Strategic Planning**- Served as NRC's Office of Nuclear Reactor Regulation representative on NRC's Strategic Planning Panel to update and reform the agency's Strategic Plan. Recommended and developed key approaches to strategies, goals, and objectives as well as methods and means of measuring effectiveness or success. Also presented the budget for NRC's largest office to the agency's Executive Resource Council while in this position.

**Employment/Affiliations:**

**Talisman International, LLC**, Senior Nuclear Safety Consultant, 2003- present

**U.S. Nuclear Regulatory Commission**, 1978-2003
- Deputy Director, Office of Nuclear Reactor Regulation
- Deputy Regional Administrator, Atlanta
- Director, Division of Reactor Projects
- Branch Chief, Philadelphia
- Senior Resident Inspector, Pilgrim Nuclear Power Station

**U.S. Navy**, 1970-1978

Director, Division of Reactor Principles, US Naval Nuclear Power School
Reactor Mechanical Assistant
Nuclear Trained Officer

**Honors and Distinctions**

Presidential Rank Meritorious Executive Award
NRC Performance and Special Achievement Awards
NRC EEO Award for Outstanding Recruitment of Hispanic Engineers
Chairman, Executive Oversight Board for major DOE M&O contractor
Member of Off Site Safety Review Committee for major US Nuclear Utility
Principle speaker for IAEA workshops for European utility and regulatory managers
Independent Member of Award Committee for private Technical and Scientific Co.
Chairman NRC License Renewal Steering Committee
Chairman NRC's Oversight Panel for MC 0350 Reviews
Member NRC's Research Effectiveness Review Board
Certified NRC Inspector and Incident Investigation Team Leader
Registered Professional Engineer, Commonwealth of Massachusetts
Qualified as Chief Nuclear Engineer and Engineering Officer of the Watch, US Navy

# Robert V. Fairbank, Jr.
## Senior Regulatory and Nuclear Consultant

**Summary**

Robert V. Fairbank, Jr. is a Senior Regulatory and Nuclear Safety Consultant with Talisman International who is recognized for his ability to solve the most complicated and important problems through rigorous analysis and application of wide-ranging experience.
He has over 35 years of nuclear industry experience, including 16 years as a senior manager. Areas of expertise include engineering, regulatory strategy and compliance, quality assurance, project management, and business management.
Nuclear Consultant for over 7 years; providing technical and litigation support, event investigation, employee concern resolution, performance assessment and improvement, independent reviews for executive management and governance boards, and assistance to companies positioning themselves to participate in the nuclear renaissance.

**Education**

M.B.A., University of Pittsburgh
B.S.M.E., Mechanical Engineering, Northeastern University

**Professional Experience**

**Engineering/Regulatory Affairs/Management –** Senior Engineering Manager responsible for over 100 engineers of all disciplines. Provided home office engineering and field technical support to nuclear power stations. Engineering Manager for many major plant modifications, overseeing design, procurement, construction, testing and turnover. Managed numerous engineering programs to enhance reliability and safety of production facility operation.

Managed Regulatory Affairs when nuclear operation was under close regulatory scrutiny. Provided expert input to regulatory/legal proceedings and expert testimony before a Federal Licensing Board. Managed license changes that improved plant reliability and availability and reduced costs. Built and mentored teams to scope, develop justification for and implement license changes. Worked with line management and the Federal Regulator.

**Project Management –** As Project Manager reduced operating costs and improved plant production by completing complex capital and regulatory improvement projects. Applied strong project management fundamentals in managing projects through all phases of the life cycle.

Managed a major design information submittal required by the Federal Regulator. Performed a complete assessment of a dual-unit nuclear plant's design and operation and confirmed compliance with its license. Supervised dozens of individuals from all functional areas over several weeks and met a very strict deadline. The submittal, provided under oath by the Site Vice President, required a rigorous well-documented process and verification of the results.

Managed engineering/project support of regulatory agency team inspections. Organized in-house teams to properly prepare; provided timely and accurate responses to inspection team requests; and promptly apprised management such that prompt action could be taken.

**Business and Process Management –** As a member of a team of senior managers performed a due diligence review for a large utility contemplating a $30B merger with a large nuclear utility. Researched all aspects of the nuclear business unit to ensure there was no major financial risk.

In the area of strategic planning, increased profitability by tightening the focus on key business results as Business Manager at Pilgrim Nuclear Power Station. Guided and facilitated Senior Management Teams in developing and implementing strategic business plans, long-term and annual operating plans and deregulation strategies & transition plans.

With respect to management of peer groups, improved functional area performance while a senior manager at Boston Edison. Led and participated in a single-unit Boiling Water Reactor benchmarking peer group. Helped managers from different companies and facilities share information, identify and implement industry best practices and standardize processes and deliverables. Facilities, both international and domestic, were of similar size and design. Facilitated several successful functional area (e.g. Security, Operations) benchmarking studies, resulting in savings of up to $7M per year and at times overcoming strong resistance to change.

While a senior manager at Boston Edison reduced costs and staffing levels through alliances. Organized and led the Northeast Energy Alliance, a group of 10 regional nuclear utilities. Individual facilities saved $6M per year and the group more than $100M per year.

In relationship to process improvement, increased engineering product quality and reduced rework and delays. While Engineering Manager at Boston Edison developed and implemented a Design Review Board; served as initial chairperson; recognized by the industry as a best practice. As Manager of Technical Quality at Boston Edison analyzed, developed and implemented processes, procedures and training programs consistent with applicable regulations and best industry practices and increased process efficiency and effectiveness.

As Engineering Manager at Boston Edison and Commonwealth Edison reduced human performance events. Analyzed and trended human performance incidents, identified causal factors and developed and implemented corrective and preventive actions.

**Event Investigations –** As project manager provided leadership and expertise to high-profile issues with potentially very significant consequences. Investigated missing nuclear fuel at two different nuclear power facilities helping to bring these issues to closure. Led a team of experts, made public presentations to Federal Regulators and state and local oversight committees. The investigations' thoroughness and rigor were recognized and credited by the Federal Regulator.

Led numerous emergent issue response teams as Engineering Manager at Boston Edison and Commonwealth Edison. Led investigations of plant events and equipment failures. Launched investigations by building multi-disciplined teams, developed action plans and schedules, applied a disciplined problem analysis process and achieved timely issue resolution.

**Litigation Support –** Provided technical consulting services to clients and helped achieve favorable outcomes in insurance and construction claims involving more than $100M. Recognized for thorough research and analysis; enabling legal counsel to build superior cases.

**Performance Assessments -** Performed independent review of major projects and project management processes for large nuclear utilities executing $100M's of work. Identified weaknesses and provided recommendations to executive management.

Member of a team of senior executives and managers performing independent review of the Mixed Oxide Fuel Fabrication Facility at Savannah River. Team performs focused periodic assessments of the project at the request of and reports findings to the Board of Governors.

Provided objective, independent and comprehensive assessments of nuclear plant performance for Commonwealth Edison and Boston Edison. Assessed key functional areas, as part of a team of senior-level industry experts. Used a standardized methodology to achieve consistent levels of excellence.

Led restart readiness team assessment of Engineering for a nuclear plant shutdown due to safety concerns. Completed a comprehensive assessment, including staff level and qualifications, processes and programs, backlog, and effectiveness of corrective actions. Identified and characterized weaknesses, and provided recommendations to support restart.

Provided independent, executive level oversight and assessment of the operation of nuclear power plants as a Safety Review Committee Member.

**Employee Concerns Resolution –** Participated in senior management teams that investigated and helped resolve employee concerns and allegations at nuclear fuel cycle and power plants. Conducted interviews, gathered information, performed analysis and developed conclusions and recommendations for executive management.

**Performance Improvement –** As Engineering Manager and Manager of Regulatory Affairs and Emergency Preparedness at Boston Edison streamlined processes and optimized staffing levels. Mentored staff in performing self-assessment, designing organizational structures, establishing performance metrics and accountability measures, and improving processes and product quality.

Member of the senior management team that turned around performance at nuclear plants.

**Management and Technical Support –** Performed an independent design review of the Yucca Mountain surface facility conceptual designs for the U. S. Department of Energy.

Assisted an international nuclear plant supplier in licensing a new reactor design. Performed safety system design reviews and helped develop and write the quality assurance program description and implementing procedures.

As Temporary Quality Assurance/Quality Control Manager for a large construction company led the resolution of a critical path restart issue at the world's largest nuclear plant recovery project.

Evaluated the capabilities of a geotechnical services company and advised Board of Directors regarding entry into emerging nuclear power market.

**Employment/Affiliations**

| | | |
|---|---|---|
| **Talisman International, LLC** | 2003-Present | Nuclear and Regulatory Consultant |
| **Fairbank Management Services,** | 2000 - Present | Nuclear and Regulatory Consultant |
| **Commonwealth Edison Company**, | 1996 - 2000 | Senior Manager |

| | | |
|---|---|---|
| **Boston Edison Company**, | 1980 - 1996 | Senior Manager |
| **Bechtel Power Corporation,** | 1978 – 1980 | Control Systems Group Leader |
| **Westinghouse Electric Company,** | 1975-1978 | Cognizant Engineer |
| **Bechtel Power Corporation,** | 1970 - 1975 | Control Systems Engineer |

## Appendix C

## Abbreviations and Acronyms

**AECL – Atomic Energy Canada Limited**
**AECB – Atomic Energy Control Board**
**ATS – Automatic Transfer Switch**
**BMD – Board Member Document**
**CAP - Corrective Action Program**
**CMD – Commission Member Document**
**CNSC – Canadian Nuclear Safety Commission**
**CRL – Chalk River Laboratories**
**ECCS – Emergency Core Cooling System**
**EPS – Emergency Power Supply**
**DC – Direct Current**
**FA – Facility Authorization**
**FSAR – Final Safety Analysis Report**
**IAEA – International Atomic Energy Agency**
**ITS – Instructions to Supervisors**
**JCO – Justification for Continued Operation**
**LCO – Limiting Condition of Operation**
**LCVC – Liquid Confinement Vented Confinement**
**LE – Licensability Extension**
**LOFA – Loss of Flow Accident**
**MHWP - Main Heavy Water Pumps**
**NECC – New Emergency Core Cooling**
**NRU – National Research Universal**
**OL – Operating License**
**PSA – Probabilistic Safety Assessment**
**QA – Quality Assurance**
**SEP – Safety Evaluation Report**
**RSEP – Reactor Safety Evaluation Report**
**SDR – Significant Development Report**
**SPOC – Single Point of Contact**
**SRC – Safety Review Committee**
**TOE – Technical Operability Evaluation**

## Appendix D

## Timeline-Sequence of Events for Major Observations

| Date | Event |
|---|---|
| 11/x/1957 | NRU first criticality |
| 3/x/1964 | AECL issued NRU Safety and Hazards Review (FSAR) – This version, plus subsequent addenda, remains the FSAR of record in the NRU OL |
| x/x/1991 | AECL Identified 7 Safety System Upgrades |
| 9/14/1992 | AECL described intent to provide Class 1 power to the MHWPs |
| 12/7/1992 | AECL informed AECB of its intent to upgrade NRU reactor in 1995/1996 to achieve off-site dose and safety goals |
| 1/28/1993 | AECL issued Concept Safety Assessment Report for the 7 upgrades, including Class 1 Power to the MHWPs |
| 4/5/1993 | AECL Upgrades Project Plan included a work package to design EPS to provide emergency power to MHWPs 104 and 105 |
| 2/4/1994 | AECL Project Procedure nominated the Project Manager to be responsible for conformance with AECB regulatory requirements |
| 6/7/1994 | AECB BMD – AECB staff concurred with the 7 Upgrades proposed by AECL. EPS installation was scheduled for 1997 |
| 3/x/1995 | AECL licensing plan stated the 7 Upgrades Modifications to be implemented per the FA change control process; EPS upgrade will provide hazard-qualified Class 1 power to the MHWPs |
| 5/x/1995 | AECL Project Procedure required a licensing/regulatory review and impact assessment of changes to NRU Upgrades |
| 2/23/1996 | AECL letter to AECB stated EPS is required to provide power to MHWPs 4 &5 and that it planned to test and qualify the existing DC motor starters |
| 6/12/1996 | AECL apprised AECB that the NRU reactor would not be operated after 12/31/2005 under any circumstances. |
| 4/x/1997 | AECL First Safety Note for EPS Upgrade stated EPS will provide hazards-qualified power for MHWPs essential for core cooling by 1998. |
| 5/31/1997 | Canada Nuclear Safety and Control Act went into effect and established the CSNC |
| 3/x/1998 | NRU FSAR included wording that seismically-qualified starters were installed. {The SAR was issued and the EPS system description described a future state.} |
| 3/x/1998 | AECL issued NRU Reactor Annual Safety Review AECL-MISC-300-97 – described 7 Upgrades – Upgrades included providing seismically-qualified EPS to MHWPs |
| 5/20/1998 | AECL apprised CNSC in a meeting that the NRU EPS Upgrade was scheduled for September 2000 installation |
| 5/21/1998 | In a AECL/CNSC meeting, AECL proposed quarterly NRU Upgrades meetings |
| 6/9/1998 | CNSC staff BMD noted AECL schedule slippages for NRU Upgrades and proposed a Licence Condition requiring completion of the upgrades and the safety report by 10/31/2000 |
| 9/x/1998 | AECL issued Revision 2 to EPS First Safety Note – An essential part of the upgrade is to provide a hazard qualified Class 1 power to the MHWPs. A recently completed |

| Date | Event |
|---|---|
| | options study showed the replacement of existing starters is necessary. |
| 10/29/1998 | CNSC issued OL NRTE 1/98 – Licence Condition 27 specified 7 NRU upgrades described in 4.5 of AECL-MISC-300-97. {The Licence Condition was retained through Amendment 6 (5/15/00).} |
| 11/30/1998 | AECL sent EPS First Safety Note to CNSC – Scope included hazard qualified Class 1 power to the MHWPs |
| 4/1/1999 | Amendment 2 to CRL OL included Licence Condition 27 and Licence Condition 30. AECL was required to report progress on the 7 Upgrades at the October 1999 CNSC Meeting |
| x/x/2000 | CNSC issued OL NRTEOL 1.00/2002. {The Licence Condition regarding the 7 upgrades was not included and not mentioned again until the 11/2005 OL} |
| 8/x/2000 | AECL issued FA AECL-FA-01, Rev. 4 - FSAR of record remained the 1964 edition plus subsequent addenda. This is the last approved version of the FA and is the FA of record in the current License. |
| 1/26/2000 | AECL committed to the CNSC to install EPS by October 2000 |
| 7/17/2000 | CNSC CMD apprised the Members that EPS would not be fully implemented by 10/31/2000, and AECL will be in non-conformance with Licence Condition 27a. The staff stated it was not proposing a new Licence Condition. |
| 8/25/2000 | NRU NECC Design Description includes EPS to the MHWPs |
| 10/31/2000 | AECL issued a revised FSAR to CNSC for approval. CNSC provided comments in a letter to AECL 6 years later. The 1964 version, plus subsequent addenda, remained the FSAR of record in the OL |
| 12/1/2000 | CNSC provided comments on the FSAR, and asked for a work plan and schedule for addressing all outstanding issues and the submission of supporting documentation and information at the upcoming RSEP review meeting on December 6, 2000. |
| 12/5/2000 | AECL issued Probabilistic Safety Assessment (PSA) to CNSC for approval. CNSC has never approved the PSA. |
| 2/27/2002 | AECL issued EPS Commissioning Plan. Reported that all EPS were tested, except for the Automatic Transfer Switches and Motor Starters for MHWPs 104 and 105. |
| x/x/2002 | Fifth of the first 5 upgrades in-service |
| 5/x/2002 | AECL Operating Procedure, "*Change Control*", the procedure specified in the Operating Licence to be used to implement the NRU Upgrades, required close-out by the Sponsor, and verification that changes are installed as described in the design; as-built drawings are available and up to date, and commissioning is complete. |
| 9/2/2002 | AECL issued Final Safety Note EPS Upgrade - Upgraded motor starters to be installed on MHWPs |
| 3/x/2003 | CNSC issued reporting requirements guidance document. It was to be issued as a Reg. Guide in 2005. {The Reg. Guide has not been issued to date.} |
| 5/29/2003 | CNSC issued OL NRTEOL-01.00/2006 with License Condition 13.1. NRU was to be shutdown 12/31/2005 unless otherwise authorized by the Commission. {The licence condition remained through Amendment 2}. There was no Licence Condition included specific to the NRU Upgrades. |
| 8/6/2003 | AECL apprised CNSC that NECC and EPS are functional, but significant effort is required for completion |

| Date | Event |
|---|---|
| 10/14/2003 | CNSC approved EPS Final Safety Note, dated September 2002 |
| 3/x/2004 | AECL NRU Licensing Plan referred to 7 Upgrades that are almost complete. No date was provided for completion. |
| 7/29/2004 | CNSC letter to AECL clarified expectation that AECL complete EPS as a condition of operation beyond 2005. |
| 8/31/2004 | AECL states NRU Upgrades will be completed by the end of the fiscal year. |
| 10/28/2004 | AECL Master Schedule showed EPS-NECC-DC Installation and Commissioning by March 2005 |
| 11/30/2004 | AECL Master Schedule showed EPS-NECC-DC Installation and Commissioning by March 2005 |
| 12/17/2004 | AECL letter to CNSC – new NECC Upgrades to have hazards-qualified EPS to MHWPs 104 & 105 |
| 1/17/2005 | Commissioning and Test Plan issued for qualified motor starters |
| 3/x/2005 | AECL issued EPS Commissioning Report. It stated the DC motor starters were not installed and that functional test will be completed after they are installed. The report will be revised after final commission tests are complete. |
| 3/x/2005 | AECL issued Rev 1 to EPS Final Safety Note – seismically-qualified auto-start circuit to MHWPs 104 & 105 |
| 3/x/2005 | NRU Annual Safety Review 2004 stated the EPS Upgrade provides hazards-qualified power to MHWPs 104 &105 |
| 3/16/2005 | EPS Design Requirements stated EPS provides qualified emergency back-up power to MHWPs 4 & 5 |
| 3/31/2005 | AECL requested tie–in of EPS to the other NRU upgrades |
| 4/x/2005 – 6/x/2005 | AECL 2008 Root Cause Analysis stated that, around this time, NRU Managers made a decision to track EPS to MHWPs separate from NRU Upgrades |
| 4/x/2005 | AECL Interim Report on the Plant Life Management Program for the NRU Reactor attached to the 4/15/2005 licence application, stated *"The last two upgrades (NECC and EPS) are now installed, commissioned, and ready for connection of EPS to the other NRU Safety Upgrades.[… ] The only remaining Upgrades work of significance is the replacement of the DC Motor Starters for Main Heavy Water Pumps #4 and #5 with seismically qualified units. One of these starter units is currently installed (2005 April) and is undergoing in-service testing on Main Heavy Water Pump #1."* |
| 4/6/2005 | EPS Design Description stated EPS provides qualified emergency back-up power to MHWPs 4 & 5 |
| 4/8/2005 | CNSC letter to AECL acknowledged AECL's agreement that EPS and NECC will be completed by March 2005, and that the deadline has not been achieved |
| 4/13/2005 | AECL informed CNSC that EPS was ready for tie-in to the other upgrades |
| 4/14/2005 | AECL Corporate QA Audit Report, Oversight of the NRU Upgrades, made no mention of the EPS tie-in to the MHWPs or the DC Motor Starters |
| 4/15/2005 | AECL, in its licence application, informed CNSC that EPS and NECC upgrades would be in service in April/May 2005 and September 2005, respectively, and that the upgrades would be seismically and environmentally qualified. The letter stated that "These safety upgrades were placed in service as noted above. The Emergency Power Supply system has been commissioned and an application has been made to the Safety Review |

| Date | Event |
|---|---|
| | Committee and CNSC to place it in service, at which time it will be fully operational and ready for connection of Emergency Power Supply power to the other NRU safety upgrades." |
| 5/9/2005 | AECL SRC approved EPS tie-ins, except to the DC Motor starters for the MHWPs |
| 5/26/2005 | AECL letter requesting CNSC approval of EPS tie-in to the other upgrades, but it did not include tie-in to the DC motor starters |
| 6/6/2005 | CNSC issued preliminary approval of EPS tie-ins except to the DC Motor starters for the MHWPs |
| 6/23/2005 | AECL letter responding to CNSC comments on the AECL Licensing Plan. AECL expressed its understanding that when the EPS is tied in to the QUERC control cabinets that the commitment made to complete EPS will have been satisfied. The tie-in to the MHWPs had not been requested and therefore was not considered by AECL to be part of the EPS upgrade completion commitment. |
| 6/29/2005 | CMD 05-H12 and CMD 05-H12.A stated the EPS Upgrade provides seismically-qualified, automatically connected power for primary coolant pumps. |
| 6/29/2005 | AECL applied to continue operation after 12/31/05 |
| 7/x/2005 | AECL Final Safety Note for the EPS Upgrade, Revision 2, stated EPS provides hazards-qualified electrical power to MHWPs 104 and 105 |
| 8/x/2005 | NRU Severe Accident Assessment stated that of all the external events, seismic events have the greatest potential safety impact on the reactor. The assessment stated that, with the upgrades, external events pose no significant risk. |
| 8/x/2005 | AECL Condition Assessment of MHWPs AC & DC Drives stated the failure probability for MHWP4 &5 DC motors is 3 x10-3, and part of the NRU Upgrades is seismically-qualified DC motor starters |
| 8/5/2005 | EPS Operating Manual indicated EPS connection to MHWPs is available, but when the manual was issued it had not been connected |
| 8/18/2005 | AECL application to extend operation for 7 months and the in-service date for EPS was October 2005. {Note: the licence renewal application was filed within 4 months of the need date.} |
| 9/19/2005 | CNSC letter to AECL, advising AECL to postpone submittal of the FSAR revision until March/April 2006, to allow time for the seven upgrades to be functional and for the reactor configuration to match the revised SAR |
| 9/19/2005 | Internal AECL email noted that the Motor Starters installation would be after year end |
| 9/20/2005 | CNSC letter commented on AECL approval to tie-in EPS to the other upgrades |
| 9/22/2005 | AECL submitted LCOs for EPS but did not submit LCOs for the motor starters or the Automatic Transfer Switches |
| 10/5/2005 | AECL internal email discussed a CNSC proposed licence condition that all the NRU upgrades must be fully operational by Dec. 31, 2005. CNSC intended to leave that condition unchanged in their supplemental CMD, and asked AECL if it can meet that date, because AECL will be held to it if it does become a licence condition. CNSC said it had about 80% confidence that AECL could meet that date. The email asked for confirmation with high confidence that the date can be met. |
| 10/5/2005 | AECL internal email stated that the seismically-qualified motor starters were a late addition to the program, and should not be part of the December 31, 2005 commitment. |

| Date | Event |
|---|---|
| 10/12/2005 | AECL slides indicate EPS upgrades to be complete in 2005 |
| 10/13/2005 | Internal AECL email questioned whether CNSC knew that AECL did not consider the DC motor starters to be part of the upgrades. The response was that the starters were not part of the upgrades, but did not answer the question as to whether this had been confirmed with CNSC. |
| 10/14/2005 | Internal AECL email stated the DC motor starters have been excluded from the upgrades completion, because they were a design change introduced later in the course of the project. |
| 10/14/2005 | AECL Operational Decision Making Meeting Minutes stated the DC starter modification is not related to EPS. |
| 10/18/2005 | At a Public Hearing, the CNSC President initiated a discussion regarding clarity of words and consistency between CNSC and AECL, noted the slides did not match up, and asked whether there was confidence that both AECL and CNSC understood the short term actions needed. A CNSC Member questioned whether the safety upgrades were clearly understood, and whether expectations regarding the operating licence condition were specific enough so that, in the future, the Commission would be able to conclude that the condition was met. AECL and CNSC replied to the concerns of the Commission Members that they both understood and agreed on the short term actions. AECL stated: "*No, Madam Chair, in fact we believe the two lists are pretty well aligned.*" CNSC stated: *"From a historical perspective, that terminology, 'seven upgrades' has been recognized through streams of numerous licensing correspondence and Commission documentation. So from my perspective it's explicitly clear."* |
| 10/18/2005 | CNSC Public Hearing AECL Oral Presentation stated: "The NRU assessment [3] and safety upgrades were implemented in a manner consistent with the objectives of the IAEA [International Atomic Energy Agency] Periodic Safety Review Process. *"All the safety upgrades are seismically and environmentally qualified."* |
| 10/18/2005 | CNSC CMD 05-H28 stated: *"A formal request to proceed with the tie-in of EPS power has been made to the AECL Review Committee and the CNSC. When the EPS tie-in is completed, verification testing will ensure that all the upgrade systems are fully functional and effective. The NRU Facility Authorization (FA) will then be revised to incorporate the Operating Limits and Conditions for all the upgrades. The only remaining NRU upgrades work of significance is the replacement of the dc motor starters for main heavy water pumps #4 and #5 with seismically qualified units."* |
| 11/11/2005 | AECL letter offered a definition of and requested CNSC concurrence with the term "Fully Operational". |
| 11/21/2005 | CNSC approved AECL's definition of "fully operational". Conditions included are that written confirmation system commissioning tests are completed, acceptance criteria have been met, and the system can fulfill the functions as required. |
| 11/24/2005 | *"Record of Proceedings, Including Reasons for Decision"* in approving continued operation of NRU beyond 12/31/05 *"AECL expressed its commitment to having the NRU seven safety upgrades fully operational by the end of December 2005. CNSC staff recommended that the Commission add a licence condition to ensure this objective is achieved."* |
| 11/24/2005 | CNSC issued Amendment 3 to OL NRTEOL-01.02/2006 with condition 13.1 Licensee shall demonstrate that all 7 NRU upgrades are fully operational by 12/31/2005. |

| Date | Event |
|---|---|
| 11/30/2005 | AECL Application for Licence Renewal to 2011 |
| 12/x/2005 | AECL licensing package supporting licence renewal stated that the new upgrades are designed and installed |
| 12/16/2005 | AECL licence renewal application for a 63 month licence extension {filed within 8 months of need date}. |
| 12/23/2005 | AECL informed CNSC that the 7 Upgrades are fully operational |
| 2/6/2006 | CNSC letter to AECL notifying of the schedule and plan for a Type 1 Inspection of NRU Upgrades. |
| 2/28/2006 | CNSC issued licensing strategy document, which stated that AECL must demonstrate 7 Upgrades are fully operational (1/06) and was invoked in OL as Condition 19.1. |
| 2/20-3/1/2006 | CNSC performed a Type 1 inspection of NRU Upgrades. Inspection scope was focused on programs. |
| 3/x/2006 | AECL licensing package in support of renewal stated 7 seismically-qualified upgrades completed in 12/05. |
| 3/x/2006 | CNSC Preliminary Upgrades Inspection Report stated *"Commissioning Adequacy, The EPS auto-start circuit from the QUERC/NECC controls has not been done yet and will be part of B-20-003 […] The EPS Commissioning Report does not demonstrate …*" |
| 3/17/2006 | AECL response to preliminary inspection report stated that EPS was not connected to the MHWPs. CNSC did not initiate enforcement. |
| x/x/2006 | CNSC internal white paper apprised CNSC supervisors that AECL is treating the tie-in as separate from the upgrades. |
| 4/6/2006 | CNSC Type I Compliance Inspection NRU Upgrades QA Audit Report stated: *"The commissioning tests of the new DC Motor Starters and ATS-3 & 4 on P-104 and P-105 are not complete […] The findings under commissioning were analyzed and a Directive OMSD-AECL-2006-T1743-QA-02-D9 was issued: Functional, performance, control, and safety requirements for the upgrades were not demonstrated by commissioning …"* |
| 4/20/2006 | CNSC issued Inspection Report - documented the commissioning tests of the new DC Motor Starters and ATS-3 and 4 on P-104 and P-105 are not complete. The cover letter states CNSC considered the upgrades cannot be declared *"fully operational"* until related Directives and Action Notices are closed. Inspectors did not identify that the upgrades were not fully operational, in violation of OL Condition, and no licensing or enforcement action was taken. The incomplete starters were cited as finding 4.9.1.8. |
| 4/26/2006 | CNSC Commission Hearing Day One re: Licence renewal application for CRL through 2011. |
| 4/26/2006 | CNSC CMD 06 H9 – stated *"In CMD 05-H28, CNSC staff proposed, and the Commission accepted, a licence condition requiring AECL to demonstrate that all seven NRU upgrades are fully operational by December 31, 2005. Following AECL's declaration of the operational status of the upgrades, CNSC staff has conducted an audit to assess the adequacy and completeness of the managed processes used to control the design, procurement, construction, commissioning, maintenance, and operation of two (Liquid Confinement/Vented Confinement and Emergency Power Supply) of the seven upgrades. The findings from this audit are summarized in Appendix E […] At the time of writing this CMD CNSC staff is in the process of considering the implications of these deficiencies to the extent that will provide the level of assurance that the upgrades* |

| Date | Event |
|---|---|
| | *possess the physical, functional and performance characteristics to meet their design objectives with high reliability […] CNSC staff will be in a position to provide more details on these regulatory requests or actions for Hearing Day 2 […] Preliminary results from the audit indicate there are significant deficiencies ... As a result there is lack of assurance that the safety upgrades possess the physical functional and performance characteristics to meet their design objectives with high reliability."* |
| 4/26/2006 | AECL CMD 06 - H9.1 – 7 stated seismically-qualified upgrades have been completed |
| 4/26/2006 | AECL SRC Quarterly Report stated the installation of the seismically-qualified DC motor starters for MHWPs P-104 and P-105 would be addressed after the documentation had been completed for the new ECCS and the EPS. The Committee noted that the unavailability of the seismically-qualified DC motor starters represents a weakness in the safety case. |
| 5/x/2006 | Minutes of the SRC Open Session stated the committee had further discussions about the unavailability of seismically-qualified DC motor starters for pumps P-104 and P-105, and asked the Proponents to review the Project's resources and priorities, in order to reduce the time at risk from the unavailability of these motor starters. |
| 5/31/2006 | AECL, stated in response to the NRU Upgrades Audit, that it is convinced the current NRU upgrades are fully operational and they will meet their functional and performance requirements. |
| 6/x/2006 | AECL NRU Upgrades Project Slides, presented to the SRC, included a slide that stated Outstanding Items Activities/Equipment - New DC Motor Starters |
| 6/x/2006 | AECL Internal Analysis Report Chalk River Laboratories Regulatory Issues Assessment Report, Regulatory Assessment Team Report conclusions<br>1. AECL had not consistently recognized or effectively dealt with issues identified as significant by the regulator in a timely manner. Subsequent AECL self-assessments reinforced CNSC concerns and led to corrective actions.<br>2. High-level ownership of regulatory issues within AECL was not always established or clear. The administrative process for prioritizing and tracking of regulatory issues was not sufficiently effective.<br>3. The importance of timely and full compliance with regulatory requirements was not consistently reflected in AECL priorities and actions taken. Traceability of regulatory requirements to AECL governing and operating documents needs improvement.<br>4. AECL was not sufficiently proactive in seeking clarification when CNSC requirements and expectations were not clear, nor did AECL proactively follow-up on CNSC submissions, to ensure CNSC staff concerns had been adequately addressed. |
| 6/15/2006 | AECL reiterated the EPS upgrades are now connected, except for MHWP #4 & 5 DC motors, and a full functional test will be performed. |
| 6/16/2006 | CNSC internal email/white paper proposed raising NRU Upgrades implementation issue at Day 2 of Licence Renewal Hearing |
| 6/18/2006 | CNSC internal email asked what is the staff's position regarding enforcement of Licence Condition 19.1 concerning the upgrades. |
| 6/23/2006 | AECL stated the Safety Upgrades meet the agreed upon conditions and have been declared "fully operational" – the Facility Manager signed the Completion Assurance Certificates. |
| 6/26/2006 | CNSC - AECL Meeting regarding the Upgrades Inspection |

| Date | Event |
|---|---|
| 6/28/2006 | AECL Information Presented for the Day Two CNSC Public Hearing cited the CNSC Inspection Report, but made no mention of the DC Motor Starters and AECLs position that the EPS Upgrade was fully operational without them |
| 6/28/2006 | CNSC Supplementary Information CMD 06-H9.B stated *"When CMD 06-H9 was written, CNSC staff was considering the implications of deficiencies found during a February 2006 audit of the NRU Upgrades and was formulating regulatory requests or actions to address the deficiencies to the extent that would provide assurance that the upgrades possess the physical, functional, and performance characteristics to meet their design objectives […] CNSC's staff review of the NRU Upgrades concluded that, although they possess the physical, functional and performance characteristics to meet their design objectives, there is a lack of assurance that they will perform their functions with high reliability."* CNSC also said that, in order to bring the upgrades to high reliability, eight directives and two action notices were issued to the upgrade project, and two directives, three action notices and two recommendations were issued to CRL site processes. |
| 6/28/2006 | CNSC Commission Hearing Day Two re: Licence renewal application for CRL through 2011. |
| 6/30/2006 | AECL submitted LCOs for the remaining upgrades, including the LCO for EPS to MHWPs, for CNSC approval. |
| 7/x/2006 | AECL issued Final Safety Note for EPS – states EPS power supplies are now being connected to MHWPs. |
| 7/5/2006 | AECL SRC Meeting included the discussions of the unavailability of seismically-qualified DC motor starters for pumps P-104 and P-105. |
| 7/6/2006 | AECL letter stated the DC starters are being replaced by hazards-qualified units. |
| 7/28/2006 | CNSC issued Licence NRU extension for 63 months (thru 6/11). Licence Condition 19.1 invoked the licensing strategy document of 2/28/06. |
| 7/28/2006 | CNSC Reasons for Decision to Renew NRU OL stated it was based on the information that upgrades are completed, and the SAR indicated the design provides adequate protection. The upgraded NRU does not pose an unacceptable risk to the public. |
| 7/31/2006 | OL included Licence Condition 19.1 *"The licensee shall comply with the requirements set out in the document entitled "Licensing Strategy for the NRU Licensability Extension Project"."* {The Licence Condition does not refer to a document number or date.} and Licence Condition 1.1 *"The Canadian Nuclear Safety Commission (hereinafter "the Commission") or a person authorized by the Commission is the sole authority to interpret the conditions of this licence."* |
| 8/15/2006 | AECL SRC approved the EPS Final Safety Note, which clearly stated the tie-ins to the MHWPs were not complete. |
| 8/31/2006 | AECL updated response to the CNSC audit stated that it will test the EPS under actual load conditions, when the new DC motor starters are connected up. In response to the findings AECL stated: Finding 4.9.1.5 *"All upgrades are now connected to the EPS, except for MHWP #4 & 5 DC motors […] Finding 4.9.1.7 Correct. Testing of the new DC motor starters is still in progress."* |
| 9/1/2006 | CNSC letter provided comments on the 2000 version of the FSAR |
| 9/29/2006 | CNSC informed AECL the LCOs are being reviewed by CNSC staff. |

| Date | Event |
|---|---|
| 10/26/2006 | CNSC provided comments on AECL NRU FSAR – 6 years after it was submitted |
| 10/31/2006 | AECL EPS Design Verification stated: *"Install EPS electrical equipment. This equipment includes MCCs, UPSs, battery banks, diesel generator sets and DC motor starters […] Completed to meet requirements with the exception of the DC motors, which are still in progress."* |
| 11/7/2006 | AECL Project Implementation Plan for the Upgrades Project. Appendix A Master Schedule showed final commissioning around the end of May 1998. *"The base scope of work was generated from Conceptual Design Documents of the seven proposed upgrades determined from assessment phase. Design Requirements Documents and Detailed Design Descriptions including Option Studies, where applicable, will be produced to form the basis for seeking approval to proceed from the appropriate governing bodies."* |
| 12/x/2006 | AECL EPS Commissioning Verification Report was prepared in response to a CNSC audit Directive to review the adequacy and completeness of the commissioning program applied to EPS. The verification report said *"In October 2005, with approval of the SRC and the CNSC, the final connections of EPS power to the other safety upgrades were completed and the system was brought to 'fully operational' […] Replacement of these starters was an add-on to the original project scope resulting from the NRU safety reanalysis. It will provide enhanced protection against Loss of Flow especially after a seismic event […] the remaining two procedures are related to the new qualified DC motor starters and will be completed after the new starters are installed."* |
| 3/x/2007 | AECL submitted Annual Safety Review – testing of MHWP starters will continue in 2007. CNSC did not initiate enforcement. |
| 3/x/2007 | AECL submitted FSAR AECL-MISC-300, Rev.1 – written as though seismically-qualified EPS is connected to MHWPs. |
| 6/x/2007 | AECL EPS Operating Manual stated *"However, MHWP #4 and #5 new DC motor starters, containing the auto-transfer switches for connecting to the alternate EPS supply, have not been installed as of this manuals release date."* {This is the Manual that indicated to the CNSC resident inspector the lack of EPS connection to the MHWPS.} |
| 7/x/2007 | AECL Assessment Document stated *"A subsequent design addition to the Upgrades work of significance has been the replacement of the DC Motor Starters for the Main Heavy Water Pumps #4 and #5 with seismically qualified units."* |
| 7/31/2007 | AECL submitted NRU Life Extension Final Report – stated replacement of motor starters for MHWPs is continuing. CNSC did not initiate enforcement. |
| 8/30/2007 | AECL issued revised PSA – [Severe Core Damage Frequency] SCDF $10^{-4}$. {CSNC had not commented on or approved the current version of the PSA} |
| 11/5/2007 | CNSC resident inspector discovers a statement in NRU operating manual, indicating that MHWPs are not connected to EPS |
| 11/7/2007 | AECL confirmed in writing that MHWPs are not connected to EPS |
| 11/8/2007 | CNSC expressed concern that NRU physical plant was not within licensing and safety parameters |
| 11/14/2007 | AECL made a verbal report that physical plant differed from 2007 FSAR and was using a TOE process to evaluate the safety significance. |

| Date | Event |
|---|---|
| 11/14/2007 | AECL completed TOE and concluded there was no loss of function, while there was reasonable assurance of adequate margins of safety. |
| 11/15/2007 | CNSC letter to AECL documented verbal AECL report that facility does not match the FSAR; requested a description of the TOE and asked for daily updates on progress. |
| 11/16/2007 | AECL informed CNSC of results of TOE |
| 11/16/2007 | NRU reactor tripped |
| 11/16/2007 | NRU reactor was restarted. |
| 11/19/2007 | NRU shutdown for 4 day regularly scheduled maintenance |
| 11/20/2007 | CNSC internal email stated that there is a huge degradation of safety without the features which ensure power is provided to the cooling pumps. *"This 1.3E-3 of severe core damage was estimated as 6.15E-9 in the PSA (assuming the missing features to be implemented.) […] The comparison between 1.3E-3 and 6.15E-9 indicates a huge degradation of safety."* |
| 11/21/2007 | CNSC informed AECL of CNSC staff's concerns regarding the depth and conclusions of the TOE, and advised that CNSC was working on a strong letter stating its position and concerns, recommending AECL not to re-start the reactor (scheduled for Thursday 11/22 at night). |
| 11/22/2007 | AECL letter notified CNSC that reactor would not be restarted, so as to continue installation of qualified motor starters for MHWPs. |
| 11/23/2007 | CNSC Staff notified the Commission Members of the Operational Event/Condition at NRU regarding the mismatch between the FSAR and the facility. |
| 11/27/2007 | CNSC and AECL senior management meeting to discuss one pump operation. |
| 11/27/2007 | CNSC issued SDR CMD 07-M38. CNSC stated the NRU reactor was shut down because the facility did not match FSAR. |
| 11/x/2007 | AECL - Purchasing developed a punch list for materials needed to finish installation of the Motor Starters, which included commodities (wire, connectors, fasteners, conduit, etc.) and two engineered components (resistors and relays). |
| 11/29/2007 | AECL letter to CNSC submitted the one pump safety case - AECL Nuclear Safety Note "NRU Safety Case for Single MHWP Operation Safety and Environmental Analysis Branch" |
| 11/29/2007 | CNSC communicated SDR to Minister NRCan office |
| 11/29/2007 | AECL submitted a safety case for one pump operation to CNSC. CNSC & AECL had no predetermined risk acceptance criteria on which to base acceptability of continued operation. |
| 11/30/2007 | In an AECL/CNSC meeting, AECL stated it did not consider the EPS tie-in to the MHWPs to be part of NRU Upgrades |
| 12/2/2007 | AECL email notified CNSC of its decision to not pursue the one pump safety case, so CNSC would not waste resources |
| 12/4/2007 | AECL issued a press release. |
| 12/5/2007 | Teleconference - CNSC and Minister NRCan |
| 12/5/2007 | AECL provided a schedule to CNSC that showed EPS connection to Pump P-104 by 12/23/07 |
| 12/6/2007 | Public Meeting CNSC Commission – CNSC President states EPS to MHWPs was always required as part of the NRU Upgrades and was not an "enhancement" – if AECL |

| Date | Event |
|---|---|
| | had not shut down NRU, CNSC would have issued an order to do so. |
| 12/7/2007 | AECL submitted a letter to the CNSC President, requesting approval of a safety case to operate with one pump connected, and indicating that if a hearing was required, it should be held on an urgent basis. |
| 12/7/2007 | CNSC letter to AECL stated that AECL's plan to develop a new safety case that is different from the one upon which the existing OL was issued requires an OL amendment and that the Commission has committed to hearing the matter expeditiously. |
| 12/8/2007 | Teleconference between NRCan Minister and CNSC President |
| 12/8/2007 | AECL submitted a draft list of actions from the November 30 meeting |
| 12/9/2007 | CNSC responded to the AECL draft action list from the November 30 meeting |
| 12/10/2007 | CNSC letter to AECL stated the Commission is prepared to vary its rules and to hear this matter of a licence amendment expeditiously, and requested AECL submit a request for license amendment and a full safety case. |
| 12/10/2007 | Acting General Counsel of the Legal Services Unit of the CNSC verbally informed the President of the CNSC of the withdrawal of legal services by the Department of Justice from the CNSC on the AECL file |
| 12/10/2007 | CNSC obtained independent legal counsel |
| 12/10/2007 | Canada's Governor General in Council issued Directive – Regulation of production of nuclear substances shall take into account the health of citizens dependent on the products. CNSC has no risk (including medical) process and acceptance criteria on which to base acceptability of continued operation. |
| 12/10/2007 | Joint letters to CNSC and AECL Presidents from NRCan Minister and HealthCan Minister. Observations that there is no difference in risk of operation before and now (safe before/safe now) and back-up power is a recent mandate. AECL said it submitted a strong case for operation with one pump |
| 12/12/2007 | NRCan Minister stated that the length of time to advise of NRU shutdown was unacceptable |
| 12/13/2007 | AECL internal memo - NRU Safety Case for one pump operation |
| 12/13/2007 | DOJ letter to CNSC advising it could not provide CNSC with legal advice |
| 12/11 & 12/2007 | Parliament (House of Commons and Senate) passed Bill C-38 to allow operation of NRU |
| 12/16/2007 | NRU reactor restarted per Bill C-38 |
| 12/x/2007 | AECL issued Assessment Document on Reliability of DC Motor Starters. |
| 12/24/2007 | CNSC email to AECL commented that the scope of AECL's Root Cause Analysis should address the reason for the tie-in not being completed after having been identified as necessary as far back as 1998 (9 years before). |
| 1/7/2008 | AECL letter to CNSC submitting S-99 detailed report |

## APPENDIX E

**List of Personnel Interviewed**

**CNSC:**

Andrei G. Blahoianu, Director, Engineering Design Assessment Division
Lawrence Colligan, former Single Point of Contact for CRL
Steve Cook, Electrical Engineer
Gerald Crawford, former acting director Compliance and Licensing Division
Alexander Delja, Thermal Hydraulics Engineer
Gerald Frappier, Safety Analysis Director
Daniel Gagne, Nuclear Facility Site Supervisor
Barclay Howden, Director General, Nuclear Cycle and Facilities Regulation,
Jafaar Karouni, Reliability Engineer
Linda Keen, former President, CNSC; Commission Member
Greg Lamarre, Director General, Directorate of Security and Safeguards
Lisa Lang, former Project Officer, Chalk River Laboratories Compliance and Licensing Division
Robert Lojk, Electrical Engineer
Constantin Nache, Project Officer for NRU
Greg Rzentkowski, Thermal Hydraulics Engineer
Miguel Santini, Director CRL Compliance and Licensing Division
Fred Taylor, former Single Point of Contact for CRL
Paul Wong, Quality Management Specialist

**AECL:**

Glenn Archinoff, Vice President Compliance, Corporate Oversight & Regulatory Affairs
John Arnold, Production Manager
Terence Arthur, CRL Facilities Licensing Manager
Andrew Ashworth, Branch Manager, Safety and Environmental Analysis
Paul Bell, Manager Nuclear Safety
Nancy Burnett, Purchasing
John Chilton, CRL Program Licensing Manager
Chris Conway, Instrumentation and Controls
Bernard DeAbreau, Commissioning
Thomas Doherty, Commissioning
Eldon Douglas, Commissioning Engineer
Christine Fahey, Director Project Management Office
Paul Fehrenbach, Vice President (retired)
Guy Gagnon, Electrical Engineer
Lance Goodick, Electrical Design Engineer, Electrical Design Group Section Head

Jean Pierre Latourneau, Licensing Single Point of Contact
Ray Leung, Licensability Staff (PSA and FSAR)
Catherine Lockley, Project Control/Support
B. E. McGee, Sr. Vice President & Chief Nuclear Officer Research & Technology Operations
Steven McCauley, Manager, NRU RESP
Ken McLennan, Facility Manager
Edward Mutterback, Upgrades Project Manager
George Poley, Design Engineering Manager
Denny See Hoye, Licensing Extension Project Manager (Retired)
Suzanne Sheridan-Cole, CRL AIMS coordinator
William R. Shorter, Director NRU Facility
Kathy Smith, Manager, Operating Experience and Corrective Action
James Walker, Safety Review Committee and Early Safety Assessment Author
Andrew White, General Manager, Programs and Nuclear Oversight, Chief Regulatory Officer

**AECL Key Personnel not available:**

Paul Lafreniere, former General Manger Reactor Operations Plant

## Appendix F

## General Description of the NRU Reactor and Safety Upgrades

### General Description of the NRU Reactor

The NRU reactor is one of the largest and most versatile research reactors in the world, and is used for a wide variety of irradiations, including fuels and materials testing, small-sample irradiations, neutron scattering research, and isotope production. The NRU reactor site has a large variety of experimental facilities that provide engineering research and development support for the other AECL programs. The NRU reactor produces a significant share of the world's supply of medical radioisotopes, the most important of which is Mo-99, used in millions of medical treatments annually.

NRU is a heterogeneous reactor, operating at power levels up to 135 megawatts (thermal). It is heavy water cooled and moderated, and surrounded by an annular light water reflector. The reactor is fueled at power. The core consists of a vessel cylinder approximately 3.7 meters in diameter and 3.5 meters high. It is made up of 227 vertical lattice sites arranged in a hexagonal array. Control rods and enriched uranium fuel rods occupy about half of the lattice sites; most of the remaining sites are used for low-temperature/low-pressure experiments and isotope irradiations, or are vacant. Two high-pressure /high-temperature loops, U-1 and U-2, supply coolant to three test sections. A number of horizontal beam facilities are also available.

The primary coolant and moderator are the same process system. Low temperature and low pressure (35°C and 0.76 MPa) heavy water is pumped via eight parallel circuits, each consisting of a pump, heat exchanger, and associated valves and piping to a common header below the reactor. Coolant is distributed to each cooled position, flowing upwards through the assembly and exiting into the upper vessel.

The reactor is controlled using 18 control/safety rods, each consisting of a drive unit and neutron absorber.

There are two independent trip systems in the reactor, the First Trip System and the Second Trip System, which activate the shutdown system when monitored operating parameters in the reactor or facilities exceed allowable limits.

The Main Heavy Water Primary Cooling System transfers the fission heat generated in the fuel to river water secondary coolant (Process Water System) when the reactor is operating, and provides decay heat removal under reactor shutdown conditions. Eight parallel branches provide primary cooling.

The Main Heavy Water Pumps (MHWPs) in the main coolant/moderator system are powered by Class 4 power from the off-site power grid. Four of the eight pumps have two-speed motors supplemented by a separate DC motor. On loss of Class 4 power, the reactor will trip and DC power is provided to two MHWPs from Class 1 power battery banks, supported through rectifiers from Class 3 diesel generators. The power to the MHWPs is also backed up from the

Emergency Power System. This ensures that forced cooling is always available to the fuel rods in the core.

The Reactor Protection System is comprised of neutron absorbing rods and their release circuits, the First Trip System and the Second Trip System.

Engineered Safety Features that are provided in the reactor are Reactor Protective System, Emergency Core Cooling Functions, Main Pump Emergency DC Drive System, Emergency Secondary Cooling Functions, Rod Monitoring System, Emergency Filtration System and the seven reactor safety upgrades. The seven safety system upgrades included an independent second trip system, qualified emergency response center, new emergency core cooling system, qualified emergency water system, main pump flood protection, liquid and gaseous confinement boundary, and emergency power system.

**General Description of the NRU Reactor Safety Upgrades**

The following is a general description of the seven major upgrades installed under the NRU Upgrades Project. All the upgrades are required to be seismically-qualified and environmentally-qualified. They are all designed to "modern" codes and standards.

**Secondary Trip System:** The Secondary Trip System is an independent second trip system that safely shuts down the reactor based on trip units detecting: seismic events, Class 4 power failure, major process water flood, excess neutron power, or excess log rate neutron power. The safety design requirements include separation, redundancy, and signal buffering.

**Qualified Emergency Response Centre:** The Qualified Emergency Response Centre is an all hazards-qualified alternative location to ensure the reactor can be placed in a stable shutdown state with adequate fuel cooling. It provides initiation and monitoring of all engineered safety features in the event that the main control room is unavailable. It houses equipment used for the other safety upgrades, which are also hazards-qualified, thereby providing separation of these systems from the other process and safety related systems in NRU.

**New Emergency Core Cooling:** The New Emergency Core Cooling system upgrade ensures that water is automatically made available to the primary cooling pumps of the emergency cooling circuits in the event of a Loss of Coolant Accident. Combined with the Liquid Confinement/ Vented Confinement upgrade, it provides for collection and recirculation of heavy water discharged from a break.

**Emergency Power System:** The Emergency Power System supplies electrical power independently and separately from the original electrical distribution system, providing Class 1, 2 and 3 electrical power to the upgrades components. It also provides back-up Class 1 power to existing DC motor starters, for emergency cooling Main Heavy Water Pump motors #4 and #5.

**Qualified Emergency Water System:** The Qualified Emergency Water System incorporates an independent water reservoir and redundant pumping system for post-shutdown heat removal via emergency cooling circuits 4 & 5. The cool qualified emergency water system water is pumped

through the secondary sides of the Main Heat Exchangers, absorbing the primary coolant heat load and returning to the reservoir.

**Main Pump Flood Protection:** The Main Pump Flood Protection is principally a passive system designed to divert water from major leaks in process piping. It ensures the proper operation of the main primary coolant pumps, including the emergency DC drive system, in the event of a major failure of the process water piping within the NRU building. The flood level detectors associated with this system are designed to trip the reactor and trigger an automatic shutdown of all four large process water supply pumps at the powerhouse.

**Liquid Confinement/Vented Confinement:** The Liquid Confinement/Vented Confinement provides a confinement boundary surrounding the reactor and a variety of rooms in the immediate area. It confines gaseous fission products, tritiated vapor, and released light and heavy water.

## Appendix G

## AECL Appearances before the CNSC Commission mid-2005 to mid-2006

1. May 19, 2005 Meeting – Interim report on Whiteshell
2. May 19, 2005 Meeting – Mid-term report on Chalk River
3. May 20, 2005 Hearing – Decommissioning Financial Guarantee for MAPLE and NPF
4. June 29, 2005 Meeting – Significant Development Report on MAPLE Guaranteed Shutdown State Event
5. June 29, 2005 Meeting – Significant Development Report on NRU Fuel Uncovered in Fuel Rod Flask Event
6. June 29, 2005 Hearing – Environmental Assessment for Continued Operation of NRU
7. Aug. 18, 2005 Hearing – Day 1 for MAPLE and NPF Licence Renewals
8. Oct. 18, 2005 Hearing – Continued Operation of NRU
9. Oct. 18, 2005 Hearing – Day 2 for MAPLE and NPF Licence Renewals
10. Dec. 1, 2005 Meeting – Update on Sewage Sludge Management
11. Feb. 16, 2006 Meeting – Update on NRU Improvement Initiative
12. Mar. 30, 2006 Hearing – Environmental Assessment for Liquid Waste Storage Facility
13. Apr. 26, 2006 Hearing – Day 1 for CRL Site Licence Renewal
14. Apr. 27, 2006 Hearing – Environmental Assessment for Shielded Modular Above Ground Storage
15. May 19, 2006 Meeting – Update on Building 250 Fire
16. June 28, 2006 Hearing – Day 2 for CRL Site Licence Renewal