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L'ÉNERGIE ATOMIQUE DU CANADA LIMITÉE

LOW- AND INTERMEDIATE-LEVEL WASTE MANAGEMENT PRACTICES IN CANADA

Pratique de la gestion au Canada des déchets de faible activité et d'activité intermédiaire

D.H. CHARLESWORTH

Paper presented at ANS Topical Meeting on the Treatment and Handling of Radioactive Wastes,
Richland, WA, 1982 April 19-20

Chalk River Nuclear Laboratories   Laboratoires nucléaires de Chalk River

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Résumé

Les déchets à faible activité et à activité intermédiaire proviennent au Canada du fonctionnement des centrales nucléaires, des établissements de recherche nucléaire, du combustible nucléaire, des installations de production des radioéléments ainsi que de nombreux organismes scientifiques, médicaux et industriels. Essentiellement, tous les déchets radioactifs solides sont stockés de façon récupérable dans cinq zones de gestion des déchets dont une partie devrait être transférée dans de futures installations d'évacuation. Le traitement des déchets en vue de leur réduction en volume et de leur stabilisation est en train de devenir une partie de plus en plus importante de la gestion des déchets de faible radioactivité à cause des avantages qu'il fournit actuellement pour le stockage intérimaire et dans le futur pour l'évacuation permanente.

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LOW- AND INTERMEDIATE-LEVEL WASTE MANAGEMENT PRACTICES IN CANADA

by D.H. Charlesworth

Atomic Energy of Canada Limited Research Company
Chalk River, Ontario, Canada

ABSTRACT

Low- and intermediate-level wastes arise in Canada from the operation of nuclear power stations, nuclear research establishments, nuclear fuel and radioisotope production facilities, as well as from many medical, research and industrial organizations. Essentially all of the solid radioactive wastes are stored in a retrievable fashion at five waste management areas from which a portion is expected to be transferred to future disposal facilities. Waste processing for volume reduction and stabilization is becoming an increasingly important part of low-level waste management because of the advantages it provides for both interim storage currently, and permanent disposal in the future.

INTRODUCTION

The management of low- and intermediate-level nuclear waste began in Canada with the operation of the NRX reactor at the Chalk River Nuclear Laboratories (CRNL) in the late 1940's. Since then, the sources of such wastes have multiplied and now encompass ten CANDU nuclear power reactors (14 more are under construction), two federal nuclear research and development establishments, several nuclear fuel and radioisotope production facilities, and about 2000 medical, research, and industrial organizations which use separated radioisotopes or small research reactors.

The types of radioactive waste generated by the institutional and industrial organizations are much the same as in other developed countries. Radioisotope production is relatively a more important source of wastes in Canada since we supply about 60 percent of the total world market for processed reactor isotopes. The low- and intermediate-level wastes arising from the operation of our power reactors have somewhat different characteristics which result from the nature of the CANDU reactor compared to light-water reactors (LWRs). Because CANDU reactors are moderated and cooled by heavy water, particular care is taken to reduce leakage from the systems and to reclaim that which does leak for return to the circuits.

As a result, the amount of aqueous wastes containing significant concentrations of radioactivity arising from their operation is much smaller than from an equivalent LWR station. The amount and nature of solid wastes produced are similar in the two types of reactor except that there is more tritium and carbon-14 in the CANDU wastes.

The reprocessing of irradiated fuel was done only on a small scale in Canada, and except for research activities, was ended before 1960. Uranium refining and fuel fabrication are, however, continuing sources of wastes on a commercial scale. Wastes containing natural radionuclides which arise from mineral exploitation are an additional important source, but their management will not be discussed in this review.

CURRENT WASTE MANAGEMENT PRACTICES

All radioactive waste management facilities in Canada are licensed by the Atomic Energy Control Board. The current operating licenses, of which there are eleven, are issued on the basis of interim storage only, not disposal. Thus, operating techniques make allowance for a potential waste retrieval step which may be required in the future if the wastes cannot be considered to have decayed to a nonradioactive state by the time the interim-storage period has elapsed. The Board has stated [1] that the extension of interim storage beyond about 50 years is not appropriate.

WASTE STORAGE AT NUCLEAR RESEARCH SITES

The radioactive wastes generated at CRNL have always been managed on-site, and since the Laboratories were the major source of wastes in Canada for many years, the management methods adopted there have often set the pattern for waste management in Canada. In the early 1950's much of CRNL's low- and intermediate-level wastes, both liquid and solid, was disposed into dune sand above the water table. The relatively poor radionuclide retardation properties of the soil (strontium-90 moves at about 3% of the groundwater velocity), although adequate to restrict releases through local surface waters to acceptable levels, has allowed sufficient migration to contaminate adjoining overburden. To reduce the spread of contamination and to ease the handling of wastes which exhibited significant gamma-radiation fields methods were developed in which all but the lowest category of waste were emplaced in near-surface containment structures, usually of reinforced concrete.

However, since the integrity of the concrete containment could not be guaranteed for as long as some of the wastes would remain hazardous, continued surveillance, maintenance, and land-use control was expected to be necessary for an indefinite period. One facet of this approach which gradually gained emphasis [2] was that the wastes may need to be retrieved and transferred either to new storage structures or to permanent disposal. As mentioned earlier, this management philosophy of retrievable storage was adopted as a policy by the AECB and is the current Canadian practice for all nuclear wastes not suitable for dispersal.

At CRNL all of the waste structures have been located in unsaturated dune sand with their tops near the ground surface and their bases at least one metre above the water table. Various designs have been used [2] but current practice has standardized on vertical reinforced-concrete cylinders ranging from 0.15 to 6 m inside diameter and 3.6 to 5.4 m deep. Each is fitted with a removable weather-proof cap.

Roughly 12 000 m^3 of solid waste, which originally contained an estimated 0.1 Ci/m^3 (4 GBq/m^3) or greater of activation or fission products, or a significant concentration of actinides, are stored in concrete containment at CRNL. Although most of these wastes arose from the activities at the Laboratories a significant fraction has been received over the last 35 years from other Canadian sources. These include the nearby 25 MWe prototype Nuclear Power Demonstration (NPD) reactor, radioisotope producers and users, and nuclear fuel manufacturers. Some of the wastes from radioisotope users are accumulated at centralized temporary storage facilities before being shipped to CRNL.

Solid wastes of lower hazard have been buried directly in the sand without additional protection. This practice of shallow burial is gradually being discontinued at CRNL and, except at AECL's other research site, the Whiteshell Nuclear Research Establishment (WNRE), it is not currently used elsewhere in Canada for reactor-generated wastes.

During the last 30 years approximately 2 x 10^6 m^3 of low-level aqueous wastes have been discharged into seepage pits in a sand knoll at CRNL. Although the sand has only modest retention capacity for dissolved radionuclides, only a small fraction of the cationic radionuclides has migrated beyond the knoll. Extensive monitoring combined with environmental research has been underway for many years in the vicinity of the waste management areas [3]. Although radioactivity releases via the stream which drains the area have remained below 0.1% of the Derived Release Limits (DRLs) [4], direct discharges of liquid wastes to the soil are to be reduced to small values within the next two years through the use of waste processing facilities.

A waste management area has been operated at the WNRE site of AECL in Manitoba for about 15 years, primarily for wastes generated on the site. The techniques used for solid-waste storage are similar to those used at CRNL but modified to suit the different hydrogeologic conditions. The overburden is primarily a clayey till in which the water table is within 1 to 2 m of the surface. Extensive hydrogeological studies [5] have shown that the operations are centred in a groundwater discharge area. Thus, groundwater flow opposes any downward dispersion of radionuclides from the facilities.

The amount of aqueous wastes generated at WNRE has been sufficiently small that its discharge to the Winnipeg River amounts to only a small fraction of the DRL. However, since there has been an increasing trend in recent years, preparations have been made to process the most contaminated waste stream to retain the radionuclides.

WASTE STORAGE BY NUCLEAR-ELECTRIC UTILITIES

The largest waste storage operation in Canada is the centralized facility of Ontario Hydro at their Bruce Nuclear Power Development (BNPD). This facility receives about 3000 m^3 per year of low- and intermediate-level solid wastes from the five reactors already operating on the site and the four Pickering A reactors 250 km away. Carter has recently described [6] the radioactive waste management practices of Ontario Hydro, including the handling of the liquid and gaseous wastes within the generating stations. The solid wastes, which have been characterized by Buchnea and Spooner [7], range in specific activity from essentially zero for much of the trash to about 35 mCi/kg (1.3 GBq/kg) for the ion-exchange resins. The latter value does not include the carbon-14 content which may range up to 200 mCi/kg (8 GBq/kg) in the resins from the moderator circuits.

At the Radioactive Waste Operations Site, which has been in use by Ontario Hydro since 1974, several types of concrete containment structures have been used based on the handling requirements of the various packages [8]. Initially, the low-level wastes, which are usually packaged in clear polyethylene bags and do not require shielding during handling, were stored in large concrete-lined trenches set in the ground. Wastes with significant radiation fields such as ion-exchange resins or filter canisters were unloaded from flasks directly into waterproof "tileholes", concrete pipes set vertically on a foundation pad in the ground with the top opening almost flush with the ground surface. The tileholes and trenches are well above the water table and are fitted with an under-drain system leading to a monitored and controlled discharge. With experience, containment-structure design has evolved, the current trend being to construct the storage facilities above ground rather than buried. The latest facilities, a prestressed, prefabricated concrete storage building [9] scheduled to be in service late in 1982, will reduce the cost of storing low-level wastes by a factor of three while reducing land consumption by a factor of ten compared to in-ground trenches.

At other waste management sites located at nuclear power stations the storage structures have also been adapted to suit local conditions. At the Gentilly site of Hydro Quebec, since the water table was at shallow depth, the concrete trenches and storage blocks have been built in raised earth mounds. At Pt. Lepreau, the coastal site of the New Brunswick Electric Power Commission, there is little overburden and the storage blocks and bunkers are built on the bedrock, completely above ground.

TRENDS IN CANADIAN WASTE MANAGEMENT

WASTE PROCESSING

Waste processing before storage has become an increasingly important part of low-level waste management [10]. The immediate objectives are volume reduction and stabilization to improve the storage operations. However, as the studies of disposal strategies have developed, the benefits of specifying waste processing procedures which will fit the eventual needs of disposal have been recognized. Since 1977 Ontario Hydro has been operating a Waste Volume Reduction Facility at its Bruce storage site. Solid wastes are segregated at their source into three categories, incinerable, processible, and nonprocessible. The wastes in the first two categories are either incinerated or compacted, and then put into storage in volume-efficient rectangular packages. The nonprocessible waste is stored in its original transport packaging. In 1980, 2800 m^3 of waste was burned in the batch-loaded controlled-air incinerator to give an average gross volume reduction factor of 40:1 [6]. In the same year 1025 m^3 of waste was compacted into 210-litre drums. Although the gross volume reduction factor for the compaction was over 4:1, the net result because of the voids between drums was a factor of only 2.5:1 in storage. Since then, a baler has been installed which, because of higher compaction forces and a rectangular package shape, achieves a net factor up to 6:1 in storage. Considerable space in the storage structures has been reclaimed by retrieving that waste which had been stored before the processing facility was available, processing it, and replacing the volume-reduced waste back into storage.

AECL is in the late stages of constructing a Waste Treatment Centre to condition CRNL's low-level waste [11]. It comprises an incinerator [12] and baler for solid wastes, an ultrafiltration and reverse-osmosis system [13] for the concentration of aqueous wastes, and equipment for incorporating the ash and the solids from the waste concentrates into a bitumen matrix [14]. The conditioned wastes will thus be in a stable, compact, leach-resistant form which is suited for both storage and disposal.

Some in-plant experience has been obtained. The incinerator is similar but smaller than the Ontario Hydro installation and has received a number of modifications during its inactive commissioning [11]. It is now operating routinely on low-level waste. The wiped-film evaporator used as the CRNL pilot-plant bituminizer has been temporarily installed at the Douglas Point G.S. where it has solidified accumulated decontamination solutions [15]. The bituminizing system, which is currently being constructed in the CRNL Waste Treatment Centre, is described in detail in a separate paper [16] to be presented at this Meeting. As well as being capable of immobilizing aqueous wastes and incinerator ash in a bitumen matrix the system can also process ion-exchange resins [17].

At WNRE an Active Liquid Waste Treatment Centre has been built to concentrate and solidify the intermediate-level aqueous wastes coming from the fuel recycle development program. The system, commissioning of which is nearly complete, uses a rising-film evaporator to produce a waste concentrate which is immobilized in a polyester resin matrix.

Tritium is an important contaminant in both solid and aqueous wastes arising from the operation of a CANDU reactor. Tritium in the form of the oxide HTO is not retained during normal waste processing, but rather is dispersed with the off-gases, condensate, or permeate. Reduction in these tritium releases is one of the benefits if a tritium removal process is coupled to the heavy water circuits of the reactor. Such a system is being installed at the Ontario Hydro Pickering A/B Generating Stations [6]. The separated product will be high-specific-activity molecular tritium which can be immobilized effectively as a metal tritide [18] for either storage or disposal.

STRATEGY FOR DISPOSAL

Another aspect of waste management procedures which is being considered as an aid to future disposal strategies is the characterization and segregation of wastes according to a measure of their hazardous lifetime [19]. Some components of the spectrum of low- and intermediate-level wastes have hazardous properties which vary widely in their duration. Wastes in which the predominant radionuclide is cobalt-60 may no longer be hazardous after 50 to 100 years. Thus, storage under surveillance for this period may need to be followed only by disposal as inactive material. However, those waste components in which longer-lived nuclides such as cesium-137 and carbon-14 are important will need disposal by techniques which provide containment and isolation for long periods for which institutional control is not appropriate. If these various components of the waste population can be segregated they can be matched to an optimal selection of disposal concepts; if they are not segregated, then any disposal concept that is proposed for use must be adequate for the most limiting component.

CONCLUSIONS

Retrievable storage of low- and intermediate-level wastes in Canada is expected to continue as an acceptable management operation for some time. Volume-reduction processes and improved characterization are expected to play an increasingly important role. Immobilization processes are also likely to be applied to some categories of waste in preparation for their eventual retrieval from storage and transfer to disposal facilities.

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