



February 4, 2009

Memorandum to the Minister

Subject: Contained Leaks at NRU Reactor, AECL Chalk River Laboratories

Purpose: Provide a written report on a small, contained heavy water leak in December 2008, and an ongoing, contained light water leak at the NRU research reactor facility at Chalk River Laboratories, Ontario.

Overview:

The NRU (National Research Universal) research reactor, owned and operated by AECL (Atomic Energy of Canada Limited), contributes to R&D in support of the fleet of CANDU reactors in Canada and worldwide, supports the conduct of important nuclear safety research, enables scientific neutron scattering experiments, and produces large quantities of medical isotopes for the healthcare of Canadians and people around the world. The facility is part of AECL's Chalk River Laboratories, where about 2,800 scientists, technicians and other highly trained staff are located.

The NRU reactor has an excellent lifetime performance record. Since going into service in November 1957 the reactor has operated safely and has been available for service 75% of the time, comparable to the best-performing reactors of its vintage in the world. NRU serves as a cornerstone of the entire Canadian nuclear power industry, and is an essential component in the development of CANDU nuclear reactor designs. Inside NRU, a nuclear reaction occurs, just as in a full-scale CANDU reactor; however, NRU is primarily a neutron source for isotope production and research and does not produce electricity. It contains testing equipment allowing scientists and engineers to put new fuels or materials into the reactor and see how they behave. NRU is a unique facility in Canada, providing critical knowledge that helps AECL build safer and more efficient nuclear power plants.

The NRU, like all nuclear facilities in Canada, is regulated by the CNSC (Canadian Nuclear Safety Commission). As stipulated in its licence

conditions, AECL is required to make reports to the CNSC that range from annual performance reports, to immediate emergency notification if a serious nuclear event were to occur. A recent licence condition was added to report events to the CNSC that could lead to interruption of the isotope supply. Apart from the licence conditions, a *Protocol for Notification and Information Sharing Amongst AECL, NRCAN, and Health Canada Concerning Shortages of Medical Isotopes (Isotopes Protocol)* was concluded in January 2008. This protocol, which is intended to mitigate the effects of isotope supply disruptions, was developed following the unexpected outage of the NRU reactor in December 2007. The Isotopes Protocol requires AECL to inform NRCAN and Health Canada of any situation at its Chalk River Laboratories that could potentially create a shortage in isotope supply.

Contained Leak of Heavy Water -- December 5, 2008

Heavy water is similar to ordinary water but weighs 10% more. It occurs naturally, so every glass of water contains a small amount of heavy water. Heavy water for scientific and nuclear use is produced by extracting it from regular water. Pure heavy water is not radioactive. In the NRU reactor, heavy water performs a dual role. Its primary purpose is to serve as a “moderator” of the fission process to allow the nuclear chain reaction to continue. One of the products of the fission process is heat, and the heavy water also acts as a coolant to remove the heat from the reactor. In its role as a moderator, the heavy water absorbs some free neutrons resulting in the formation of tritium which is radioactive. Tritium is produced faster than it is eliminated through radioactive decay, so the level of tritium builds up in the heavy water over time.

Small traces of tritium exist in the natural environment as a result of cosmic rays, which bombard the Earth’s atmosphere from space. Tritium emits a very low energy radiation, which is not harmful in minute quantities. Tritium management systems are in place at nuclear facilities to limit worker and environmental exposure, and thereby protect against energy given off by tritium. Some forms of tritium are safe to use in industrial self-lighting products, such as airport runway lights and theatre emergency exit signs.

For worker safety, NRU is carefully designed to minimize leakage. Materials and equipment used are of the highest standards. Maintenance and operation of NRU are organized to maximize the reliability of the systems. Should a leak occur, NRU heavy water systems are equipped with leak detection and collection systems, which ensure that staff are quickly alerted to any loss and that such losses are contained within the facility. Heavy water leaks are directed by a system of pipes and drains to a collection point where they can be transferred into drums for storage or

clean-up. There is no direct leak path from the NRU cooling system to the external environment. Small amounts that evaporate are discharged through ventilation systems and those discharges are monitored and reported.

- On December 5, 2008, with the NRU reactor in safe shutdown mode, routine monitoring detected a slight increase to the normal amounts of heavy water in ventilation and drainage systems, which was informally reported to CNSC. Operating staff at NRU have detailed instructions on how to respond to leaks, as part of a comprehensive set of instructions used by licensed NRU operators. Increased monitoring was instituted and a search was started to locate the source of the detected heavy water. AECL informed federal officials on December 5 of potential impacts on isotope supplies due to the NRU shutdown, and on December 6 of the heavy water leak.
- On December 8, AECL determined through its calculations that the heavy water leak was a reportable event, and, on December 9, AECL submitted the required report to the CNSC. In total, 47 kg of heavy water leaked from the NRU reactor, which contains approximately 68,000 kg of heavy water. All the heavy water was contained and collected within the NRU facility, as is the case when a heavy water leak occurs. However, it is estimated that approximately 4.5 kg of heavy water evaporated and was drawn from the facility by the ventilation system. This release path is continuously monitored and AECL has reported that this emission amounted to less than one thousandth of regulatory limits.
- Of the collected liquids, approximately 14 kg is stored in specially designed heavy water storage drums. Approximately 28.5 kg of heavy water, mixed with light water from a leak in the fresh water reflector tank (see below), was pumped to a storage tank at AECL's Waste Management Centre for future processing.

Contained Fresh Water Leak in NRU Reflector Tank

Surrounding the NRU reactor to enhance reactor performance is a cylindrical reflector tank. The water in this tank is "light water" (essentially purified tap water). A small crack in a weld of this fresh water tank has existed for a number of years, and is being managed through periodic repairs during maintenance outages. The water that emanates from this fissure is transported to the on-site Waste Treatment Centre at Chalk

River Labs, is purified prior to its release to the Ottawa River per Ministry of Environment, CNSC and Health Canada regulations, and is monitored by AECL staff according to environmental standards. Although the leakage is not a concern to the CNSC from a health, safety or environmental perspective, AECL has plans for a repair to reduce the current leakage rate for operational reasons.

The collected heavy water, along with other waste water from the Chalk River site, will be treated at Chalk River's Waste Treatment Centre to reduce contamination. Prior to any release of water to the river, water is treated to remove the majority of radio-nuclides. All applicable release limits are agreed with the CNSC, and adhered to by AECL, consistent with Ministry of Environment regulations.

In instances of handling water with tritium, which is not removed in the treatment process, concentration levels dictate whether the water will be stored or released. Releases from AECL's Waste Treatment Centre are carefully monitored and released at a controlled rate, subject to provincial and federal regulatory limits. AECL routinely monitors water in the Ottawa River for concentration of tritium. For example downstream from Chalk River Labs, at Petawawa, tritium concentrations in the Ottawa River are similar to the naturally-occurring level upstream of Chalk River, and negligible compared to the Canadian drinking water standard.

Assessment

Heavy water and nuclear materials continue to be safely and securely managed at AECL's Chalk River Laboratories. On January 28, 2009, the CNSC issued a public statement of clarification to correct erroneous media reports about the NRU, and provided the following assurances regarding the 47 kg of heavy water safely collected from the reactor:

- **At no time was the public or the environment at risk.**
- **There is no radioactive material leaking into the Ottawa River associated with the leaks.**
- **AECL acted appropriately in its reporting to the CNSC.**
- **Since the heavy water leak did not pose a risk to the public or the environment, reporting of the leak to the public was deemed unnecessary.**

Regarding the fissure in the reflector tank of the NRU, the CNSC has concluded that there are no health, safety or environmental concerns with the handling of the purified tap water that is collected and treated.

CONCLUSIONS

Based on communications since December 5, 2008, the reporting systems and protocols established between AECL and government departments to address potential medical isotope supply disruptions have worked effectively to disseminate the information available. The medical community in Canada has received timely information regarding the availability of medical isotopes and the operational status of NRU.

Reports on the events of December 5, 2008 were appropriately made by AECL, and appropriate actions were taken to ensure that the health and safety of Canadians and the environment were not put at risk.

In terms of public disclosure of NRU events, AECL, in co-operation with the CNSC, will introduce voluntary disclosure of reportable events occurring at Chalk River Laboratories, for example, by making the contents of reportable events to the CNSC readily available on AECL's website.

Submitted by:

A handwritten signature in black ink, appearing to read "Hugh MacDiarmid". The signature is fluid and cursive, with a large, stylized initial "H" and a long horizontal stroke extending to the right.

Hugh MacDiarmid
President & CEO, AECL

Copy:

G. Carr, Chair, AECL
C. Doyle, DM NRCAN

About NRU

From fuel testing, to materials and component life cycle work, to industry-leading safety and design work, NRU provides the nuclear industry the technology support it requires for safe and reliable operation, as well as a major portion of global medical isotopes used in thousands of daily medical treatments every day. Completed in 1957, NRU is one of the world's largest research reactors at 135 Megawatts (thermal). NRU has undergone significant upgrading and modernization over the years, and remains a major Canadian science and technology asset. NRU has been the birthplace of many scientific achievements. Canadian physicist Bertram Brockhouse won the Nobel Prize in Physics for his influential work using neutron scattering to explore materials and learn about structure at the atomic level.

The National Research Council's Canadian Neutron Beam Centre at NRU today enables scientists from across Canada and around the world to investigate new materials with neutrons. Each year more than 200 professors, students and industrial researchers come to the Canadian Neutron Beam Centre to make use of this national resource. Because neutrons can probe any kind of material, they can be applied to research in metals, alloys, polymers, biomaterials, glass, ceramics, thin films, cement and minerals. This work is leading to advances in medical, industrial and scientific fields to the benefit of all Canadians.

Key Medical Isotopes Produced at the Chalk River Laboratories:

- Molybdenum-99 (and Technicium-99m): Used for medical diagnosis (imaging) of the brain, thyroid, heart, lungs, liver, kidney, spleen and bone marrow.
- Iodine-131: An isotope used in therapy, imaging and diagnosis for thyroid cancer.
- Iodine-125: Used in in-vitro diagnostics, bone densitometry and prostate cancer treatment.
- Xenon-133: A medical diagnosis tool for scanning lungs.
- Cobalt 60: Used in cancer treatment applications.
- Carbon-14: Used as a radiotracer in a variety of biological compounds.
- Iridium-192: Used as intense source of radiation for industrial imaging, including radiography and weld inspection. Also used in portable units for cancer therapy and radiography.