AECL-7901

ATOMIC ENERGY OF CANADA LIMITED

L'ÉNERGIE ATOMIQUE DU CANADA LIMITÉE

FOLLOW-UP OF AECL EMPLOYEES INVOLVED IN THE DECONTAMINATION OF NRU IN 1958

Suivi des employés de l'EACL ayant participé à la décontamination du NRU en 1958

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Résumé

En mai 1958, le hall du réacteur NRU a été sérieusement contaminé par une barre de combustible endommagée qui s'est brisée lorsqu'elle a été déchargée du réacteur. Des produits de fission radioactifs ont été projetés dans le hall du réacteur et dans les zones adjacentes lorsqu'une section de la barre de combustible est tombée dans la fosse de maintenance où elle a brûlé. Des employés de l'EACL et d'autres personnes ont mis deux mois et demi pour effectuer la décontamination du NRU. On donne, dans ce rapport, les résultats d'une étude en suivi des employés de l'EACL ayant participé à cette décontamination. Aucune augmentation, importante statistiquement, n'a été relevée en ce qui concerne le nombre de décès dus au cancer ou autre maladie chez ces employés.

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ABSTRACT

In May 1958 the NRU reactor hall was badly contaminated by a damaged fuel rod that broke apart during its removal from the reactor. Radioactive fission products were spread around the reactor hall and into adjacent areas when a piece of the fuel rod fell into the maintenance pit and burned. AECL staff and others completed the decontamination in 2½ months. This paper reports the results of a follow-up study of the AECL participants. No statistically significant increases in deaths from cancer or other diseases were found in this group.

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1. INTRODUCTION

The NRU reactor had been in intermittent operation for about six months when a trip occurred on 1958 May 23. Alarms indicated high radioactivity in the coolant circuit (1). The cause of this radioactivity was eventually traced to the rupture of the aluminium sheath of one of the fuel rods due to "waterlogging" of the fuel (2). The contamination of the reactor hall and some of the adjacent area occurred when the attempt was made to remove the damaged rod from the reactor vessel.

The rod removal procedure that was followed had been used successfully on previous occasions. However, this time the guide tube of the rod removal flask jammed on the damaged rod and a modified system had to be used. The damaged fuel rod then stuck part way up the removal flask, the coolant was lost and could not be replaced. The fuel probably began to burn at this point. The rod removal flask carried on toward the storage bay and some debris from the rod dropped on top of the reactor. A three-foot section of the rod fell into the maintenance pit where it burned.

Some of the highest exposures of personnel occurred when wet sand was thrown on the burning fuel rod in the maintenance pit and during the subsequent removal of the rod with some of the sand to the active waste dump the next day (1). The radiation fields were at least 1000 R/h above the maintenance pit and on top of the reactor. The fire was put out in about 15 minutes. The highest recorded exposure was 5.3 rem (1). The next day the burned

segment had to be removed to decrease the radiation fields. A special tray was constructed to hold the segment. A team of about 35 men using long-handled tools, the overhead crane and a specially shielded flat bed trailer loaded the tray and hauled it to the waste disposal site. The average dose was 1.4 rem with the highest being 6.4 rem for this operation (1).

To reduce radiation fields further, about 40 men whose jobs did not normally involve exposure to radiation were brought in to clean up the debris and the remainder of the contaminated sand from the maintenance pit (3). This operation resulted in the most serious over-exposures of the entire clean-up. Prior permission had been given for exposures of up to 5 rem for these people (1). Time was to be restricted to 1.5 minutes per man - radiation fields were about 200 R/h - but 14 men exceeded the 5-rem limit; of these, 11 were under 6 rem, 2 were about 10 rem and 1 man received 19 rem (1). After this phase of the clean-up, radiation fields in most areas were reduced to a few R/h.

The following week was spent in organizing the decontamination process and in assessing the extent of the problem. In contrast to the 1953 operation in NRX when the reactor was essentially dismantled and rebuilt, this operation was now a straight-forward decontamination operation. Up to June 6 the work was carried out by about 300 AECL staff. At this time normal radiation dose limits (0.3 rem/week) were re-imposed on AECL staff, and military and civil defence personnel were asked to help (1). They were to be allowed exposures of up to 5 rem. One person exceeded this limit by 0.02 rem, 11 exposures were between 3 and 5 rem and all others were below 3 rem. The cleaning of the walls and high areas of the reactor hall was done by a commercial cleaning company from Ottawa (1).

2. SOURCE OF PARTICIPANTS

As in the 1953 clean-up operation, the majority of the people who took part in the NRU decontamination in 1958 were AECL staff. An effort was made to use, wherever possible, staff whose duties

did not normally involve exposures to radiation. The reactor staff did, however, carry out the early stages of the decontamination themselves.

Table 1 gives the affiliations and numbers of the people involved. From inter-branch memoranda and other sources a list of participants has been prepared. Of the total of about 1200 participants 832 were AECL staff. For eight of these only surnames, initials and badge numbers were available. No other information could be found to indicate that these people were employed by AECL. These names may, in fact, be the result of typing errors in the original lists. A further 13 people who are not readily traceable were attached staff from India, the United Kingdom and the United States. Eight hundred and eleven people were identifiable and potentially traceable AECL staff. Approximately 50 of this group were short-term employees who were hired for a two-month period to work in the clean-up operation.

TABLE 1

Affiliation and numbers of NRU decontamination workers

AECL	Military	Civil Defence	Other
832	∿300	16	29

The remaining participants were from a variety of sources. Two weeks after the accident the Canadian military services were asked to help. CRNL has records of about 300 armed services personnel who were here in June and early July. The Department of National Defence is assisting in the accumulation of personal identifying information on these people so they can be included in the AECL Health Study (4). Sixteen of the participants were from the Civil Defence Unit at Arnprior, Ontario. We have been unable

to obtain personal identifying information on these individuals. This was also the case with the 29 employees of a commercial cleaning company who were responsible for the final cleaning of the high areas of the reactor hall.

3. RADIATION EXPOSURES

Exposure records have been kept at Chalk River since 1945. The records are complete from 1956 February. No attempt has been made to separate the exposures accumulated during the decontamination of NRU from the doses recorded for normal work at the same time. Hughes and Greenwood (1) reported the distribution of doses greater than 100 mrem received from 1958 May 24 to June 29 - the period when most of the work in high radiation fields was done. From this table it can be calculated that 800-900 man-rem were required for the operation up to that time. Internal CRNL memoranda indicate that about another 300 man-rem were required before reactor start-up in August. The total is less than half that required for the 1953 NRX clean-up. The total received by non-AECL employees was approximately 300 man-rem, the remaining 800-900 man-rem being received by the 832 AECL employees involved in the clean-up operation.†

There were some cases of internal contamination especially in the early days of the operation. Much of it was subsequently traced to improper use of the respirators (1,3). However, doses associated with these internal contaminations were far below regulatory limits and were considered negligible (1). Although not formally required, the exposures of three persons with whole

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†Note that radiation doses were measured in R rather than rem. As noted elsewhere (5), there is good reason to believe that the radiation doses recorded in the 1950's are about two times higher than would be currently recorded using improved radiation dosimeters. However, for reasons of prudence the 1958 dose records have not been corrected and are accepted as actual doses in rem.

body doses of 10-19 rem and ten persons with high concentrations of radioiodine in bioassay samples were reported in 1958 by CRNL medical authorities to the Workmen's Compensation Board. Of the eleven people in this group who remained with AECL and who were therefore traceable, all were still alive in May 1982.

4. MORTALITY

The methods employed to trace the participants in the 1958 clean-up are described elsewhere (5,6). 274 of the 832 clean-up workers left the employment of AECL in later years. The remaining 537 stayed with the company and were either still employed, had retired from AECL or had died before 31 December 1980. With the assistance of the Computer Records Office and the Office of the General Manager, Plant Administration and Operations, all these people have been traced. One hundred and six deaths have occurred in this group to 1980 December 31, the remaining 431 persons being alive at that date. Causes of death for deaths occurring before the end of 1979 were obtained from the Canadian Mortality Data Base at Statistics Canada in Ottawa (7), and for those deaths occurring in 1980, from records at the Office of the Registrar General for Ontario in Toronto. Expected death rates are based on the general male population of Ontario (8).

Table 2 gives the observed and expected figures for the major causes of death for the group that remained with AECL. The predicted number of deaths for this group based on the male population of Ontario was 101.8. Deaths both from cancer (24 compared with 22.5) and from cardiovascular diseases (56 compared with 51.3) were slightly higher than expected. Neither of these differences is statistically significant (9).

The occurrence of some cancers is of more interest than others because they are known to be associated with exposure to ionizing radiation. Leukemia and cancers of the lung, thyroid and breast were found in excess among survivors of the bombings in Japan (10,11,12). Excesses of other types, such as pancreas and

TABLE 2

Mortality among 537 AECL participants in the 1958 NRU clean-up

Cause of death	Observed	Expected	SMR*
Cancer	24	22.5	1.07
Cardiovascular diseases	56	51.3	1.09
Accidents and other external causes	9	11.2	0.80
All other causes	17	16.7	1.01
All causes	106	101.8	1.04

* SMR is the ratio of observed to expected deaths.

multiple myeloma, have been reported in some studies of radiation workers (13,14,15). The predominant cancer in the AECL group was that of the lung: 7 observed, 6.2 expected. There were 2 deaths from pancreatic cancer† (1.1 expected). None of the deaths to the end of 1980 were from multiple myeloma or leukemia (0.3 and 0.8, respectively, were predicted). However, 2 deaths were from cancers of the lymphatic and haematopoietic system other than multiple myeloma or leukemia (expected 0.8).

† The expected figures for cancer of the pancreas and multiple myeloma are based on Canadian statistics. Because the Province of Ontario publishes the causes of death using the A code, which is a combination of certain ICD codes to form larger groupings, actual numbers of deaths from these two cancers are not available for Ontario.

Figure 1 shows the cumulative number of deaths by age for cancer and non-cancer deaths: graph A before age 65, graph B after age 65. Deaths from all types of cancer were close to expected values. There would appear to be no increase in cancer mortality in old age from delayed effects of occupational exposure to ionizing radiation. Non-cancer deaths showed no increase before age 65 but were slightly higher than expected after age 65.

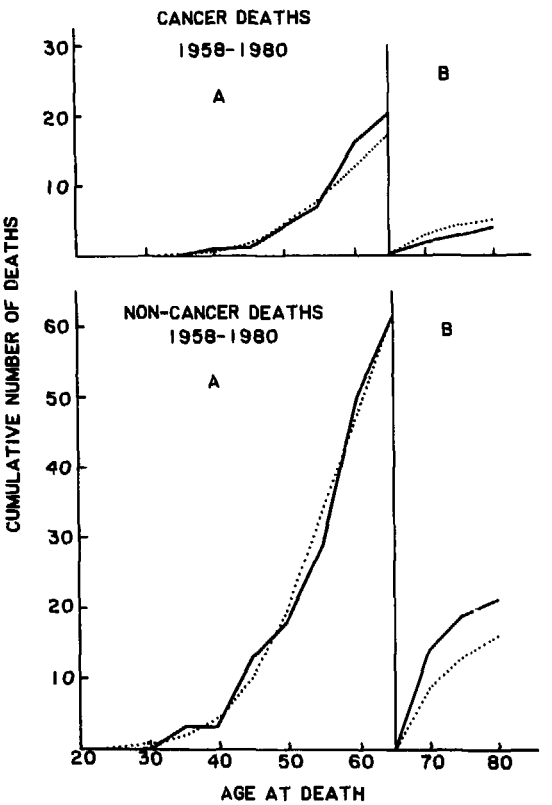

Figure 1. The cumulative number of deaths by age at death before and after age 65 for long-term AECL employees who participated in the NRU clean-up. The dotted lines are the expected numbers of deaths and the solid lines the observed numbers of deaths. The upper graphs are for cancer deaths, and the lower graphs are for non-cancer deaths.

The standardized mortality ratios (SMR) for the group that remained with AECL are also shown in Table 2. With the exception of accidents and external causes of death, these values are those expected for the general population. This is in contrast to the SMR's for the 1953 clean-up, where all values except that for cardiovascular diseases were less than 1.0 (5). SMR's for cancer, cardiovascular diseases, accidents and all other causes of death for the 307 male Chalk River Nuclear Laboratories employees who died between 1966 and 1980 were all less than 1.0 (6).

Table 3 shows the observed and expected values for mortality if all traceable AECL employees who worked in the clean-ups of both NRX and NRU are considered as a single group. These figures have been corrected to make allowance for the fact that 194 persons participated in both clean-ups. There were 207 deaths in

TABLE 3

Mortality among 905 AECL participants of NRX and NRU clean-ups considered as a single group

Cause of death	Observed	Expected	SMR
Cancer	45	47.6	0.94
Cardiovascular disease	114	112.9	1.01
Accidents and other external causes	17	21.0	0.81
All other causes	31	36.0	0.86
All causes	207	217.5	0.95

the combined group when 217.5 were expected; of these deaths 45 were from cancer when 47.6 were predicted. Standard mortality ratios for this group are also shown in Table 3.

A separate calculation has also been carried out for the 194 persons who participated in both clean-up operations in 1953 and 1958 (Table 4). The total number of deaths observed to the end of 1980 was 39 whereas 40.3 would have been expected based on statistics for males of the same age in the general population of Ontario (SMR = 0.97). There was no excess of cancer deaths in this group (7 observed, 8.8 expected).

TABLE 4

Mortality among 194 long-term AECL staff who participated in both the 1953 and 1958 clean-ups

Cause of death	Observed	Expected	SMR
Cancer	7	8.8	0.79
Cardiovascular diseases	26	20.3	1.28
Accidents and other external causes	2	4.7	0.42
All other causes	4	6.5	0.61
All causes	39	40.3	0.97

The remaining 274 participants in the 1958 NRU clean-up left AECL sometime after 1958 August to work elsewhere. The only readily available source of mortality data on this group is the Canadian Mortality Data Base. From a manual search for members of this group we obtained recorded deaths up to the end of 1979. Any member of this group who left Canada and subsequently died would not be recorded and hence would not be found. Table 5 indicates the numbers and distribution of the deaths found for this group. No expected figures or SMR's are given for this group as it is improbable that all deaths have been located.

TABLE 5

Causes of death among participants who left AECL to work elsewhere

Cause of death	Observed
Cancer	2
Cardiovascular diseases	16
Accidents and other external causes	3
All other causes	3
All causes	24

With only 106 deaths having occurred among long-term AECL employees who participated in the 1958 clean-up no attempt has been made to examine cause of death in relation to occupational exposure to radiation. It is expected that this type of analysis

will be done by the National Cancer Institute of Canada as part of the long-term study of all AECL employees now underway (4). Again as in the 1953 operation, the total cost of the clean-up in man-rem would be insufficient according to current risk estimates to cause a single fatal cancer (16,17,18).

ACKNOWLEDGEMENTS

The authors wish to thank M.E. Smith and her staff at the Vital Statistics and Disease Registries Section, Health Division, Statistics Canada, for assistance in using the Mortality Data Base and E.W. Pike for the use of death records in the Office of the Registrar General of Ontario. We are also grateful to the many people from the Chalk River Nuclear Laboratories who helped in the collection of data for this report: especially G. Cowper, R.M. Holford, R.M. Rondeau, J.M. Vincent, A. Lemke, M.M. Hanlon, C. Lamb, J.H. Collins, M. Myers, D.W.S. Evans, N. Oelke, and D. Peplinski.

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