United States Department of State

Washington, D.C. 20520

February 5, 2001

XSNM03171

Ms. Janice Dunn Lee
Director, International Programs
United States Nuclear Regulatory Commission
Rockville, Maryland

Dear Ms. Lee:

I refer to the letter from your office of October 25, 2000 requesting the views of the Executive Branch as to whether issuance of an export license in accordance with the application hereinafter described meets the applicable criteria of the Atomic Energy Act of 1954, as amended:

NRC No. XSNM03171 -- Application by Transnuclear, Inc for authorization to export to Canada 9.377 kilograms of U-235 contained in 10.05 kilograms of uranium in the form of metal enriched to a maximum of 93.3 percent. The highly enriched uranium (HEU) will be used for the production of medical isotopes in the NRU reactor operated by Atomic Energy of Canada Limited's Chalk River Nuclear Laboratories.

The proposed export to Canada would take place pursuant to the Agreement for Cooperation Between the United States and Canada, as amended, as confirmed in the enclosed letter dated December 5, 2000 from the Canadian Nuclear Safety Commission.

The Executive Branch has reviewed the application and concluded that the requirements of the Atomic Energy Act, as amended by the Nuclear Non-Proliferation Act of 1978 and the Energy Policy Act of 1992, have been met and that the proposed export would not be inimical to the common defense and security of the United States.

The Executive Branch has reviewed the physical security measures that are applicable to the proposed export and concluded that physical security will be adequate. The consultations required under Section 133 of the Atomic Energy Act, as amended, have been completed.

Section 134 of the Atomic Energy Act, as amended, (also referred to as the Schumer amendment to the Energy Policy Act of 1992) adds the following conditions to approval of HEU exports:

> *"a. The Commission may issue a license for the export of highly enriched uranium to be used as a fuel or target in a nuclear research or test reactor only if, in addition to any other requirement of this Act, the Commission determines that--*
>
> > *"(1) there is no alternative nuclear reactor fuel or target enriched in the isotope U-235 to a lesser percent than the proposed export, that can be used in that reactor;*

"(2) the proposed recipient of that uranium has provided assurances that, whenever an alternative nuclear reactor fuel or target can be used in that reactor, it will use that alternative in lieu of highly enriched uranium; and

"(3) the United States Government is actively developing an alternative nuclear reactor fuel or target that can be used in that reactor.

"b. As used in this section--

"(1) the term 'alternative nuclear reactor fuel or target' means a nuclear reactor fuel or target which is enriched to less than 20 percent in the isotope U-235;

"(2) the term 'highly enriched uranium' means uranium enriched to 20 percent or more in the isotope U-235; and

"(3) a fuel or target 'can be used' in a nuclear research or test reactor if --

"(A) the fuel or target has been qualified by the Reduced Enrichment Research and Test Reactor Program of the Department of Energy; and

"(B) use of the fuel or target will permit the large majority of ongoing and planned experiments and isotope production to be conducted in the reactor without a large percentage increase in the total cost of operating the reactor."

The Executive Branch believes that the three conditions of Section 134 are met based on the following:

(1). Argonne National Laboratory has confirmed that there is no low enriched uranium target material currently available that can be used as an alternative to HEU for production of medical isotopes by Chalk River Laboratories.

(2) The Embassy of the United States in Canada and the Canadian Ministry of Foreign Affairs have exchanged diplomatic notes confirming that both Governments agree that all entities producing medical molybdenum-99 be required to use low enriched uranium targets when such targets are available. Moreover, the Department of Energy (DOE), in the enclosed letter dated January 24, 2001, reported a recent meeting between DOE and Argonne National Laboratory RERTR Program representatives with Atomic Energy of Canada and MDS Nordion on cooperation in LEU target development. The letter confirms that DOE and RERTR Program Managers have concluded that the course of action being followed continues to meet the criteria of the Schumer Amendment for the active development of an LEU target for medical isotope production.

(3) Argonne National Laboratory has an active DOE-funded program underway for the development of low-enriched uranium targets for production of medical isotopes.

The Executive Branch has also taken note of the applicant's explanation that this new HEU request is necessary because start-up of the two new Maple reactors and the associated New Processing Facility (NPF) for medical isotope production has been delayed because of problems with the reactor shut-off rod system and NPF tubing installations. As a result Atomic Energy of Canada Ltd (AECL) needs to continue operation of the old NRU reactor and associated processing facility for production of medical isotopes. The 10 kilograms of HEU requested represents a one year supply for the NRU. An initial shipment of 5 kilograms of HEU needs to be made by March 1, 2001 to meet production requirements. AECL had earlier anticipated shutting down the NRU by May 2001 as the first of the Maple reactors came on line and the NPF initiated production of medical isotopes from targets irradiated in the Maple reactor. Dr. Jean Pierre Labrie, General Manager, Research and Isotope Reactor Business, Atomic Energy of Canada, Ltd. has prepared detailed responses to the questions raised by NRC staff with respect to the foregoing situation, which have already been provided to the NRC by the applicant's attorneys. In addition, the Department of Energy has provided the enclosed report regarding the Sandia National Laboratory isotope production program which was terminated in 1999 for lack of private company interest in pursuing Mo-99 production on a commercial basis.

In view of the foregoing, the Executive Branch recommends that the required determinations be made and that the requested license be issued.

Sincerely,

Richard J. K. Stratford
Director
Nuclear Energy Affairs

Enclosures: (1) assurance letter
(2) DOE letters
(3). AECL responses to NRC questions.

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

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Your file Votre référence

Our file Notre référence

11-2-3
IL-AI-3528.0/2001

December 5, 2000

Mr. Richard Goorevich
Acting Director
Nuclear Transfer and Supplier Policy
Office of Arms Control and Nonproliferation
Department of Energy
Washington, D.C. 20585
USA

Dear Mr. Goorevich:

Reference is made to your letter dated November 21, 2000, concerning licence XSNM03171.

I confirm that the transfer of the material as identified on the above-noted licence application will be subject to all of the terms and conditions of the Agreement for Cooperation concerning the Civil Uses of Atomic Energy between the Government of Canada and the Government of the United States, and that the intermediate consignee, Atomic Energy of Canada Limited, Chalk River, Ontario is authorized to receive and possess the material.

Yours sincerely,

W. Angus Laidlaw
Nuclear Non-proliferation Officer
Non-proliferation, Safeguards
and Security Division

c.c.: Sean Ochlbert, US DOE
Betty L. Wright, USNRC

Canada

Department of Energy
National Nuclear Security Administration
Washington, DC 20585

January 24, 2001

Mr. Richard J. K. Stratford
Director
Office of Nuclear Energy Affairs
Department of State
Washington, DC 20520

Dear Mr. Stratford:

I have considered the facts with respect to Canadian efforts to meet the requirements of the Schumer Amendment as they apply to license application XSNM03171 to export ten kilograms of highly enriched uranium (HEU) to Canada for production of medical radioisotopes in the NRU reactor. It is my view that the finding in my letter to you on February 19, 1999, which stated that the criteria of the Schumer Amendment were met still pertains.

In an effort to obtain first hand knowledge of the situation, I sent Drs. Armando Travelli and George Vandergrift of the RERTR Program at Argonne National Laboratory (ANL) and Carl Thorne, an advisor to me, to Chalk River Laboratory on January 10-12 to meet with Atomic Energy of Canada Ltd. (AECL) and MDS Nordian officials.

It was confirmed at the meeting that recently discovered safety problems in the new Maple 1 reactor will necessitate the continued operation of the NRU reactor past the projected May 2001, shutdown if there is to be no break in the supply of radioisotopes by Nordian to its customers in the United States. The new Maple 1 reactor is currently undergoing corrective actions and is projected to be on line by the June or July this year. The Maple 2 reactor is receiving the same modifications as the Maple 1 and will probably be on line in approximately three months after Maple 1. As you may recall these two 10 MW reactors were designed for the single purpose of irradiating targets for the production of medical radioisotopes. Continued operation of the NRU is not without problems either. The AECL must obtain approval from the Canada Nuclear Safety Commission (CNSC) to put additional waste material into the Fissile Solution Storage Tank (FISST) at the NRU. A decision by the CNSC is expected soon.

I am pleased to report that steps were taken at last week's meeting to begin an active program of cooperation between AECL and Argonne in Phase II of the Conversion Plan. The Argonne effort will address the processing of waste in the New Processing Facility (NPF) from Low Enriched Uranium (LEU) targets. This is the area of the conversion to LEU targets that is most technically challenging. The LEU targets will have five times

the mass of Highly Enriched Uranium (HEU) targets. A reduction of the volume of the waste is critical in order to conduct the process within the space constraints of the hot cells in the NPF. The program begins with the preparation of a program plan by Argonne by the end of February 2001. Then begins a series of tests and experiments, followed by an evaluation of the impact of the findings on the NPF process. This part of the Conversion Plan could take as long as two years to complete. Given the above information, I conclude that all requirements of the Schumer Amendment are being fulfilled at this time. Should you have any questions, please do not hesitate to call me at 202-586-2100.

Sincerely,

Trisha Dedik
Director
International Policy and Analysis
for Arms Control and Nonproliferation
Office of Defense Nuclear Nonproliferation

UNITED STATES GOVERNMENT **DEPARTMENT OF ENERGY**

memorandum

Date: January 30, 2001

To: Robin DeLaBarre, Department of State

From: Sean Oehlbert, Department of State

Subject: Annular Core Research Reactor

I am writing this memo in response to your request for information regarding Sandia National Laboratory's Annular Core Research Reactor. The question you sent to me is provided below:

> What is the status of the Annular Core Research Reactor (ACRR) at Sandia National Laboratory that was in the process of being reconfigured to produce molybdenum 99 (Mo-99)? There had been an expectation that sustained production of Food and Drug Administration (FDA) approved Mo-99 would be achieved in 1999 and it would reach the production capacity of the Canadian reactors sometime in 2000. Are there any other sources of Mo-99?

The program at Sandia National Laboratory was terminated in 1999 after the ACRR had been converted to full time Mo-99 production and the Hot Cell facility modifications were nearly complete to support 100% of U.S. demand for Mo-99. At this time, the ACRR reactor has been converted back to pulse operations to support Department of Energy (DOE)/Defense Programs testing needs and the Hot Cell is in cold standby as a non-nuclear facility.

After careful consideration of the overall isotope program's needs, DOE terminated the program because of the unsuccessful effort to privatize the Mo-99 production. Specifically, program management felt that the increasing diversity of the world's supply of Mo-99 had significantly negated the urgency of establishing an emergency backup capability in the United States.

There are four major commercial producers of Mo-99. These producers are located in Canada, Belgium, the Netherlands and South Africa. All other holders of this technology are believed to be on the laboratory scale.

If you have any questions, please contact me at 586-3806.

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James A. Glasgow
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December 22, 2000

VIA FACSIMILE

Mr. Ronald D. Hauber
Director, Division of Non-Proliferation,
Exports and Miltilateral Relations
Office of International Programs
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
4E9 OIP/NEMR
Rockville, Maryland 20852

Re: Export License Application XSNM- 03171 -- HEU for the NRU Reactor in Canada

Dear Mr. Hauber:

On December 14, 2000, I received a memorandum from Robin DeLaBarre of the Bureau of Nonproliferation Affairs, Office of Nuclear Energy Affairs, enclosing a copy of questions prepared by your office in connection with the above-referenced export license application. His memorandum requested a response from the applicant.

Dr. Jean Pierre Labrie, General Manager, Research and Isotope Reactor Business, Atomic Energy of Canada, Ltd., has now prepared the enclosed responses to each of the NRC's questions. If the NRC or the Executive Branch has additional questions in connection with this application for an export license, we will be glad to respond promptly.

Sincerely,

Jim Glasgow

James A. Glasgow

cc: Robin DeLaBarre

JAG/lrf:

Enclosures: As stated

Export Licence Application XSNMO3171
HEU for the NRU Reactor in Canada
2000 December 22

	US Nuclear Regulatory Commission Questions	AECL Answer
1 (a)	In previous discussions with the NRC, Atomic Energy of Canada Limited (AECL) and MDS Nordion underscored the need to begin operating the new MAPLE reactors and the New Processing Facility (NPF) as soon as possible to ensure a reliable supply of medical radioisotopes. The key rationale was that the NRU reactor has been operating since 1957 and it could not be operated at the required production rate beyond May 2001 because of severe limitation on the storage capacity of AECL's Fissile Solution Storage Tank (FISST). Now in light of unforeseen technical difficulties operating the MAPLE reactors and NPF, an effort is underway to identify options to increase NRU storage capacity to make it possible to extend its operation. What is the status of this effort, when will it likely be completed, and how much additional storage capacity will be possible?	AECL is authorized by the Canadian Nuclear Safety Commission (CNSC) to operate FISST up-to a maximum uranium concentration of 7.0 g/L. The Criticality Safety Document (CSD-01, Rev 7) to increase the uranium concentration from 7.0 g/L to 7.6 g/L has been submitted for approval to AECL's Nuclear Safety Criticality Panel (NSCP) and the CNSC. The NSCP granted approval to increase the uranium concentration in FISST on December 19, 2000. A formal request for approval is being made to the CNSC and a response from the CNSC is expected in January 2001. If approved by the CNSC, the increase in uranium concentration limit would allow use of FISST until July 2002, which represent about 14 months additional storage capacity.
1 (b)	Will there be sufficient storage if it becomes necessary to operate NRU beyond the schedule presently envisioned?	An increase in the uranium concentration limit from 7.0 to 7.6 g/L would provide sufficient storage to operate NRU for medical isotope production until July 2002, which is beyond the schedule presently envisioned for bringing the MAPLE reactors and NPF into operation.
1 (c)	Could this extra time provided by extending the operation of the NRU provide sufficient time to convert	In response to questions from the Commission during the July 10, 2000 Public Meeting, Dr. Ian Trevena stated that the concept

	US Nuclear Regulatory Commission Questions	AECL Answer
	the MAPLE reactors and NPF to LEU?	development phase (Phase 2) was expected "to take about 18 months, going to the end of 2001. Therefore, the implementation phase (Phase 3) cannot begin earlier than the end of 2001." For the reasons discussed at length in the Public Meeting, firm timetables for completion of the Implementation Phase cannot be specified at this time. However, the completion of Phases 2 and 3 will extend years beyond the extended date that is anticipated for use of the NRU. Consequently, AECL's proposed extension of the use of the NRU for about 14 months, until about July 2002, does not present an opportunity to convert the MAPLE Reactors and the NPF to operate with LEU targets.
1 (d)	Has this been evaluated as an option to avoid loading HEU in the MAPLE reactors and NPF? If so, what are the results of the evaluation?	HEU targets have been irradiated in the MAPLE 1 reactor during commissioning, as these are part of the reactor core. As stated above, the increase in uranium concentration in FISST does not provide sufficient time to convert the MAPLE reactors and NPF to LEU.
2 (a)	Have consultations with Canadian Nuclear Safety Commission (CNSC) regulatory authorities begun regarding the continued use of NRU and expansion of storage capacity?	The Criticality Safety Document (CSD-01, Rev 7) was submitted to AECL's Nuclear Safety Criticality Panel (NSCP) for approval to increase the uranium concentration limit in FISST from 7.0 to 7.6 g/L and to the CNSC for information at this time. One meeting was held with the CNSC criticality specialists and licensing staff.
(b)	What factors will need to be (or have been) addressed to obtain necessary approvals by CNSC? What is the projected schedule for CNSC review of continued use of NRU? Are there any other factors that must be addressed?	The formal request to increase the FISST uranium concentration limit to 7.6 g/L is being made to the CNSC, after receiving NSCP approval on December 19, 2000. The request to the CNSC is to amend Chalk River Laboratories Licence NRTEOL-1.00/2002 and change the Molybdenum-99 Facility Authorization, AECL-FA-07, Rev 6, May 2000, to increase the uranium concentration

	US Nuclear Regulatory Commission Questions	AECL Answer
		limit in the FISST from 7.0 to 7.6 g/L. CNSC approval of the change is anticipated in January 2001. There are presently no other factors than those indicated above to address.
3.	What is the status of recovering HEU shipped to the Dounreay facility in the United Kingdom? What is the likelihood the HEU will be processed at Dounreay and has there been any indication when you might expect to know the details?	Dounreay had completed in September 2000 an engineering review and design substantiation of the Uranium Recovery Plant. As of December 15, 2000, there were no indications from Dounreay as to when regulatory approval will be granted to restart the Plant. Dounreay representatives have indicated that assuming regulatory approval was granted in the near future, the earliest time period when recovery of AECL's material would begin is in March to June 2002.
4 (a)	Has any of the HEU authorized for export under licence XSNM03060 been shipped to the MAPLE reactors? If so when and how much?	To date the following shipments have been made: 250 targets 31 January 2000 250 targets 12 October 2000 250 targets 29 November 2000 250 targets 18 December 2000 The total amount of HEU received to-date under export under licence XSNM03060 is about 20 kgU.
4 (b)	Could any of that material or a portion of the remaining balance in the United States be used in the NRU?	The isotope production process in the NRU reactor and existing Molybdenum-99 Facility is based on uranium-aluminium alloy targets. The isotope production process in the MAPLE reactors and New Processing Facility is based on uranium dioxide targets. These process are not interchangeable and consequently MAPLE targets cannot be processed in the existing Molybdenum-99 Facility, similarly, NRU uranium-aluminium alloy targets cannot be processed in the New Processing Facility. The current export

	US Nuclear Regulatory Commission Questions	AECL Answer
		licence XSNM03060 is specifically for manufactured HEU dioxide targets for use in the MAPLE reactors and New Processing Facility. The existing Molybdenum-99 Facility cannot process targets received under export licence XSNM03060. Converting HEU dioxide targets for the MAPLE reactors received under export licence XSNM03060 to HEU aluminium alloy targets for the NRU reactor and existing Molybdenum-99 production facilities is beyond AECL's facilities' current capabilities and would require significant development work to achieve and regulatory approvals to implement. Consequently, this option is beyond the time period required to manufacture HEU aluminium alloy targets and sustain continued supply of medical isotopes from the NRU reactor.
4 (c)	Similarly, given the delay, will it be possible to reduce the total amount of HEU already requested and approved for export to the MAPLE reactors? Or is there a possibility that it will be necessary to amend the export licence XSNM03060 to extend the expiration date as a result of the delays and the licence conditions limiting annual HEU exports to the MAPLE reactors?	The delay in completing the commissioning of the MAPLE reactors and New Processing Facility also delays the build-up of operating experience to identify methods for achieving their conversion to LEU. The delay does not affect the need for the total amount of HEU currently approved for export to the MAPLE reactors. Depending upon the date when the MAPLE reactors assume operational status and the progress of Phases 2 and 3 of the HEU to LEU conversion program, it may be necessary to request an amendment to export license XSNM03060 to extend the expiration date.
5 (a)	What is the current licensing status of the MAPLE reactors and the NPF?	The CNSC operating licences for the MAPLE reactors and NPF NPROL-62.2/2001 and NSPFOL-03.1/2001 remain in effect.
5 (b)	What are the view of the CNSC with respect to the	The view of the CNSC with respect to the technical problems

	US Nuclear Regulatory Commission Questions	AECL Answer
	technical problems associated with the reactor shut off rod system and deficiencies in the tubing installations in the MAPLE reactors and NPF?	associated with the reactor shut off rod system and deficiencies in the tubing installations in the MAPLE reactors and NPF are contained in CMD 00-M74 attached.
6 (a)	Have there been any new developments with respect to the LEU conversion process, even though just discussed in July?	AECL arranged a meeting with MDS Nordion at SGN offices on November 16, 2000, to finalize the scope and schedule of the Phase 2 Conversion Development Program, which is based on increasing the waste solidification capacity of the NPF. MDS Nordion communicated with ANL on the meeting and their participation in Phase 2 work. A meeting with ANL and MDS Nordion at AECL's Chalk River Laboratories is being arranged in January 2001.
6 (b)	For example, have you come to any conclusions about having to build an additional processing facility rather than modifying NPF? In July, it was indicated that a decision on this particular issue would be made by September 2000?	In July 2000, MDS Nordion indicated that the Phase 2 Conversion Development Program would take about 18 months and the outline of the program would be completed in September. In November 2000, MDS Nordion and AECL met with SGN to finalize the detailed scope of work, which includes precipitation studies with ANL. A meeting is being arranged with ANL, MDS Nordion at AECL's Chalk River Laboratories in January 2001. A decision on the construction of an additional processing facility would be premature at this time without the results of the Phase 2 Conversion Development Program. A commitment for a decision on this particular issue by September 2000, was not made by MDS Nordion or AECL at the July 2000 meeting.
6 (c)	Also, have there been any interactions with Canadian and US FDA regulators?	MDS Nordion has not yet had discussions with the USFDA regarding LEU. Interactions have been on the process for receiving approval for medical isotopes produced in the MAPLE reactors.

CMD 00-M74

(Ref.: CMD 00-M37
CMD 00-H11)

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Your file: Votre référence

Our file: Notre référence

2000-11-27

26-1-62-0-0

TO: Commission Members

AUX : Commissaires

FROM: Directorate of Fuel Cycle and Materials Regulation

DE LA : Direction de la réglementation du cycle du combustible et des matières nucléaires

PURPOSE: Information

BUT : Information

SUBJECT: Failure of Shut Off Rods in the MAPLE 1 Reactor at the Chalk River Laboratories

OBJET : Défaillances des barres d'arrêt du réacteur MAPLE 1 aux laboratoires de Chalk River

SUMMARY

This report provides an update on the investigations carried out by AECL and by CNSC staff of the failures of shut off rods that occurred during commissioning of the MAPLE 1 reactor. It also provides information on AECL's proposed program of corrective actions and actions to prevent recurrence.

This report is provided for information and in response to a request made at the Commission meeting of August 16, 2000.

RÉSUMÉ

Ce rapport fournit une mise à jour sur les évaluations faites par ÉACL et par les agents de la CCSN sur les défaillances des barres d'arrêt qui ont eu lieu lors de la mise en service du réacteur MAPLE 1. Il fournit également des renseignements sur le programme des activités correctives proposé par ÉACL ainsi que sur les mesures pour en prévenir la récurrence.

Ce rapport est fourni à titre de renseignements et en réponse à la demande faite à la réunion de la Commission du 16 août 2000.

Canada

CMD 00-M74

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CMD 00-M74

Failure of Shut Off Rods in the MAPLE 1 Reactor at the Chalk River Laboratories

1. INTRODUCTION

This report provides an update on the investigations carried out by AECL and CNSC staff of the failures of shut off rods that occurred during commissioning of the MAPLE 1 reactor. It also provides information on AECL's proposed program of corrective actions and actions to prevent recurrence. It is provided for information and in response to a request made at the commission meeting of August 16, 2000.

2. FAILURES OF CONTROL ABSORBER RODS AND SHUT OFF RODS

As was reported in CMD 00-H11 and in CMD 00-M37 (Significant Development Report), AECL reported several events that involved failure of a MAPLE 1 control absorber rod (CAR) or shut off rod (SOR) to fall fully into the core when tested. The first failure (of a CAR) occurred on December 23, 1999 and the most recent failure (of a SOR) occurred on July 18, 2000. These failures cast doubt on the reliability of Safety System 1 (SORs) and Safety System 2 (CARs) and prompted in-depth evaluations by both AECL and CNSC staff. The following sections discuss the findings to-date of these evaluations and the status of actions to correct the problem and prevent its recurrence.

2.1 Safety Significance of the Failures

CNSC staff concluded that the SOR and CAR failures had no direct impact on public or worker safety. All failures occurred when the reactor was already shut down. Furthermore, each failure involved only one SOR or CAR. The shutdown systems are designed such that the system remains effective with one SOR (Safety System 1) or CAR (Safety System 2) unavailable.

However, the failures showed that the SORs and CARs were significantly less reliable than was assessed and accepted in the licensing safety assessment. In the case of the SORs, AECL failed to detect this until after fuel loading into MAPLE 1. CNSC staff considers that its failure to detect and correct the problem sooner represented a serious breakdown in AECL's program for management of safety. The status of AECL's proposed course of action to address this is discussed in section 2.3. The CNSC incident Inspection Team (IIT), described in section 2.4, will assess the need for changes in CNSC regulatory processes. CNSC staff plans to present the IIT's findings to the Commission at its January 2001 meeting.

2.2 SOR Design, Operation and Maintenance

AECL concluded that design changes were needed to assure the future reliability of the SORs. Prototype testing of the original SOR design showed acceptable reliability. However, management of the test program was questionable. Some planned testing was not done and some testing was done under conditions not representative of the real reactor. For example, AECL did no qualification tests on production SORs, although its Design Verification Plan called for it. Also, the prototype tests were done with the test rig's circulating pump shut down, which is not representative of conditions in the real reactor.

AECL concluded that the original SOR design was vulnerable to jamming by relatively small particles and that ingress of such small particles cannot be ruled out (even with improved filtering, etc.). As a result, AECL staff recommended design changes to increase the bearing clearances over most of the SOR travel. With the proposed design change, there would still be tight clearances at the end of travel to provide "down" sensing for the SORs. However, a rod sticking near the end of its travel would have little impact on safety system effectiveness. AECL staff also proposed design changes to the SORs and their hydraulic supply system to reduce the likelihood of particles being created or introduced downstream of the filters.

Besides the design changes, AECL proposed changes to operating and maintenance procedures, based on the lessons learned from the MAPLE 1 SOR failures. The original procedures were found to be deficient. This is at least partly attributable to inadequate transfer of design information to operating and maintenance staff.

When this report was prepared, AECL had not yet submitted details on its proposed design changes. CNSC staff expects to receive more details on the proposed change in early-December. The proposed change will require approval of AECL's Office of the Chief Engineer, of AECL's Safety Review Committee and CNSC approval. AECL is currently doing prototype testing of modified SORs and will include the test results in the request for approval of the proposed change.

2.3 Management and Organizational Issues

AECL's investigation identified deficiencies in managed processes that contributed to the occurrence of the SOR failures. These included inadequate engineering supervision, a breakdown in communication between engineering and the project and inadequate design verification. For example, AECL's investigation team found that design changes recommended as a result of feedback from the Korean HANARO reactor were not fully implemented. They attributed this to a desire to avoid design changes for contractual and schedule reasons.

They also found evidence that short-cuts were invoked to complete the job on schedule. For example, as mentioned in section 2.2, prototype testing was done with the pump shut down and some planned tests were not done. Schedule pressures seem to have been a factor in both decisions. They also found evidence of inadequate design completion assurances. Specifically, the completion assurances were signed off although key design documents were incomplete. These included the test reports that could have alerted AECL staff and management to the incomplete state of SOR testing. As a result, AECL's commissioning staff did not have access to documentation that described the testing done and, more importantly, what remained to be done. Several commissioning tests on the SORs, in the MAPLE 1 reactor, were also done with the primary cooling system (PCS) pump shut down.

CNSC staff concluded that the management and organizational issues identified by AECL's investigation team were both serious and widespread. This raised questions on the quality of the "as built" facility that extended beyond the issue of SOR reliability. We therefore requested AECL to address these wider implications of their findings. AECL's response states that it is taking the following actions to address these concerns:

(a) AECL is performing detailed reviews of the as built state of two other systems important to safety. These are the reflector dump system (part of Safety System 2) and the Exhaust Air Filtration System. The investigation will include reviews of the design, construction and commissioning, concluding at the commissioning completion assurance step. This detailed investigation includes reviews of feedback of information, design verification and completion assurance, change control, documentation and quality assurance (QA). These are all areas that were found to be deficient and to have contributed to the SOR failures. AECL's detailed investigation of the as built state of these two systems is scheduled to be completed by November 30, 2000.

(b) AECL is also performing less detailed reviews of the as built state of other MAPLE 1, MAPLE 2 and NPF systems. These are aimed at identifying systems and components that are susceptible to construction deficiencies similar to those found on the SOR hydraulic lines and that may not have been adequately verified after the construction was completed. This assessment is also scheduled to be completed by November 30, 2000.

(c) AECL will prepare a lessons learned report, in accordance with its overall QA manual to ensure that lessons learned are fed back to other AECL projects.

In addition, AECL has proposed corrective actions to address the specific recommendations of its internal root cause investigation report. These include actions to assure proper control of the design, fabrication and testing of the revised SOR design and to ensure that the revised SOR design adequately reflects feedback from HANARO. AECL's proposal includes a review of the project's design verification plan and design completion assurances and actions to correct any gaps found. At the end of this process, AECL will reconfirm the design completion assurances. AECL has committed to ensure that all corrective actions relevant to the MAPLE reactors will be implemented before it seeks approval to proceed with the next phase of commissioning.

CNSC staff reviewed AECL's proposed program of corrective and preventive actions. We concluded that it does address the key issues related to fitness for service of MAPLE reactor systems. However, its effectiveness will depend on how rigorously it is followed. In addition, it may be necessary to expand the program, to address any findings of the reviews described in items (a) and (b). As a result, CNSC staff intends to do its own follow-up review. CNSC staff will be seeking assurance that (1) AECL has done enough to uncover any potential problems beyond the issue of SOR reliability and (2) that AECL has corrected the identified management and organizational deficiencies and any additional problems found so as to assure effective management of safety in the future.

The lessons learned from MAPLE 1 SOR failures may have implications on the adequacy of AECL's quality management processes. CNSC staff will follow up appropriately on this after the IIT report, mentioned in section 2.4, is finalized.

2.4 CNSC Incident Inspection Team Review

Following the SOR failure on July 18, 2000, CNSC staff formed an incident inspection team (IIT) to evaluate the SOR failures and AECL's response to them. The team was led by a specialist from the CNSC's Event and Investigations Section and team members were drawn from Safety Evaluation Division "A" and from the Quality Management and Human Factors sections.

The scope of the IIT's inspection included the following:

- the conditions preceding the series of control and shut-off rod failures;
- the event chronology;
- equipment performance;
- any precursors to the event;
- the safety significance of the event; and
- the adequacy of AECL's investigation.

The IIT evaluated documents submitted by AECL, inspected facilities both at CRL and at AECL's premises in Mississauga and interviewed AECL staff involved in the project. The IIT's inspection is now complete and the IIT expects to complete its final report in December. CNSC staff plans to present the report to the Commission at the January 2001 meeting.

3. DISCUSSION AND CONCLUSIONS

AECL and CNSC staff evaluations revealed deficiencies in how AECL managed and performed work. These deficiencies allowed MAPLE 1 to be started up and commissioned with safety systems that were significantly less reliable than was assessed and accepted in the licensing safety assessment. CNSC staff concluded that these management and organizational deficiencies (described in section 2.3) had implications that extended beyond the specific question of SOR reliability. In particular, they cast doubt on the as-built quality of other systems in the MAPLE reactors and NPF. For example, AECL and CNSC staff found evidence that design and commissioning work on the SORs was incomplete or improperly performed. However, these deficiencies were not found by AECL's internal completion assurance processes. This raised questions on the adequacy of the completion assurances that AECL had submitted for other systems.

Follow-up actions are required both to assure the reliability of the SORs and CARs and to address management and organizational deficiencies. These must be completed before CNSC staff approve any of the following activities:

- Phase C commissioning of MAPLE 1
- fuel loading into MAPLE 2
- hot (radioactive) commissioning of the New Processing Facility.

CNSC staff concluded that AECL's proposed program of corrective and preventive actions does address the key issues. However, its effectiveness will depend on how rigorously it is followed and AECL may need to expand the program, to address any additional findings. As a result, CNSC staff intends to monitor AECL's progress in implementing the proposed program.

In conclusion, CNSC staff finds as follows:

1. The SOR and CAR failures had little direct impact on public safety.

2. The as-installed SORs were significantly less reliable than was assessed and accepted in the licensing safety assessment.

3. AECL's failure to detect and correct the problem earlier constitutes a serious breakdown in its program for management of safety. The SOR reliability problem should have been corrected during the design process. Failing this, it should have been detected by the completion assurance processes.

4. CNSC staff follow-up work is required to confirm that AECL has taken effective action to assure the reliability of the SORs and CARs and to address the identified management issues. This includes confirmation that AECL has done a sufficiently thorough review to identify any problems affecting other systems and has corrected any such problems found. It also includes reviews of AECL's processes for completion assurances. We consider completion of this follow-up and acceptance of the results to be prerequisites to CNSC approval (required by licence condition C2) to proceed with future commissioning phases of the MAPLE reactors and NPF.

5. The lessons learned from the MAPLE 1 SOR failures may have implications on the adequacy of AECL's quality management processes. CNSC staff will follow up appropriately on this after the IIT report, mentioned in section 2.4, is finalized.

ABBREVIATIONS AND ACRONYMS

AECL	Atomic Energy of Canada Limited
CAR	Control Absorber Rod
CNSC	Canadian Nuclear Safety Commission
CRL	Chalk River Laboratories
DIF	Dedicated Isotope Facilities
FME	Foreign Materials Exclusion
IIT	Incident Inspection Team
MMIR	MDS Nordion Medical Isotope Reactor project
PCS	Primary Cooling System
OLC	Operational Limits and Conditions
QA	Quality Assurance
SOR	Shut Off Rod