SEA DISPOSAL EXPERIENCE OF THE NETHERLANDS

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INTRODUCTION

Sea disposal of low and intermediate level radioactive wastes (LLW/MLW) has always been a practice on which goverments of different countries held quite different views. The Netherlands have participated in sea disposal operations in the frame of OECD/(E)NEA organization since the first international test-disposal was carried out in 1967 and had carried out some very limited dumpings on its own from 1965 on. In order to show that the radiological impact of a disposal practice as foreseen would be minimal, a hazard assessment was made based on a simple model for transprot of radionuclides[1] and some recommendations were given for the containers to be used. Various countries opposed the initiative and in order to clarify matters a special meeting was arranged and held in Lisbon in 1966. However, the views of both sides did not change during this meeting. These contradictory attitudes of the various European countries towards sea disposal have only partly changed since that time and have resulted in a continuous scrutiny of all the operations carried out over the years. The operations carried out by Belgium, the Netherlands, the United Kingdom and later Switzerland therefore stood under strict international control. This control has finally resulted in the NEA Multilateral Consultation and Surveillance Mechanism of 1977 for Sea Dumping of Radioactive Waste[2], based on the regulations of the London Dumping Convention. Participating countries have set guidelines for waste packages[3], for operational procedures[4] and have to reconsider with five year intervals the suitability of proposed (and used) dumping sites. Countries have to notify NEA six months in advance about every planned sea disposal operation and to submit detailed information about the wastes and procedures. This to enable participating countries to criticize the plans if desired.

An important part of the NEA supervision is the presence on board of the NEA appointed representative with far reaching powers concerning the radiological as well as technical aspects of the dumping operations. The quantities of waste prepared for sea disposal in the four countries have been such that there is each year a UK operation and a combined one with packages from Belgium, the Netherlands and Switzerland.

DEVELOPMENT OF CONTAINERS

In the first years of the sea dumping practice much use was made of British experience in this area and the first guidelines for containers were of British origin. From the beginning ocean depths of about 4000 m have been considered as adequate and necessary depths. Therefore requirements for the containers to be able to withstand high pressures have been rather strict. Though, in the early analysis, it was assumed that the containers would arrive at the ocean floor undamaged, but upon arrival at the bottom the contents would immediately be released. The recent guidelines say that the package should be strong enough to remain intact upon impact on the sea floor and for a period of time thereafter to minimize to the extent reasonably achievable the radioactivity which might ultimately be released. Depending on the contents of a containertype various pressure equalizing devices have been used, but gradually the tendency was towards preparation of containers in such a way that hardly any void space would be left within. Tests in pressure chambers and actual "field" tests carried out in England[5] and later in Japan showed that when concrete lined containers were made such that the wall lining was hardened first and then some days later the lid was poured there would be a crevice between wall and lid acting as a water ingress channel to equalize pressures. The main type of containers used in the Netherlands is a 200 liter drum with a re-enforced concrete lining and a concrete lid. In our case the concrete bottom is applied first and wall plus lid in one operation later on so that the crevice is at the bottom end. These packages have been used for the general production of laboratory, hospital and industrial types of LLW and for certain categories of wastes from nuclear power stations. MLW from these stations such as solidified evaporator concentrates and spent ion exchange resins have been placed in 200 liter drums surrounded by 20 cm of re-enforced concrete later covered with a concrete lid. These containers designed in Switzerland have been subjected to the various tests indicated by the IAEA transport regulations and are classified as B(U) type containers. In the 9 m droptest these containers loose a certain amount of concrete pieces and chips till the depth of the first re-enforcement. These concrete containers can be and are stored in the open air until a dumping operation takes place, in contrast to the steel drums that are kept indoors to prevent premature rusting.

In the past there have been difficulties with the solidification of certain types of sludges and during one of the operations some contamination of the ship has occured because of a few leaking containers in which the material had not been properly solidified. With the present well developed and streamlined production procedures the average number of packages rejected during the inspections is 1 per 1000. This is a very low rejection rate for an industrial practice.

SHIPS USED

In the first ten years when the amounts to be disposed were in the order of 1000 to 2000 tons, a small cargo-ship, the TOPAZ, was used that had four holds and only very simple derricks. Therefore special provisions had to be made to handle the containers at sea. They had to be hoisted from the hold onto a dumping platform welded on the gangway and extending a small distance outboard. From this platform drums could be pushed or rolled overboard. Penduling motion of the hoisted load was limited by using so-called goal-posts with a steel wire that prevented extensive swing of the containers. Since this was a rather time consuming process, it was considered to use a completely different ship, a so-called bottom discharging ship, where the waste drums can be placed in one large hold that opens at the bottom by hydraulically moving the 2 half-ships apart. One experiment carried out in the North Sea with drums filled with ordinary sand was very successful. However, for three reasons no use was made of this kind of ship in actual disposal practice. The first one was the very low speed of the few ships available at that time that had a license for the open oceans, so that part of the cost advantage would be neutralized and further the very limited accomodation on board so that there was no room for escorting officers and their equipment. The most important reason however was that the hold could not be made watertight.

For recent operations larger ships (3500 tons) have been used, being equiped with modern cranes swinging outwards quite easily and being able to handle a number of 200 liter drums at a time. The 2.5 tons, B-containers are also very easily handled and when the weather conditions are good enough the whole dumping operation itself takes 3 to 3.5 days.

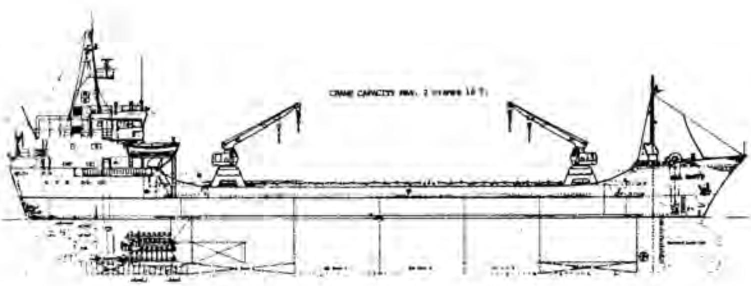

Fig. 1 Side-view of the 3500 ton ship used.

The rather small size of the dumping area necessitates precise navigation. For some years a satellite navigation system is in use that assures very accurate positioning.

During the cruise radiological safety is assured by measuring the γ-radiation fields at accessible places on and in the ship and proper stowing of the drums in the hold. In practice radiation levels of the packages vary to a large extent between < 1 and 1000 mr/h surface doserate with the majority having a very low radiation level. The total cargo must obey a certain distribution of the radiation levels of the individual containers. The escorting officer has to check on the stowage of the drums in order to stay within allowed radiation limits for the crew during the loading repository dumping phase.

WASTE MATERIALS AND QUANTITIES DUMPED

In a previous chapter it was already indicated that the nuclear power stations present for dumping their LLW from daily operations and cleaning work as well as precoat filters, solidified concentrates and resins. From laboratories and hospitals the official collecting service operated by ECN receives all kind of laboratory trash and residues from radioisotope applications. From hospitals also occasionally discarded encapsulated sources such as radium needles are received for disposal. Also from industrial isotope applications discarded radiography sources are offered to the collecting service. The waste quantities dumped over a series of years by the Netherlands are listed in Table I, according to the usual classification of Ra-226, alpha wastes, beta-gamma wastes (except ^{3}H) and tritium. For comparison also the total amounts disposed in the North-East Atlantic within the OECD/NEA frame are given.

RISK ANALYSES OF DUMPING LLW IN THE DEEP OCEAN

A number of risk analyses have been made concerning the dumping practice. A first one done in 1966 was already mentioned in this paper. In 1973 a revised analysis was made based on the model of Webb and Morley[6]. The most recent analysis to determine the continued suitability of the present dump site in the North-East Atlantic was made in 1979 and was partly based on the general risk analysis of the IAEA[7]. The present dumping area in use since 1974 is located within 10 nautical miles north and south of 46^{o} 00' N and 16^{o} 00' W - 17^{o} 30' W, its area is about 4 x 10^{3} km^{2}. The distance to the nearest land is over 700 km and the average depth of the ocean at the site is about 4.400 m. In the analysis the oceanographic characteristics of the area are considered. Furthermore the absence of tectonic activity, of potential resources on the ocean floor and intensive traffic is discussed as well as the position towards zones

TABLE I

Amounts of LLW and MLW disposed in the North Atlantic approximate activity in curies at time of packaging

From the Netherlands in:	radium	α-emitters	β/γ-emitters	^3H	metric tons
1965-1973	0.4	-	70	-	3086
1974	0.8	-	20	550	500
1975	0.01	1.5	90	400	901
1976	0.01	1.0	900	100	1911
1977	0.1	9.0	400	190	3015*
1978	3.0	2.0	1065	470	1562
1979	0.2	0.02	535	310	2122
1980	0.3	0.3	435	100	1885
1981	3.8	3.0	1725	125	2035
Total from the Netherlands	9	17	5240	2245	17035
Total in North Atlantic 1967 - 1981	190	1.2×10^4	4.2×10^5	4.3×10^5	82911
Average Ci/year	14	900	3.2×10^4	5.4×10^4†	
IAEA limit Ci/year	10^4	10^5	10^7	10^{11}	

* First use of B-containers
† Averaged over 8 years since 1974

wherein cables for telecommunication are present. These aspects are of interest in relation to the question whether the dump site obeys the criteria set in the IAEA recommendations and annex III of the London Dumping Convention. Also in relation to the same annex a summary is presented of the quantities dumped since 1967 and composition as well as the radiotoxicity of the radionuclides in the waste. In the radiological analysis a summary is given of the oceanographic and radiologic bases of the IAEA definition. The results are presented in the form of release limits for separate and grouped radionuclides. Since no site specific analysis was made the radiological impact is found by a direct comparison of the general IAEA release limits and the average amounts of the annual dumpings. The dumpings until 1979 subdivided over the various groups of radionuclides are less than one percent of these release limits. In Table I of this paper the IAEA limits are presented as well as the average amounts dumped per year until 1981. The radiological analysis must be revised within five years. In order to do this on the basis of a more site specific dispersion and exposure model specific research in a number of areas is recommended. The Netherlands recently started a study of physical, chemical and biological processes in the deep ocean aimed at defining critical pathways.

INCIDENTS

Some incidents of a technical nature did occur over the years. They can be placed in various categories, the most important being inadvertent presence of some liquid that later leaks out and a drop of a container being hoisted. In the latter case the risk of contamination is small since it was shown in drop tests that the 200 l dumping package can be dropped 4 m on a concrete base without serious damage and the large B(U) containers pass the 9 m drop test.

One typical incident was mishandling of some drums containing solidified liquid, without a non-active lining. When the handling equipment used to reposition the drums from standing to lying did occasionally pierce the steel small chips of the active contents came out and contaminated the trucks. Fortunately this type contamination can easily be removed.

AUTOMATIC SOLID WASTE COMPACTION SYSTEM-PROCESS DESCRIPTION

The Netherlands' waste collecting service distributes standard 100 l steel drums to the low level solid waste producers in the country for filling at their sites.

The wall thickness of these drums is 1 mm. Each has a steel lid with a spanring. The drums are transported to the compaction system on a wooden pallet. With a fork-truck the pallets are placed in front of an input station. Here a man transfers the drums from the pallet onto a conveyor-system. At this point the identification numbers of the drums are fed into the connected computer. At the end of the conveyor each drum is weighed and its radiation level is roughly measured. This data is also transferred to the computer.

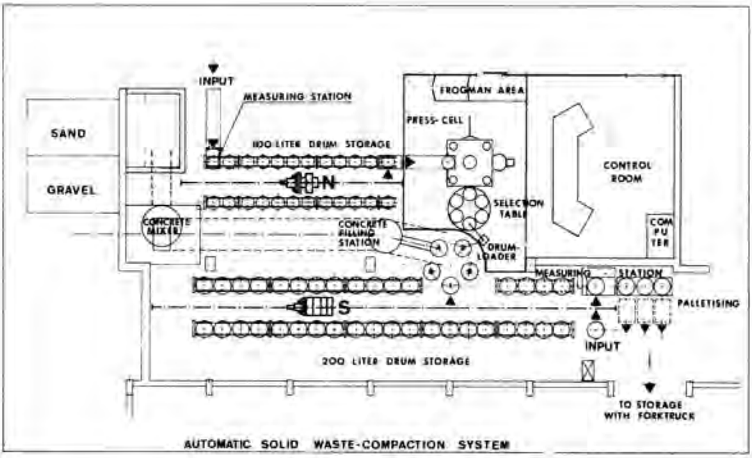

Fig. 2-Plan view of the ECN automatic solid waste-compaction system

A transporting unit (Fig. 2) takes the drums from the measuring station and stores them into one of two storage racks with a total capacity of 140 drums, six high. At the same time the administrative data accompanying each cargo of 100 liter drums are put into the computer by the terminal in the control-room. These data are drum no., code of the customer, the transport form number, the six most important nuclides present and the estimated activity per nuclide.

When the compaction-program is started, the transporting unit N takes out a drum from the storage rack, normally in sequence, but when needed the computer makes a selection on the basis of weight, drums of more than 40 kg, or rediation level, drums of more than 100 mrem/h for balancing purposes. Each drum is transported to an airlock connected to the press-cell. A pushing device places the drum from the airlock in front of the press as can be seen on Fig. 3. Figure 4 is a simplified drawing of the press itself.

A drum is placed in the middle of the press by the press-loader. The press-clock is lowered about 10 cm around the drum to fix it in position, then the press-loader is withdrawn. Now the press-clock is completely lowered around the drum, whereby the main-cylinder compacts the drum with a total force of 1500 tons (15 MN) which is equal to 800 kg/cm^2 (80 MPa). When the main-cylinder and the press-clock have returned to their highest position the packet is pushed from the middle of the press onto a selection table. The packet has a diameter of 49 cm and the height depends on the kind of waste.

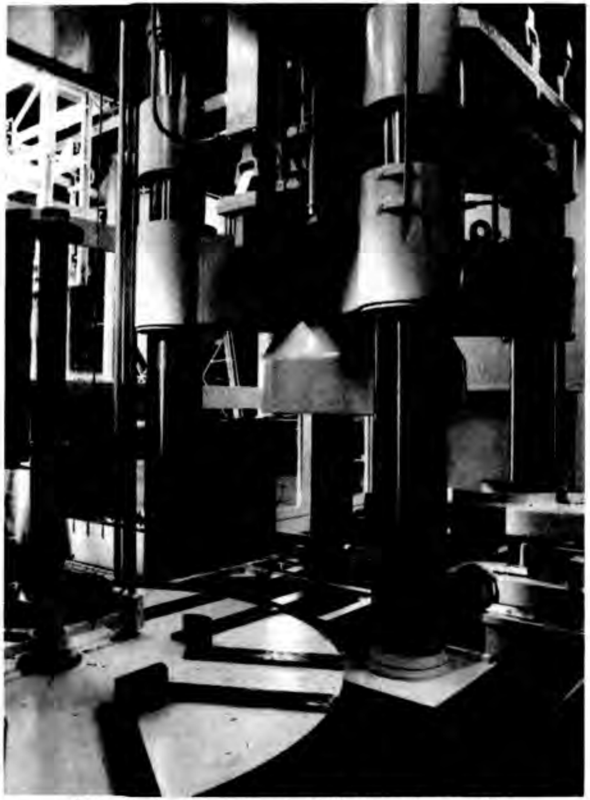

Fig. 3-Photograph of 1500 tons hydraulic press. Note entry of drum through air-lock.

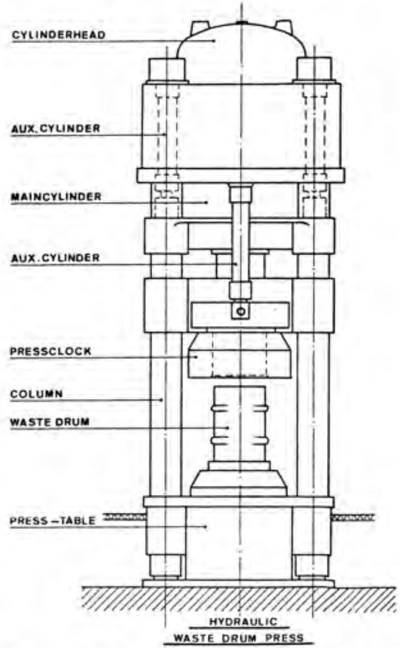

Fig. 4-Schematic drawing of the hydraulic press.

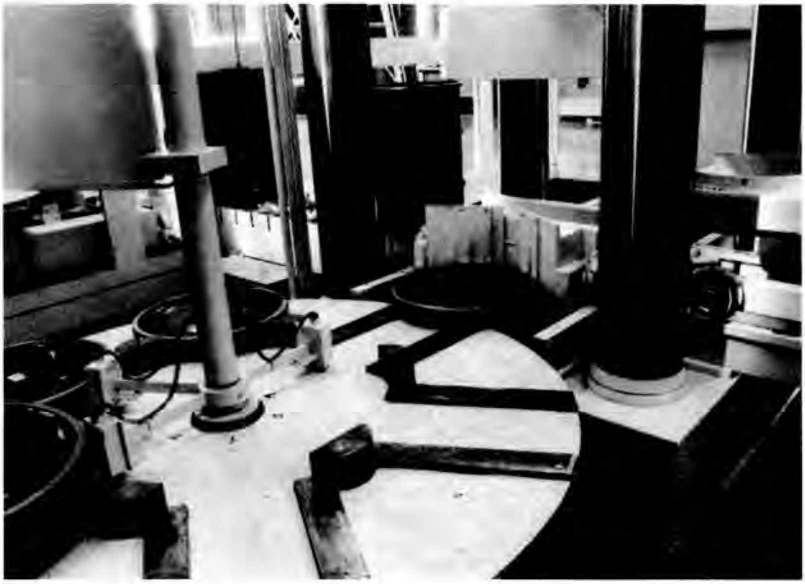

Fig. 5-Photograph of selection table with compacted drums

The selection table, shown on Fig. 5, can hold six packets and turns them successively under the packet-height meter and under the packet grab. The measured height of each packet is fed into the computer. Besides the use of this datum for the optimal stacking it also forms a part of the cost calculation.

The compacted waste is still surrounded by the metal of the drum. In most cases this metal keeps the waste neatly together. Sometimes the expansion force, for example in the presence of rubber, is too strong to maintain a flat packet, but even then the containment is such that contamination of the cell is astonishingly low. The cell is built of steel and glass plates. The underpressure in the cell is maintained at 100 Pa. The air filtered by Hepa-filters. Access to the cell is via the frogman-area. Drain-water from the cell is collected in a waste water tank and transferred to the water treatment facility.

In the storage area for 200 l disposal drums with a capacity of 100 drums an empty drum is placed on the input table where a specially constructed iron positioning holder is placed inside. On the bottom of the drum a layer of 10 cm of concrete is then poured. Thereafter the drum is placed in the storage-racks with the transporting unit S (Fig.2). These racks are built in three levels. When the concrete is hardened the drum is placed on a turn-table, that turns the drum to its loading position. The packet-grab inside the press-cell places a number of packets into the 200 liter drum to a maximum height of 64 cm. Each time the free space in the drum is measured so that the computer can make an optimum filling. During the filling sequence the air from the drum is sucked into the press-cell. The turn-table then transfers the drum to the next position, which is the concrete filling station.

The concrete, prepared in the concrete mixer, must have a minimim compressive strength of 22.5 N/mm^2 after twenty eight days, based on a 150 mm cube test. In practice this is 40 N/mm^2. From the mixer the concrete is transferred to the concrete filling station. By a srew-conveyor the concrete is poured into the drum. A shock-table distributes the concrete evenly throughout the drum and between the packets. This is shown on photograph 6. After filling there is always a concrete layer of at least 10 cm above the top packet. Completed drums are replaced in the racks for hardening of the concrete. After two days the concrete is strong enough. The drum is then transferred to the measuring station. Here the weight and the radiation level of the package is measured. The radiation is measured by four GM-probes which turn in 1 minute around the package. The highest value is fed into the computer. As mentioned in the NEA Guidelines for sea dumping packages of radioactive waste[3], the drums are divided in four radiation categories and marked accordingly with a coloured band around the drum. A package with a weight lower than 250 kg is not accepted by the computer system in order to guarantee the required minimum specific gravity of 1.2. The average weight of a package is 400 kg. After the measuring procedure three drums are pushed on a table which places the packages on a special type of pallet. A fork-truck transfers the pallets into the interim-shed where an optimum storage is reached by placing the pallets 8 to 9 high. Once a year the drums are transported to the harbour of Ijmuiden for disposal into the Atlantic Ocean. On board of the ship the presence of a so-called dumping list is obligatory. This list, a computer printout, contains of each 200 l package all relevant information such as drum number, type, treatment, code, content, treatment-data, storage-date, as well as estimated activity in millicuries of Ra-226, alpha-emitters, beta-gamma emitters $t_{1/2} > 0{,}5$ year, beta-gamma emitters $t_{1/2} < 0{,}5$ year and tritium.

In addition information is printed about packets that were placed in the dumping package such as customer no., form-no., 1001 drum no., nuclides, activity per nuclide, radiation level and weight. So, when a package might drop or otherwise fail during transport to the dumping area a complete picture of its contents is available. After two years of experience it can be said that the total system is working well. The average volume reduction is 80% including batches of partly precompacted waste, concrete blocks, iron tools etc. The whole system can be operated by one man.

Fig. 6-Section of a 200 liter dumping package

POLITICAL AND PUBLIC REACTIONS

On one occassion in the past a mishap occurred whereby one 200 l container, not of Dutch origin, did not sink when pushed overboard. By immediate action of the crew and one of the escorting officers the contents of the drum could be salvaged. The incident was duly reported by the NEA escorting officer to NEA and to his national authorities. The latter fact caused a governmental political intervention and the request to NEA to immediately cancel the further operation, in this case the U.K. part of it. Fortunately in a hurriedly organized meeting the authorities concerned could be satisfied that the incident was indeed a very rare occurrence and gave their consent to continue.

In recent years public opposition in the Netherlands has steadily grown against the sea dumping practice. The process started with peaceful demonstrations near and at the harbour of Ijmuiden and actions such as dumping of imitation waste containers in the harbour or in coastal water so that they returned to the beach causing a local commotion because of the painted radioactivity marker. The last two years demonstrations became more serious and people locked themselves to the gates of the ECN-site before the trucks left for Ijmuiden so that the transport was delayed and also fastened chains to the rudder of the ship in order to prevent its maneuvering. The actions culminated in violence on board whereby navigation instruments were destroyed before the crew could prevent it. This action took place in Belgium at Zeebrugge harbour.

The organized demonstrations required the use of a rather extensive police force to clear the road blocks and to prevent other difficulties. In 1981 the trucks with waste containers were only allowed to travel in convoy headed by some police vehicles and also with these vehicles in the rear. This type of transport, completely opposed to the previously used strict time schedule for the transport, caused a significant cost increase of the whole operation.

One opposing group in 1981 was the Green Peace organization together with a number of private persons and some environmental societies. They made an appeal to the administrative court of the Council of State requesting suspension of the license issued by the ministry of public health and environmental hygiene to ECN to carry out the dumping operation. This was done on the basis of a recent general law on environmental impact. They obtained suspension of the operation until the court decided that their request to stop the operation because of its postulated consequences was denied[8]. This intervention caused a delay of about 3 months.

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