Canadian Nuclear Safety Commission

Commission canadienne de sûreté nucléaire

Record of Proceedings, Including Reasons for Decision

In the Matter of

Applicant: Atomic Energy of Canada Limited

Subject: Request for the Approval of the Return to Service of the National Research Universal (NRU) Reactor

Public Hearing Date: July 5, 2010

Canada

RECORD OF PROCEEDINGS

Applicant:	Atomic Energy of Canada Limited
Address/Location:	2251 Speakman Drive, Mississauga, Ontario L5K1B2
Purpose:	Request for the Approval of the Return to Service of the National Research Universal (NRU) Reactor
Application received:	June 10, 2010
Date of public hearing:	July 5, 2010
Location:	Canadian Nuclear Safety Commission (CNSC) Public Hearing Room, 280 Slater St., 14th. Floor, Ottawa, Ontario
Members present:	M. Binder, Chair A.R. Graham — M. J. McDill R. J. Barriault — D.D. Tolgyesi
Secretary:	M.A. Leblanc
Recording Secretary:	M. Young
Senior Counsel:	L. Thiele

Applicant Represented By	**Document Number**
• H. MacDiarmid, President and CEO; • W. Pilkington, Chief Nuclear Officer; • H. Drumhiller, Vice-President of Operations/NRU Repairs; • R. Lesco, Chief Nuclear Engineer and General Manager of Engineering; and • A. White, Chief Regulatory Officer and General Manager of Programs and Nuclear Oversight.	CMD 10-H12.1 CMD 10-H12.1A CMD 10-H12.1B
CNSC staff	**Document Number**
• R. Jammal; • P. Elder; • M. Santini; • R. Awad; and • B. Carroll.	CMD 10-H12
Intervenors	**Document Number**
Canadian Nuclear Workers' Council, represented by D. Shier, G. Peplinski and G. Tapp	CMD 10-H12.2
Darlene Buckingham	CMD 10-H12.3
Jennifer Tsun	CMD 10-H12.4
Bill MacCallum	CMD 10-H12.5
Others	
Emergency Management Ontario, represented by M. Morton, D. Nodwell and K. Blyer.	

Application: Accepted

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Introduction

1. Atomic Energy of Canada Limited (AECL) has made a request to the Canadian Nuclear Safety Commission[1] (CNSC) for approval of the return to service of the National Research Universal (NRU) reactor located at Chalk River Laboratories (CRL) in Chalk River, Ontario. The current CRL Nuclear Research and Test Establishment Operating Licence, NRTEOL-01.07/2011, is valid until October 31, 2011.

2. On May 15, 2009, during a forced shutdown of the NRU reactor, AECL detected a heavy water leak from the reactor vessel. In order to repair the leak located in the vessel wall, AECL defueled the reactor and drained the heavy water.

3. While the operating licence for CRL covers most aspects of the vessel repair, two unique aspects, the vessel repair with an acceptable fitness-for-service safety case and acceptance of the return-to-service strategy, require the Commission's approval.

4. To return the reactor vessel to service, AECL had to repair the parts of the vessel that had structurally-significant wall thinning due to corrosion and AECL had to develop a strategy to mitigate the corrosion. CNSC staff confirmed that the repairs provide structural integrity to the reactor vessel and that the repairs were done within the applicable nuclear Codes and Standards. CNSC staff noted that the repairs passed the vessel leak test approval by the Technical Standards and Safety Authority (TSSA), and the acceptance of the final Repair Report by CNSC staff is pending.

Issue

5. In considering the request, the Commission was required to decide whether to approve the return to service of the NRU reactor.

Public Hearing

6. Pursuant to section 22 of the NSCA, the President of the Commission established a Panel of the Commission to review the request for approval. The Commission, in making its decision, considered information presented for a public hearing held on July 5, 2010 in Ottawa, Ontario. The Commission varied the *Canadian Nuclear Safety Commission Rules of Procedure*[2] so that AECL's request would be dealt with in a fair and expeditious manner. This variation significantly compressed the notification period and the time usually allocated for the submission of documents. During the public hearing, the Commission considered written submissions and heard oral presentations from CNSC staff (CMD 10-H12) and AECL (CMD 10-H12.1, CMD 10-H12.1A and CMD 10-H12.1B). The Commission also considered oral and written submissions from four intervenors (CMD 10-H12.2 to CMD 10-H12.5).

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[1] The *Canadian Nuclear Safety Commission* is referred to as the "CNSC" when referring to the organization and its staff in general, and as the "Commission" when referring to the tribunal component.
[2] Statutory Orders and Regulations (S.O.R)./2000-211.

Decision

7. Based on its consideration of the matter, the Commission concludes that AECL is qualified to return the NRU reactor to service and to carry on the activity authorized by the current licence. The Commission is satisfied that AECL, in carrying on that activity, will make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed. Therefore,

> the Commission approves the return to service of Atomic Energy of Canada Limited's National Research Universal reactor, located in Chalk River, Ontario. The current licence, NRTEOL-01.07/2011, remains unchanged and is valid until October 31, 2011, unless suspended, amended, revoked or replaced.

8. With this decision, the Commission directs AECL to provide updates on the progress and effectiveness of the Organizational Corrective Action Plan every six months after the restart of the reactor, to be presented at public proceedings of the Commission. The Commission requires annual in-service inspections of the vessel and the first inspection must be no later than nine months after the NRU reactor restart. The Commission also notes that the vessel leak test was approved by the TSSA and that the acceptance of the final Repair Report by CNSC staff is pending.

Issues and Commission Findings

9. In making its licensing decision, the Commission considered a number of issues relating to AECL's qualification to carry out the proposed activities and the adequacy of the proposed measures for protecting the environment, the health and safety of persons, national security and international obligations to which Canada has agreed.

Vessel Leak Repair

Vessel Condition Assessment

10. AECL provided information regarding the discovery and consequences of the heavy water leak in the NRU reactor. AECL stated that the leak was detected on May 15, 2009, at a time when the reactor was shut down, and that AECL determined that the leak originated in the lower vessel wall of the reactor. AECL presented a detailed description of the location of the leak, which had occurred in the vicinity of the base of the J-Rod annulus, between the reactor water reflector wall and the reactor vessel wall. AECL stated that they identified corrosion sites on the lower vessel wall and, as a result, AECL decided to defuel the reactor and drain the vessel during the week of July 8, 2009.

11. AECL stated that the primary consequence of the leak was the release of a limited amount of tritiated heavy water. AECL stated that the majority of the heavy water was collected and drummed, although there was some loss due to evaporation. AECL further stated that, although the small through-wall penetration in the vessel wall did not pose any safety concerns, the degradation did pose a concern for ongoing vessel integrity. AECL noted that there was no threat to the health and safety of persons or the environment due to the leak.

12. AECL stated that, following the leak, the liquid releases of radioactive substances were within normal operating levels, but the evaporative losses resulted in airborne releases of tritium from the NRU reactor stack. AECL stated that although tritium emissions to air were well below the regulatory limit, the airborne releases exceeded AECL's weekly action level for nine weeks. AECL noted that once the heavy water was removed from the vessel, the leak stopped and emissions of tritium to air decreased to amounts below the action level. AECL noted that the dose to the public from the increased airborne tritium emissions was less than 10% of the derived release limit.

13. CNSC staff provided information regarding their oversight of AECL's assessment of the vessel condition. CNSC staff reported that AECL's assessment of the vessel condition was comprehensive and allowed AECL to identify the needed repairs.

Technical Assessment of Vessel Degradation Mechanism

14. AECL stated that the cause of the vessel leak was determined to be corrosion from the formation of nitric acid in the annulus. AECL explained that radiolysis of air, which had leaked into the annulus, in the presence of water that leaked from the light-water reflector, formed nitric acid. AECL noted that the formation of nitric acid was also the cause of a NRU reactor shutdown in 1972, which resulted in the replacement of the original vessel.

15. AECL stated that the corrosion from nitric acid at the base of the vessel was not detected in the 2004/2005 life assessment study for the NRU vessel, and the focus had been on the upper parts of the vessel, where the original vessel had failed. AECL further stated that they incorrectly assumed that corrosion was inactive at the base of the vessel because carbon dioxide (CO_2) was injected low into the annulus and CO_2, being heavier than air, would suppress the formation of nitric acid. AECL stated that this corrosion has been occurring at the bottom of the annulus over the life of the second vessel.

16. AECL stated that they conducted numerous inspections of the vessel in order to determine the extent of the corrosion in the vessel. AECL explained that they conducted visual inspections using a remote video camera, conducted non-destructive examination (NDE) inspections, and also conducted vessel material examinations by removing material from the vessel wall. AECL provided detailed information regarding findings from these inspections, which found three variations of the corrosion

mechanism: generalized low-degradation corrosion of the upper regions of the vessel wall and at the base of the vessel, localized corrosion at the base of the vessel, and highly-localized corrosion pockets that can lead to small perforations in the vessel wall, observed at a discrete elevation consistent with the floor of the annulus. AECL stated that, based on these findings, AECL was able to prepare a strategy to repair the vessel.

17. CNSC staff required that AECL perform a detailed technical root cause analysis of the vessel corrosion to support the fitness-for-service case. CNSC staff stated that they accepted AECL's assessment and concurred with AECL that nitric acid is the dominant cause of corrosion. CNSC staff noted that the studies have not conclusively dismissed other possible corrosion mechanisms. CNSC staff noted that an In-Service Inspection, not later than nine months after the NRU reactor restart, will be required to confirm that AECL's corrosion allowance is conservative. CNSC staff further noted that, to support long-term operation, AECL will have to develop an In-Service Inspection plan for future inspections.

18. CNSC staff stated that they have no safety concerns regarding the condition of the vessel, provided that AECL continues with appropriate in-service inspections. CNSC staff explained that none of the possible corrosion mechanisms will challenge the structural integrity of the vessel over a short period of time. CNSC staff stated that they expect AECL to submit their final Corrosion Mechanism Assessment report within 90 days of the vessel return to service as part of the final Fitness for Service Report.

19. The Commission sought further information regarding AECL's discovery of the corrosion. AECL responded that the corrosion had been occurring over the lifetime of the vessel and was not a recent development. AECL explained that they did not identify the localized corrosion in 2006 at the base of the vessel, prior to the licence renewal for CRL, because the technology for NDE had not been developed, and AECL's assumption that CO_2 would displace the air in the annulus was not correct. AECL further stated that the coupons that were taken from the annulus were not examined because they did not represent the vessel as a whole.

20. The Commission sought further information regarding the cause of the corrosion, noting the history of issues with the NRU reactor vessel. AECL responded that, although the original vessel was replaced, leaks in the reflector continued to appear in the second vessel. AECL noted that there was a design issue in both cases in that the design was susceptible to light water leaks developing in the reflector. AECL stated that a number of actions have been taken over the years to mitigate these leaks but they have not been eliminated. AECL noted that, once the corrosion was discovered, AECL conducted further inspections in other areas of the vessel to ensure that the rest of the vessel had not degraded. CNSC staff added that although minimal corrosion was identified elsewhere in the vessel, the corrosion at the bottom of the vessel was the only concern.

21. The Commission expressed concerns regarding AECL's failure to identify the corrosion prior to the 2006 licence renewal for CRL. The Commission sought further

information in this regard. CNSC staff responded that, in support of the licence renewal, AECL performed a Condition Assessment of the vessel, which failed to identify the corrosion. CNSC staff stated that, as a result, AECL was required to demonstrate that conclusions reached in the Condition Assessment were valid (see the section on "Gaps between 2009 Condition Assessment and 2005 NRU Life Condition Assessment" in this *Record of Proceedings*). CNSC staff noted that, despite the large operational impact, the leak event had a minimal safety impact, and AECL has not identified any major gaps in the safety case for the NRU reactor.

Repair Strategy

22. AECL provided information regarding the repair strategy for the vessel. AECL stated that, following months of development, welding wall build-up was chosen as the primary mode of repair. AECL noted that they determined that the weld-repaired vessel could be shown to meet applicable codes and standards to achieve a permanent repair.

23. AECL stated that they performed a preliminary fitness-for-service assessment to provide guidance on the repairs required to ensure that structural integrity would be maintained under expected loads such as pressure and seismic loading, and taking into account the effect of future wall loss through corrosion. AECL stated that 10 areas were determined to need repair.

24. AECL discussed the manner in which they developed the repair strategy for each of the 10 areas. AECL explained that each of the 10 repairs required a different welding strategy, which included weld build-up, weld build-up over backing plates, and weld build-up with structural plates. AECL stated that they conducted trials and utilized mock-ups to develop and proof-test tooling and procedures for the repairs. Once the repair process was qualified, AECL submitted a Repair Plan to CNSC staff for approval. AECL noted that they developed the weld procedure to meet applicable codes and standards. CNSC staff and the TSSA reviewed the procedure. AECL further noted that the TSSA qualified all weld operators on the weld procedure.

25. CNSC staff stated that they accepted the approach proposed by AECL, which required regulatory approval of both the Repair Plan for the vessel and the Inspection and Test Plans for each repair site. CNSC staff stated that they approved the Repair Plan and Inspection and Test Plans for each repair site prior to the start of welding, including the description of the repair procedure, repair areas, tools and staff training.

26. AECL stated that they began the repairs in December 2009. AECL presented a summary of the weld repair areas, including the weld area, the thickness of weld build-up, and whether backing strips or structural plates were used.

27. The Commission asked for specific, technical details regarding the repairs, including the materials used in the repairs. AECL provided this information to the satisfaction of the Commission.

28. The Commission sought further information regarding the corroded areas, identified in AECL's documentation, that were not repaired. AECL responded that the repair strategy was to repair areas that, according to the structural analysis, would not meet structural requirements or that had an existing leak. AECL stated that every area that was not repaired meets structural requirements and has an adequate corrosion allowance. AECL further stated that they will be applying mitigation strategies in order to minimize the possibility that these areas will require repairs in the future.

29. The Commission asked how the physical changes from the repairs will affect the performance of the vessel. AECL responded that there would not be any significant change in the operating performance of the NRU reactor.

30. The Canadian Workers' Council, in their intervention, presented information regarding the work environment for AECL employees during the repairs. The Canadian Workers' Council noted that there were four lost-time accidents during the span of the outage and two of them were directly related to the repair work. The Commission asked for more information regarding the lost-time accidents. The Canadian Nuclear Workers' Council responded that two of the injuries were related to a lapse in awareness and attention to detail. AECL noted that, despite the four lost-time injuries, the lost-time accident rate decreased in the past year over the prior year.

Post-Repair Inspection and Reporting

31. AECL provided information regarding the post-weld inspections of the vessel repairs. AECL stated that, following each repair, a remote visual inspection was performed as well as NDE examinations. AECL noted that these inspections were used to detect surface cracks, measure the thickness of weld build-up, and detect any lack of fusion between the weld and the vessel wall. AECL noted that the procedures for these examinations and the qualification process for individual inspectors were demonstrated to the TSSA and/or CNSC staff.

32. AECL noted that the only area that could not be inspected was the heat-affected zone below the welds as there was insufficient space at the bottom of the vessel to properly deploy the inspection tool. AECL further noted that they are currently developing a tool in order to carry out an inspection in this area during a future outage. AECL noted that the risk of a undetected flaw is low, based on the inspections of the accessible weld perimeters and the fact that the stress field in the vessel is expected to be oriented in a manner such that there is no driving force for crack growth.

33. AECL presented a summary of the results of the weld inspections. AECL stated that, overall, the repairs have been successful in meeting acceptance criteria, although there are three areas where AECL detected a lack of fusion and one area where AECL detected a reportable indication. AECL stated that engineers have assessed these locations and determined that the structural integrity is acceptable. AECL noted that

any requirements for follow-up inspection will be provided in the Repair Report and the final Fitness for Service Report.

34. AECL stated that once the final repair was completed, the final test for the vessel was an in-service leak test. AECL explained that once they had completed the prerequisites for refill, the water level in the vessel was raised in stages and completed on June 22, 2010. AECL noted that, during refill, AECL detected slightly elevated tritium levels in a sector of the annulus. AECL explained that because this tritium could have been indicative of water from the vessel seeping into the annulus, AECL took steps to investigate the source. AECL reported that detailed visual inspections and swab samples did not reveal any signs of moisture, and, over time, the tritium levels decreased.

35. AECL stated that on June 23 and 24, 2010, authorized inspectors from the TSSA conducted the formal verification that the vessel repairs were effective and that there were no vessel leaks. AECL explained that this “in-service leak test” consisted of a detailed visual examination and no evidence of any leaks was found during the examination. AECL noted that examinations that were completed prior to the June 23, 2010 earthquake were repeated following the earthquake and no changes were detected. In addition, AECL stated that, following the in-service leak test, the vessel was drained and additional visual inspections were undertaken in the vicinity of the repair sites where elevated tritium had been detected. AECL stated that no cracks or imperfections were detected.

36. CNSC staff stated that, prior to the restart of the reactor, AECL will be required to submit a Repair Report, which must demonstrate that established codes, standards and processes were followed and the detailed results of the post-repair inspections confirm the vessel fitness for service. CNSC staff noted that weld areas that AECL was not able to completely inspect will be analyzed in the final Fitness for Service Report, which must be submitted by AECL within 90 days following the vessel returning to service, in accordance with standard industry practice.

37. CNSC staff confirmed that the repairs and post-repair inspections completed to date had all been done in accordance with the Repair Plan. CNSC staff noted that in the areas where a lack of fusion was detected, the lack of fusion does not affect the structural integrity of the vessel. In addition, CNSC staff stated that AECL must demonstrate that the reportable indication will not impact the structural integrity of the vessel as part of the Repair Report.

38. The Commission asked about the elevated tritium levels detected during refill. AECL stated that they had not identified the source of the tritium. AECL stated that, since they drained the vessel, the tritium levels returned to background levels. AECL noted that they have filled the vessel twice since and have not detected a significant increase in tritium levels. AECL further noted that they will continue to monitor the situation but they will not be taking further action. CNSC staff stated that they have no concerns regarding the structural integrity of the vessel and that they will ensure that AECL has

proper procedures in place to take appropriate action in a timely fashion if a measurable leak does develop.

39. The Commission sought further information regarding the nature of the reportable indication. AECL stated that the reportable indication is a 60-millimetre long defect that is oriented in such a manner that it will not experience a crack-opening mode of loading. AECL stated that the flaw will be included in the ongoing in-service inspection for the reactor. CNSC staff stated that they currently have no concerns regarding the defect, and concurred with AECL's approach to verify that there is no growth in the defect over time.

40. The Commission also sought further information regarding the locations where a lack of fusion was detected. AECL responded that their structural assessment concluded that the minor lack of fusion was acceptable and would not increase in size during operation. AECL stated that the lack of fusion does not pose a safety issue. CNSC staff concurred that none of the lack of fusion locations will impact the structural integrity of the vessel.

41. The Commission expressed concerns regarding the possibility of local bending and asked if AECL or CNSC staff have any concerns regarding residual stress or local bending during operation. AECL responded that they examined the heat affected zone of the repairs to ensure that there are no issues in this regard.

42. The Commission also expressed concerns regarding possible local bending in the only area that could not be inspected, the heat affected zone below the welds. The Commission sought further information from AECL, noting that AECL is planning to develop a tool to inspect this area and that AECL has indicated that there is no driving force in this zone from the stress field in the vessel. AECL responded that the information they presented included a representation of the vessel after the repair and a numerically predicted stress field of the local membrane stresses after the repair. With regards to local bending stresses, CNSC staff responded that they expect that the measurements that have been taken before and after welding at these locations will determine what the bending stress components are so that they can be incorporated in the fitness for service assessment.

43. The Commission asked when the tooling would be developed in order to inspect the heat affected zone below the wells. AECL responded that the tooling for this inspection is currently under development and AECL will have the tooling available, and the qualified procedures available, to complete this inspection in the first extended shutdown within the first quarter of 2011. CNSC staff stated that they are fully satisfied with the nine-month timeframe for the first inspection.

44. Some intervenors expressed concerns regarding the effects of the June 23, 2010 earthquake on the NRU reactor facility. The Commission sought assurance that there were no negative consequences of the earthquake on CRL. AECL responded that they had carried out a broad inspection of the facilities at CRL following the earthquake and

there was only minor damage to some temporary buildings and no injuries to personnel. AECL noted that no abnormalities were observed regarding the NRU reactor facility. AECL explained that the earthquake had a peak ground acceleration[3] of 0.006 g at CRL and the NRU reactor safety systems are qualified for an earthquake of 0.24 g, 40 times greater than the June 23, 2010 earthquake. AECL further stated that the NRU reactor has a 'seismic trip' safety system that will safely shut the reactor down in the event of an earthquake of 0.06 g, or 10 times greater than the June 23, 2010 earthquake.

45. The Commission asked what the consequences would be if an earthquake greater than 0.24 g were to occur at CRL. AECL responded that, following a seismic event of that magnitude, the plant would be safely shut down and the fuel would be cooled. AECL noted that, while the reactor structures might not remain operable following such an event, it would be in a safe state. AECL further noted that their emergency response plans are robust and AECL is prepared to deal with this type of event. A representative from Emergency Management Ontario stated that, in the event that there is an accident that results in an offsite release of radiological material from the facility, an appropriate action would be taken in accordance with the provincial Nuclear Emergency Response Plan.

Vessel Fitness for Service

46. CNSC staff stated that, in order to support the operation of the NRU reactor, AECL is required to submit a comprehensive safety case that demonstrates that the reactor vessel is repaired and fit for service. CNSC staff explained that the AECL NRU reactor vessel fitness for service assessment was divided into two stages: the preliminary assessment to determine the areas that need repair and the final assessment to be completed within 90 days after returning the vessel to service. CNSC staff stated that they accepted AECL's preliminary fitness for service report for short-term operation.

47. CNSC staff stated that in order to monitor future reactor vessel condition on a continuing basis, AECL was required to submit an in-service inspection program that covers the NRU reactor vessel, as well as its implementation plan. CNSC staff noted that AECL has developed the in-service inspection program to identify and monitor any deterioration in the integrity of the vessel on a continual basis. CNSC staff reiterated that the first inspection must be no later than nine months after the NRU reactor restart.

48. AECL stated that they have planned a three- to four-week maintenance shutdown within nine months of the restart of the reactor in order to conduct the required in-service inspection program inspections, as well as additional maintenance activities. AECL further stated that they are planning annual four-week maintenance shutdowns for every year thereafter, to ensure continued and on-going fitness for service.

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[3] Peak ground acceleration is expressed in g, where g is the acceleration due to gravity; 1 g = 9.81 m/s^2

49. CNSC staff noted that AECL's maintenance of the vessel fitness-for-service safety case is an on-going activity to account for new inspection information and will form part of the documentation to support any future operating licence renewal applications.

50. CNSC staff confirmed that the repairs provide structural integrity to the reactor vessel and that the repairs were done within the applicable nuclear Codes and Standards. CNSC staff noted that the repairs passed the vessel leak test approval by the TSSA, and the acceptance of the final Repair Report by CNSC staff is pending. CNSC staff stated that the repaired vessel is fit for service for the initial operating period of no more than nine months. CNSC staff noted that, in the long-term, extended outages will be required for AECL to maintain the fitness-for-service safety case for the reactor vessel.

51. The Commission sought further information regarding the future routine maintenance for the NRU reactor. AECL responded that the NRU reactor will run on a 28-day cycle with 23 days of operation and five days of maintenance. In addition, AECL stated that they will perform an annual extended maintenance shutdown, the first of which would be within nine-months of restart, in the first quarter of 2011.

52. The Commission asked whether the new scheduled maintenance shutdowns will have an effect on isotope production. AECL responded that they can continue to harvest isotopes when the reactor is shut down during the five days of maintenance and, as such, there is no interruption in the production of isotopes with the 28-day operating cycle. AECL noted that, with the scheduled outages, other isotope producers in the world can adjust their production schedules to ensure that there is no reduction in the worldwide isotope supply when the NRU reactor is shut down.

53. The Commission asked what activities are expected to be performed during the upcoming maintenance shutdowns. AECL responded that the activities include repair inspections and corrosion mitigation activities. AECL stated that they will also work towards reducing and eliminating leakage from the reflector.

Conclusion on Vessel Repair

54. Based on the information presented, the Commission is satisfied that the NRU reactor vessel has been repaired in accordance with applicable nuclear Codes and Standards, and is fit for service for an initial operating period of no more than nine months. The Commission requires annual in-service inspections of the vessel and the first inspection must be no later than nine months after the NRU reactor restart.

Return to Service

Reactor Readiness for Service

55. CNSC staff stated that the NRU Return to Service project includes all the activities

other than the vessel repair that must be completed prior to the NRU reactor restart. CNSC staff explained that the Return to Service Plan is divided into three groups of activities: fieldwork, procedures and supporting activities. CNSC staff stated that these activities are considered non-routine, and, as such, AECL was required to submit documentation for review and to demonstrate a systematic approach to the Return to Service.

56. CNSC staff provided information regarding the requirements of the three groups of activities for the Return to Service Plan. CNSC staff also provided information regarding the oversight and verification activities they conducted with respect to the Return to Service project. CNSC staff stated that the verification activities provide assurance that the essential aspects of the Return to Service project are being managed responsibly and executed safely.

57. CNSC staff stated that the reactor readiness for service is based on an AECL process where all reactor systems and components are assessed and confirmed available and functional for return to service. CNSC staff stated that this process includes a review of all maintenance and repair activities, and confirms that all preparation work for restart is complete.

58. CNSC staff stated that, for the completion of the Readiness for Service declaration by AECL, the complete refuelling of the reactor is required, and as such, it will only come after the Commission's decision to allow refuelling beyond the guaranteed subcritical state. CNSC staff stated that they will verify the readiness for service completeness and continue to provide regulatory oversight throughout the remaining activities under the Return to Service project until the NRU reactor is back in operation.

59. The Canadian Nuclear Workers' Council supported AECL's request to re-start the NRU reactor and expressed the view that the repairs to the NRU reactor are complete and that AECL meets all requirements to operate the reactor. Another intervenor supported the restart of the NRU reactor due to its role as a producer of medical isotopes.

60. Several intervenors were of the opinion that the NRU reactor should not be re-started. The intervenors expressed several concerns, including the risks associated with radioactive materials, the age of the facility, the location of the facility and its proximity to the Ottawa River, and the likelihood of earthquakes in the region.

61. The Commission asked AECL when they expect to restart the reactor. The representative for AECL responded that AECL would restart the reactor following CNSC staff's approval, and the current schedule was to restart the reactor and resume the production of medical isotopes by the end of July.

62. The Commission asked about the life expectancy for the repaired vessel. AECL responded that the target of the repair program was to assure a vessel life to 2021. AECL explained that the repair meets structural requirements and provides for some

corrosion allowance, and the AECL's ability to mitigate corrosion will determine the life of the vessel. AECL stated that, with the mitigating strategies that are in place and that will be in place, vessel will remain fit for service through its expected life.

63. The Commission inquired about the safety system tests that AECL must perform to ensure that the reactor is ready for service. AECL responded that, as a part of the Return to Service project, all of the systems are being thoroughly tested to confirm that they are fully available to perform their safety functions.

64. The Commission asked if AECL is on track to complete the 800-plus activities for the Return to Service. AECL responded that the activities will be completed before the NRU reactor is back into service, including maintenance, testing and training activities. CNSC staff stated that CNSC site inspectors will be monitoring to ensure that the activities are complete.

Refuelling Strategy

65. CNSC staff stated that, following the successful repair of the vessel, AECL was required to demonstrate that the NRU reactor core can be safely refuelled and that the reactor can be returned to normal operation, within the safe envelope established in the current NRU Safety Analysis Report and Facility Authorization.

66. CNSC staff stated that the following new operational states need to be considered for the return to service: sub-critical core during refuelling, approaches-to-critical with a partially loaded core and approach critical with a fully loaded core starting at very low neutron levels. CNSC staff stated that AECL has analyzed these reactor states and CNSC staff is satisfied with AECL's safety case for fuel reloading.

Procedure Development and Training

67. CNSC staff stated that they reviewed all of the procedures that AECL had developed under the Return to Service Plan. In addition, CNSC staff reviewed AECL's training plan and training requirements in support of the Return to Service. CNSC staff stated that AECL has a robust plan for providing a sufficient number of qualified staff for the NRU reactor restart. CNSC staff stated that, although there are opportunities for improvement regarding documentation practices, CNSC staff are satisfied with the Return to Service training plan and its implementation.

68. In addition to the Return to Service training plan, CNSC staff stated that they had reviewed AECL's licence requirements for certified staff. CNSC staff stated that AECL's certifications have remained valid and AECL's certified staff have met the continuing training requirements of AECL's operating licence. CNSC staff stated that AECL has a sufficient number of certified staff to support restart activities.

Conclusion on Return to Service

69. Based on its consideration of the presented information, the Commission is satisfied that the NRU reactor core can be reloaded and the reactor operated within the safe envelope established by the current operating licence. The Commission is satisfied that the Return to Service activities and the training of NRU reactor personnel are adequate in supporting a safe restart of the NRU reactor.

Organizational Root Cause Analysis

70. CNSC staff stated that organizational factors have been identified as major contributors leading to the NRU reactor vessel leak. CNSC staff asked AECL to analyze the organizational root causes and develop a corrective action plan (CAP) for its future improvement. CNSC staff stated that AECL's root cause analysis identified numerous causal factors, which point to organizational weaknesses that are consistent with the results of the Safety Culture Self-Assessment (SCSA) that AECL performed in 2008. CNSC staff noted that AECL agreed that the CAP should address both the root cause analysis and the SCSA results.

71. CNSC staff stated that AECL submitted the final version of the Organizational CAP on April 30, 2010, and that CNSC staff found the plan to be comprehensive and meeting the stated objectives. CNSC staff stated that they remain concerned that weaknesses may remain in the areas of planning, scheduling and execution of work and intergroup relations, and, as such, CNSC staff will continue to track the implementation of the corrective actions to determine their effectiveness.

72. CNSC staff stated that the Organizational CAP is an important long-term element to prevent the recurrence of events such as the vessel leak. CNSC staff stated that the CAP identified the essential elements required to correct organizational weaknesses and CNSC staff will need to carefully oversee the implementation of the CAP. CNSC staff recommended to the Commission that AECL should provide updates on the details of the CAP implementation every six months for at least the next two years.

73. The Commission inquired about the organizational weaknesses that led to the leak event. AECL responded that the problem was that the staff who were working with the vessel did not recognize the risk presented by the corrosion, and the staff who were corrosion experts were not involved in general, ongoing corrosion monitoring. AECL noted that they have made organizational changes to ensure that this does not reoccur.

74. The Commission sought assurance that AECL has made improvements in order to continue to operate the NRU reactor safely and effectively. AECL responded that they took advantage of the outage to perform all outstanding maintenance on the NRU reactor, to conduct inspections and perform walkdowns of the reactor systems, and to ensure that nothing was overlooked. AECL stated that the reactor is in better condition

than before the leak and that AECL will operate the NRU reactor safely and reliably.

75. The Commission expressed concerns regarding AECL's walkdown findings that some of AECL's field installations did not match documentation. CNSC staff responded that the purpose of the walkdowns was to make these findings so that they could be corrected. AECL stated that the findings have been assessed and acted on accordingly.

76. The Commission asked the Canadian Nuclear Workers' Council whether they have seen an improvement in AECL's organization and standards of operation. The representative for the Canadian Nuclear Workers' Council responded that there has been ongoing training for employees, with new training programs, as well as an improved reporting culture.

77. The Commission asked CNSC staff if any licence amendments are required for the restart. CNSC staff responded that the licence does not need to be amended for the restart. CNSC staff noted that AECL's operating licence for CRL will expire in 2011, and, as such, AECL's licence renewal application must reflect the inspection and reporting requirements going forward.

78. The Commission concurs with CNSC staff's assessment of the importance of the Organizational CAP. The Commission directs AECL to provide updates on the progress and effectiveness of the Organizational Corrective Action Plan every six months after the restart of the reactor, to be presented at public proceedings of the Commission.

Gaps between 2009 Condition Assessment and 2005 NRU Life Condition Assessment

79. CNSC staff stated that AECL's condition assessment of the reactor vessel performed in 2005 did not identify the wall thinning that led to the leak. As such, CNSC staff required that AECL address the gaps between the 2009 Condition Assessment and the 2005 NRU Life/Condition Assessment and ensure that no other critical items were missed or incorrectly evaluated.

80. AECL stated that they had conducted a review of the 2005 assessments and divided the gap analysis into two components: the gap of the vessel condition assessment and the gaps of the rest of the condition assessments.

Vessel Condition Assessment Gap

81. CNSC staff presented information regarding AECL's vessel condition assessment gap document. CNSC staff stated that AECL presented a satisfactory review of the 2005 assessment of the reactor vessel. CNSC staff reported that AECL presented three main causes for gaps in the 2005 assessments. CNSC staff stated that AECL is required to

follow-up on these matters in order to correct any shortcomings and further refine the process for condition assessments.

Remaining Condition Assessment Gap

82. CNSC staff presented information regarding AECL's remaining condition assessment gap. CNSC staff reported that AECL identified 29 systems that had a potential for a gap that might affect the safety envelope of the NRU reactor. CNSC staff concurred with AECL's conclusion that the bounding events described in the NRU Safety Analysis Report remain valid and that there is little impact to safety as a consequence of the identified gaps. CNSC staff stated that they expect AECL to address these gaps as a part of the Integrated Safety Review for AECL's licence renewal application.

83. CNSC staff stated that, although the gaps have been shown to have no safety significance, some gaps could have an impact on the reliability of the reactor operation. CNSC staff stated that they expect AECL to review the findings of its assessment, and CNSC staff will continue to monitor the gaps analysis and dispositions.

Conclusion on Condition Assessment Gap

84. The Commission is satisfied that AECL has performed a gap analysis between the 2009 Condition Assessment and the 2005 NRU Life/Condition Assessment. The Commission is satisfied that the identified gaps have been shown to have no safety significance and expects AECL to continue to address the findings of the gap analysis.

Investigation into Defected Fuels

85. AECL provided information regarding the small number of fuel failures that occurred prior to the forced outage in May 2009. AECL explained that between May 2008 and February 2009, the fission-product activity in the NRU reactor heavy water system was found to be increasing above normal levels. AECL determined that the most likely source was the NRU reactor fuel and, as a result, 28 fuel rods were selected as the likeliest sources of the activity. AECL stated that, once the selected rods were removed from the NRU reactor, the activity measured in the heavy water system decreased until the May 2009 shutdown.

86. AECL stated that they visually examined ten of the 28 fuel rods and two of the 120 fuel elements were found to have small defects in the aluminium cladding. AECL noted that their investigation into the cause of the defects is ongoing.

87. AECL further stated that, in preparation for returning the NRU reactor to service, they have assessed the fuel to be reloaded and all fuel meets design requirements. AECL stated that they have taken measures to ensure that the likelihood of fuel failures

remains low, including quarantining the batches from which the defected fuel came, using fuel that was in the NRU reactor at the time it was shut down in May 2009, and using new fuel from different batches than those quarantined. AECL noted that, as a result of this event, AECL formalized the process for responding to rising activity levels in the heavy-water system.

88. CNSC staff stated that AECL was required to implement mitigation measures in order to verify, isolate and remove the failed fuel. CNSC staff further stated that they are satisfied with AECL's procedure to address this issue.

89. The Commission sought further information regarding AECL's inspection of the defected fuel. AECL responded that they originally examined ten of the 28 fuel rods that were believed to have the highest probability of having defected elements and, following that, AECL examined four more. AECL noted that, at this point, there are diminishing returns because they have gone from the highest probability to lower probabilities. AECL further noted that there is a significant dose associated with disassembling the fuel rods for examination, and it is important to keep doses ALARA (As Low As Reasonably Achievable).

90. The Commission inquired about the safety consequences of the defected fuel bundles. AECL responded that the defected bundles cause the reactor to release radionuclides into the reactor coolant, which increases the radiation fields in the facility. AECL noted that it takes a significant amount of time to bring the coolant back to low activity levels. AECL stated that the main safety issue is to keep doses to workers ALARA and to keep the reactor operation as clean as possible.

91. The Commission asked what oversight activities CNSC staff will be performing as a result of the defected bundles. CNSC staff responded that they will oversee AECL's follow-up activities. CNSC staff explained that AECL is required to complete an investigation on the cause of the defects and to develop a defined procedure for how they will deal with potential defects. CNSC staff noted that AECL should also perform stricter monitoring of the coolant to ensure that they identify and remove the defect more quickly.

92. Based on the above information, the Commission concludes that AECL has adequately addressed the issue regarding defected fuel.

Application of the *Canadian Environmental Assessment Act*

93. Before making a licensing decision, the Commission must be satisfied that all applicable requirements of the *Canadian Environmental Assessment Act*[4] (CEAA) have been fulfilled.

94. CNSC staff reported that they had completed an Environmental Assessment (EA)

[4] Statutes of Canada (S.C.) 1992, chapter (c.) 37.

determination. CNSC staff stated that there was no requirement for an EA pursuant to subsection 5(1) of the CEAA. CNSC staff explained that the operation of the NRU reactor until 2012 was previously assessed under the CEAA in 2005, and, at that time, the CNSC concluded that the continued operation of the NRU reactor was not likely to cause significant adverse environmental effects. CNSC staff noted that no new construction, operation, expansion, modification or decommissioning activities are proposed with the approval to reload fuel and restart the NRU reactor from the shutdown state.

95. Therefore, the Commission is satisfied that all applicable requirements of the CEAA have been fulfilled.

Conclusion

96. The Commission has considered the information and submissions of AECL and CNSC staff as presented in the material available for reference on the record.

97. Based on its consideration of the matter, the Commission concludes that AECL is qualified to return the NRU reactor to service and to carry on the activity authorized by the current licence. The Commission is satisfied that AECL, in carrying on that activity, will make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

98. Therefore, the Commission approves the return to service of Atomic Energy of Canada Limited's National Research Universal reactor, located in Chalk River, Ontario. The current CRL Nuclear Research and Test Establishment Operating Licence, NRTEOL-01.07/2011, remains unchanged and is valid until October 31, 2011, unless suspended, amended, revoked or replaced.

99. With this decision, the Commission directs AECL to provide updates on the progress and effectiveness of the Organizational Corrective Action Plan every six months after the restart of the reactor, to be presented at public proceedings of the Commission. The Commission requires annual in-service inspections of the vessel and the first inspection must be no later than nine months after the NRU reactor restart.

M. Binder

AUG 1 1 2010

Michael Binder
President,
Canadian Nuclear Safety Commission

Date