AN ACCIDENT INVOLVING TRANSPORT OF RADIOACTIVE MATERIALS, CANADA 1994 MARCH

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ABSTRACT

AECL-Chalk River Laboratories (CRL) located at Chalk River, Ontario, routinely ships radioisotopes in bulk to Nordion International Inc. in Kanata, Ontario. On 1994 March 22, an AECL vehicle carrying three packages containing radioisotopes collided with a tractor trailer carrying steel, approximately 15 km east of the Chalk River Laboratories. The AECL-CRL emergency response plan was activated. A series of post-accident meetings were held to evaluate the effectiveness of the plan and to address any identified deficiencies. AECL-CRL is continuing to work towards addressing the identified deficiencies.

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INTRODUCTION

Atomic Energy of Canada Limited (AECL) is a crown company incorporated in 1952 under the Companies Act, pursuant to the Atomic Energy Control Act. There are several branches of the Company, located mainly in eastern Canada, one of which is Chalk River Laboratories (CRL) located 200 kilometres northwest of Ottawa on the Ottawa River (Figure 1).

The facilities located at CRL primarily conduct research in support of the CANDU* reactor, but a second major activity is to produce radioisotopes for use in medical treatments. To this end, a wide variety of radioisotopes are shipped daily from CRL to Nordion International Inc. (NII) in Kanata, Ontario.

SHIPMENT OF RADIOISOTOPES TO NORDION INTERNATIONAL INC.

The raw radioisotopes produced in the NRU research reactor and separated at CRL (Figure 2) are shipped to NII, where they are refined and packaged for shipment to various domestic and international destinations.

Included in the list of radioisotopes produced at CRL and shipped to NII are molydenum-99, xenon-133 and samarium-153.

Molybdenum-99 (Mo-99) is shipped to NII from CRL as a liquid. This radioisotope is the most important one produced at CRL, being the raw material for technicium-99 (Tc-99m), the worlds most widely used diagnostic isotope. Tc-99m is used to scan almost every human organ as well as our bones. More than ten million diagnostic procedures are performed annually using this radioisotope.

Xenon-133 (Xe-133) is shipped to NII from CRL as a gas. This radioisotope is used in lung scanning.

Samarium-153 (Sm-153) is shipped to NII from CRL as a solid powder. This radioisotope is used to relieve pain in terminally ill bone cancer patients.

Packages Used to Ship Radioisotopes

Mo-99 is shipped to NII from CRL in the "Nordion International Inc., model F279 Shipping Flask, a Type B(M) package. This flask consists of a cylindrical steel outer container, a removable drawer, a product bottle and a shipping pallet. The external dimensions of the container are 670 mm diameter by 705 mm high. The flask is mounted on a 200 mm high shipping pallet. The total mass of the package is 2265 kg.

* CANDU: CANada Deuterium Uranium. Registered trademark

Xe-133 is shipped to NII from CRL in the Nordion International Inc. F-278 Flask with F-334 Overpack, together a Type B(U) package. The F-334 Overpack consists of a fibreglass reinforced plastic shell encasing a honeycomb filling. Inside the honeycomb is a steel cylinder enclosing thermal insulation and an inner fibreglass liner This overpack houses an inner F-278 container which is secured between the upper and lower halves of the overpack by eight tension latches. The F-278 container consists of a stainless steel encased lead cavity which encloses a leaktight stainless steel cylinder with a two-valve assembly The maximum dimensions of the entire package are 1540 mm high by 1090 mm diameter. The total mass of the package is 294 kg.

Sm-153 is shipped to NII from CRL in the Nordion International Inc. F-271 Transport Package, a Type B(U) package. This flask consists of an inner container and a crush and fire shield outer assembly. The inner container consists of a lead-filled, stainless steel encased cylinder and removable plug. The outer crush and fire shield consists of a conical, finned, insulated mild steel shell with a skid attached by bolts. The overall dimensions are 1100 mm by 1173 mm high. The total mass of the package is 1640 kg.

METHOD AND HISTORY OF SHIPMENTS

CRL has been producing Mo-99 since the early 1970's with the production of Xe-133 and Sm-153 beginning in the mid 1980's and early 1990's respectively. Production of other radioisotopes has been going on since the 1950's. Consequently, AECL vehicles have been travelling regularly to NII (formerly AECL Commercial Products), a distance of about 200 km for nearly 40 years. Since all of the packages containing radioisotopes are shipped from CRL to NII by road, some 110,000 km are logged each year by AECL vehicles making about 275 trips. The vehicles used vary, from a six-ton truck to a tractor trailer and pup, depending on the number and types of packages being transported.

During this time, there have been only two accidents. The first accident occurred on 1976 June 2. The AECL vehicle, a four-ton truck carrying one F-127 package containing irradiated enriched uranium (93% U-235) and one Type "A" package containing strontium-90, was headed to AECL Commercial Products (now NII) in Kanata. The vehicle left the road near Renfrew, Ontario, a town approximately 100 km west of Ottawa, and overturned causing major damage to the vehicle. Neither the F127 package which remained tied to the vehicle nor the Type "A" package sustained any appreciable damage, and there was no spill of radioactivity. Both packages were subsequently transferred to another AECL vehicle, which then transported the packages to Kanata.

The second accident occurred on 1994 March 22. The remainder of this paper describes the accident, the response to the accident, and actions taken to improve the response.

1994 MARCH 22 ACCIDENT

On 1994 March 22, a shipment of radioisotopes left CRL for NII. The shipment consisted of three packages. The first package loaded on the vehicle was an F-334/F-278 which was carrying Xe-133. The second package loaded was an F-279 which was carrying Mo-99. The third and last package loaded was an F-271 which was carrying Sm-153. All three packages were tied down to the vehicle bed using specially designed tie-down devices. The AECL driver left the CRL site at approximately 1915 hours, 1994 March 22.

The vehicle proceeded east along Highway 17 towards NII in Kanata. Approximately 15 km from the CRL site, the vehicle was sideswiped by a tractor trailer carrying steel, travelling west along a flat, straight portion of Highway 17, referred to locally as the "Petawawa Plains". The time was approximately 1940 hours. The road was clear, as was the weather. Temperatures were mild.

After the collision, the AECL vehicle proceeded approximately 50 m before swerving sharply, overturning, finally coming to rest in the westbound ditch. The vehicle ended up on its side, damaged extensively. The westbound vehicle remained on the road after the collision, proceeding approximately 1 km before coming to rest.

IMMEDIATE ACTIONS TAKEN

The accident occurred just after the evening shift change at AECL. A passing motorist called the Ontario Provincial Police (OPP). Several off-duty AECL employees on their way home came upon the accident scene minutes after it happened. One of those employees immediately secured a cellular phone from another motorist at the scene and called AECL Protective Services at approximately 1945 hours, who in turn activated the Emergency Response Plan (ERP).

SUBSEQUENT EVENTS

Emergency Response Plan activated
Ambulance called
Transport Branch called
Radiation Protection (RP) Health Surveyor called
NII informed
OPP set up roadblock at 2020 hours
Ambulance arrived - transported driver to Deep River Hospital
CANUTEC contacted by OPP
Monitoring equipment arrived at the scene, monitoring was conducted - no spill detected
Senior AECL Officers, Public Affairs called
Radiation Protection and Nuclear Materials Managers arrived on scene
Atomic Energy Control Board informed
Arrangements made to return packages to CRL
Senior Officer, Public Affairs arrived at scene
Photography called
Driver transferred to Ottawa Civic Hospital due to massive head and internal injuries
Heavy equipment operators arrived at CRL - began gathering recovery equipment
Roadblock set up by OPP taken down at approximately 2330 hours, traffic flow resumed
Heavy equipment arrived at scene
Packages transferred to alternate vehicle, damaged truck loaded onto flatbed
Packages, damaged vehicle returned to CRL
Radioisotopes transferred to other packages for shipment to NII
Accident scene cleaned up - earth that had diesel fuel absorbed into it was replaced by clean earth by CRL personnel

RESULTS OF THE ACCIDENT

Damage to the AECL Vehicle

The AECL vehicle involved was a five-ton, single-axle GM truck, with a rear steel bed with plywood and steel sides. A steel partition was located just behind the cab of the vehicle. A canvas tarpaulin covered the rear of the vehicle and its contents when travelling.

The AECL vehicle sustained major damage, some as the result of the impact with the other vehicle, the rest from when it overturned. The cab of the vehicle was crushed, with the fibreglass and steel body being badly damaged. The plywood and steel rear was smashed completely, with pieces being scattered along both sides of the highway. The steel bed was slightly twisted, but otherwise undamaged. The steel partition was badly bent when the vehicle overturned. One of the two rear tires on the driver side was completely torn off. With the vehicle on its side, a small amount of diesel fuel leaked out of one of the fuel tanks.

Damage to the Packages

The F-334/F278 carrying Xe-133 was secured at the front of the vehicle. It was the tallest of the packages. The

F-334 performed as designed. The outer fibreglass shell and honeycomb filler crushed and protected the inner steel cylinder. There was no damage to the thermal protection, nor was there any damage to the inner, F-278 shielding, and containment vessel. The F-278 was later transferred to another F-334 overpack and sent to NII.

The F-279 carrying Mo-99, was secured behind the F-334 Overpack. It was the shortest of the three packages. Its cylindrical steel outer container suffered a minor scrape. The steel skid on which the flask sat, was slightly bent. The tie-downs kept the package firmly secured to the bed of the vehicle. There was no loss of contents. This package was transferred to CRL, where its contents were transferred to another, similar flask, which was shipped to NII the day after the accident. After repairs, the flask was later returned to service.

The F-271 carrying Sm-153, was secured at the back of the vehicle behind the F-279 package. Its outer crush and fire shield assembly received minor damage when the vehicle overturned. The tie-downs kept the package firmly secured to the bed of the vehicle. There was no loss of contents. The package was transferred to CRL where its contents were transferred to another, similar flask, which was later shipped to NII the day after the accident. After repairs, the flask was later returned to service.

Damage to the Other Vehicle Involved

The other vehicle involved, a tractor trailer carrying steel, received some superficial damage along the driver's side as the result of the collision.

ASSESSMENT OF THE EFFECTIVENESS OF THE RESPONSE TO THE ACCIDENT

A series of meetings were held after the accident, to assess the effectiveness of the response to the accident. The focus was to assess what went right, either by design or through fortunate circumstances, as well as what went wrong due to lack of design or unfortunate circumstances.

What Went Right (by Design)

The packages carrying the material played a very important role in ensuring that the contents carried do not escape.

All three containers carried at the time of the 1994 March 22 accident were licensed Type "B" packages. They were designed in accordance with IAEA (International Atomic Energy Agency) Safety Series No. 6. This standard includes drop and fire tests requirements designed to simulate the accident conditions of transport. It is significant to note that, with the exception of the F-334 overpack, not only did the packages survive the accident, they were returned to service a short time later. (The F-334 overpack could not be salvaged. It was designed to be expendable in the event of a serious accident)

What Went Right (Fortunate Circumstances)

There were a number of fortunate circumstances surrounding the accident.

The accident itself occurred about 15 km from the CRL site. Consequently, there were knowledgeable people close by who could respond in short order. Equipment was readily available and was on the scene very quickly.

The accident occurred in a rural area. There were no people, houses or business premises needing evacuation.

The temperature was mild, with a little snow on the ground. Many of those who responded to the accident were on the scene for several hours.

The accident occurred at approximately 1940 hours, which coincided with a shift change at CRL. As a result, many AECL-CRL personnel arrived on the scene almost immediately. Off-duty firemen provided emergency first aid to

the injured driver. An off duty Radiation Protection Branch Radiation Health surveyor helped assess the situation, providing valuable information to those people at the scene until the response team members arrived. Another off-duty person called Protective Services, who initiated the emergency response plan. Still others helped with traffic control and information transfer.

The tie-down devices did not fail during the accident. Tie-downs are designed to the requirements of ANSI N14.2, to withstand the loads during normal transport conditions, not accident conditions.

No fire resulted from the accident. While the packages are designed to survive such conditions, had there been a fire,response actions would have been more complicated and prolonged.

The ambulance staff who responded to the call were returning from a previous call and were on the scene in minutes. This allowed the injured driver to be transported to hospital very quickly.

The AECL driver was the only casualty. There were no other vehicles in the immediate vicinity, although several arrived on the scene shortly afterwards.

One of the motorists who came upon the scene, had a cellular phone which was used by others at the scene to make several crucial calls.

Deficiencies (Current Plan)

During the post-accident meetings, a number of items were identified as being absent from the current emergency response plan.

In trying to get to the scene, emergency response personnel had to pass long lines of traffic and OPP officers manning the roadblocks. Had special escorts been pre-arranged, the responding people could have been on the scene earlier. While not a big problem for this accident, it was felt that had circumstances been different (e.g., different location, time, etc.), it could have created serious problems.

Related to this was the fact that emergency response personnel did not carry any official identification, and this hindered access to the accident scene.

There was no cache of radiation monitoring equipment readily available outside the CRL site for use in the event of an accident.

The emergency response personnel had no dedicated communication equipment or lists of phone numbers available in the event of an emergency. Fortunately, a passerby did have a cellular phone which was used to make the initial calls.

There was no dedicated emergency response vehicle available to serve as a base for the response activities.

What Went Wrong (Unforeseen Circumstances)

A number of unexpected occurrences were identified, that could have affected the response efforts.

Unfortunately, the ambulance drivers had not received any training in dealing with accidents involving radioactive materials and were initially apprehensive when attending to the injured driver. Similarly, hospital staff were unsure. Fortunately, qualified AECL people at the scene, and later at the hospital, were able to explain and assure medical staff of the lack of radioactive contamination.

The accident happened in an area where Canadian Forces Base personnel from CFB Petawawa were conducting

exercises. On this particular night, military helicopters were in the area. Shortly after the accident, a helicopter arrived and tried to help those below by hovering above and shining a spot light on the scene. Fortunately there had been no radioactive release during the accident and therefore no contamination spread resulted from the helicopter downdraft.

CONCLUSIONS

In considering what went right and what went wrong, as well as the circumstances that night, several conclusions were drawn:

- The response plan was effective, but it did require improvements in several areas.

- Judging from the difficulties encountered with non-AECL emergency response personnel the night of the accident, that there is a need to establish and maintain a permanent liaison with those personnel regarding radioactive materials shipments in this movement corridor. Training sessions may be needed.

- Caches of dedicated response equipment that can be taken to the scene at short notice are required at places off the CRL site. This equipment should include, among other things, clothing and radiation monitoring equipment.

- There is a need to improve methods of getting the response team to the accident scene quickly, safely and in a coordinated fashion.

- Human factors surrounding accidents involving serious injuries need to be considered. This includes counselling for the victim's family, as well as others who may have been traumatized by the accident.

REMEDIAL ACTIONS

To address the deficiencies, a number of remedial actions have been identified, some of which have already been addressed, the remainder of which are in the process of being addressed.

Remedial Actions Taken to Date

The emergency response plan in place at the time of the accident has been reviewed and revised to incorporate many of the changes required. The plan will be reviewed regularly with input being sought from a wide variety of AECL-CRL staff, including the response team members.

Calls have been made to various groups around the area, including the OPP and the hospitals in an effort to improve communications and establish or re-establish a liaison with them. This liaison will continue to be developed.

A list of telephone numbers to call in the event of an aecident has been provided to response team members.

Remedial Actions Still to be Taken

Identification cards for response team members will be issued shortly.

Counselling for victims and their families and for response personnel, in the event of an accident is being arranged.

A Mobile Command Centre, which will house equipment to be used when responding to an emergency, has been ordered and will be delivered in early 1995.

FINAL COMMENTS

Hopefully accidents, especially serious ones such as this one, will not happen frequently. Equipment and training must be provided and plans must be reviewed and updated regularly, to minimize the consequences of such occurrences. The existing plan worked well although the fortunate circumstances at the time of the accident, and the role that these played is acknowledged.

ACKNOWLEDGEMENTS

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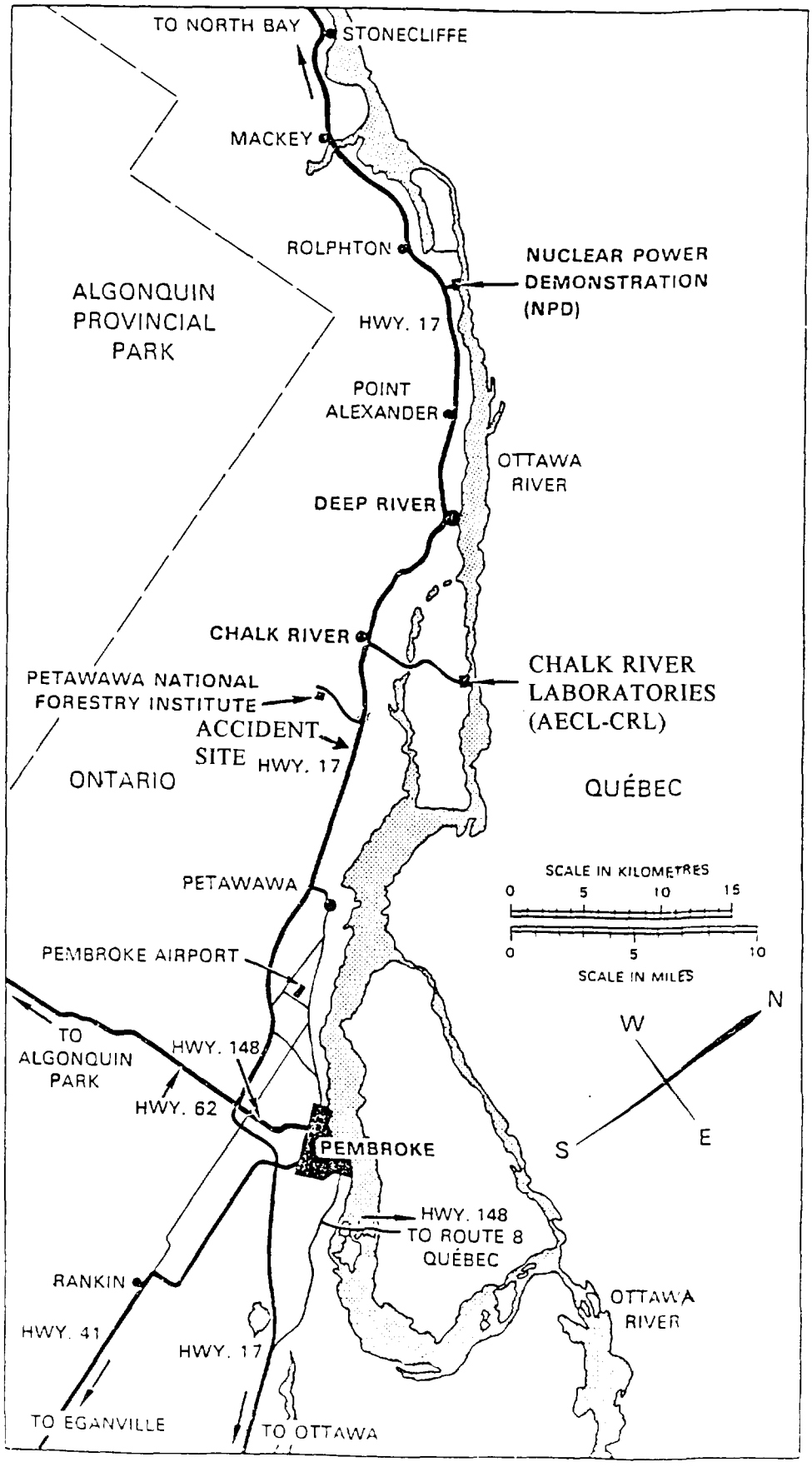

FIGURE 1

Location of AECL-CRL

Radioisotopes Produced in NRU and Their Uses

Molybdenum-99

Used for nuclear diagnostic imaging - substance is injected into patient attached to a compound that will travel to target area, such as the heart, and images are created by monitoring the activity from outside the patient. Almost every organ in the human body is scanned using Mo-99's daughter product, Tc-99m (Technicium). Bone scans are another common use. Physician's use the scans to detect cancer, infections, abnormalities, to test the function of organs, and many other uses. Mo-99/Tc-99m is used in more than 2/3 of all nuclear diagnostic procedures, over 10 million tests worldwide annually.

Iodine-131

Used for both diagnosis and therapy of thyroid problems such as hyperthyroidism and thyroid cancer.

Iodine-125

Used for laboratory (in-vitro) tests of human blood, urine, semen, etc to detect a wide variety of diseases, drugs and antibodies for cancer detection. Widely used - an estimated 300 million tests annually worldwide!!

Xenon-133

A radioactive gas used to scan the lungs to detect blood clots, cancer and test their function.

Samarium-153

A bone palliation agent - injecting the material alleviates the pain associated with terminal bone cancer.

Co-60

Used for cancer therapy together with a cancer therapy machine that directs and times the beam. The gamma radiation from the Cobalt-60 is directed at cancerous tissue to kill the tumour cells. Cobalt therapy is credited with approximately half of all cancer cures. Approximately half a million people are treated annually around the world.

FIGURE 2

Radioisotopes Produced in NRU Research Reactor and Separated at AECL-CRL