CONTROLLED CONTAINMENT,
RADIOACTIVE WASTE MANAGEMENT IN THE NETHERLANDS

Hans Codée
COVRA N.V.
4380 AE Vlissingen
The Netherlands
Telephone: ++ 31 113 616666
Facsimile: ++ 31 113 616650
E-mail: HCCOVRA@ZEELANDNET.NL

ABSTRACT
All radioactive waste produced in The Netherlands is managed by COVRA, the central organisation for radioactive waste. The Netherlands forms a good example of a country with a small nuclear power programme which will end in the near future. However, radioisotope production, nuclear research and other industrial activities will continue to produce radioactive waste. For the small volume, but broad spectrum of radioactive waste, including TENORM, The Netherlands has developed a management system based on the principles to isolate, to control and to monitor the waste. Long term storage is an essential element of the management system and forms a necessary step in the strategy of controlled containment that will ultimately result in final removal of the waste. Since the waste will remain retrievable for long time new technologies and new disposal options can be applied when available and feasible.

INTRODUCTION
It takes at least three years for the skin of a banana to decay. Chewing gum can last for 20 to 30 years. Some radioactive wastes decay within days while others remain active for thousands of years. Hazardous substances with heavy metals such as cadmium or arsenic or with asbestos do not decay at all. When left in our living environment, highly dangerous substances such as the smallpox virus can even grow in number. By international agreement the smallpox virus is only contained and kept under strict control at a very few places. Hazardous materials, among which hazardous waste, must be isolated from our living environment and controlled, to mitigate the potential threat to living species. When radioactive waste is contained and the containment is controlled, risks to living species can be brought down to acceptable or even negligible levels.

For the management of radioactive waste in The Netherlands a system has been developed of controlled containment. During the lengthy period of time that radioactive waste has to be isolated from our living environment, both the type of control and the type of containment will change with time.

All radioactive waste produced in The Netherlands is managed by COVRA, the Central Organisation for Radioactive Waste. COVRA operates a facility at an industrial area where the conditioning and the long-term storage (at least 100 years) of the radioactive waste takes place. A picture of the facility is given in figure 1.

In the following paragraphs a description will be given of **what** waste quantities have to be managed by COVRA. Followed by a description of **how** the management is done and next it will be explained **why** this is a solution for The Netherlands.

Fig. 1. The COVRA facility at the industrial area Vlissingen-Oost

WHAT WASTE QUANTITIES HAVE TO BE MANAGED IN THE NETHERLANDS?

Low and medium level waste

In The Netherlands there are some 200 producers of radioactive waste, varying from research establishments of which two operate a research reactor, an operating nuclear power plant and a nuclear power plant preparing for safe enclosure, all sorts of industries and hospitals. Most of them generate only small volumes of low and medium level waste. These small volumes however cover a wide range of waste forms: solids, liquids of all natures, slurries, animal carcasses, machines, equipment, sealed sources etc.

Annually some 300 m^3 of conditioned low and medium level waste is produced. Most of it is conditioned at the COVRA facilities. Resins and evaporator sludges from the nuclear power plants are directly conditioned at the site of the nuclear power plants.

In the COVRA treatment building various installations are available, such as a super compactor, a dedicated incinerator for biological waste, a dedicated incinerator for organic liquids, shearing and cutting installations, a cementing station and a wastewater treatment system. The final conditioned waste form is a cemented package of 200 or 1000 litre. These packages are stored in storage buildings.

Over a period of 100 years the total volume of low and medium level waste that has to be stored, including low and medium level waste from reprocessing and including the waste from decommissioning, is estimated to be 60,000 m^3.

TENORM

Relatively large volumes of low level radioactive waste or TENORM (Technologically Enhanced Naturally Occurring Radioactive Materials) are produced in the ore processing industry. High quality phosphor production in a high temperature process in The Netherlands results in TENORM production in the form of a stable and solid calcinate. The phosphor production plant generates around 1000 tonnes of calcinate per year. The activity in this calcinate is dominated by polonium, bismuth and lead isotopes and ranges from 500 to 4000 Bq/gram. These elements are concentrated in the calcinate because they are volatile at the high temperatures in the electrofurnace. The dust is recirculated in the furnace and calcined. The radioisotopes Pb-210, Bi-210 and Po-210 are highly radiotoxic but their half-lives are relatively short: 22 years, 5 days and 138 days respectively. Depending on the initial activity the material will have decayed to exemption/clearance levels within 100 to 150 years. So after the foreseen storage at COVRA as radioactive waste, the material can be disposed of as chemical waste.
The calcinate is collected in 20-foot containers, with a maximum payload of 30 tonnes.

Depleted uranium from uranium enrichment is generally not regarded as waste. The depleted material still contains uranium that - depending on economic factors- can be used as feed material for an enrichment process. However when larger quantities are in stock and real use is not foreseen within some tens of years, the product comes close to the definition of waste. Depleted uranium is normally also not included in the scope of TENORM waste because it is produced in the nuclear industry. As a product it does however not differ much from other TENORM waste. In the Netherlands a maximum of 2500 tonnes of depleted uranium is produced per year. In this material U-238 and all daughters are present. The activity is around 10,000 Bq/gram. For depleted uranium a solution similar to the one as for the calcinate has been chosen: storage of unconditioned material in larger containers.
The depleted uranium is produced as UF_6. This is not a stable product suitable for long term storage and therefore this depleted UF_6 will have to be transformed in the very stable U_3O_8. This will be done in foreign installations.
For depleted U_3O_8 the argument to wait for decay to exemption/clearance levels is not applicable. The potential value of the material for reuse dominates the choice not to embed the material in a cement matrix. If reuse does not take place in the far future and the decision is taken to dispose of the material, then this can be done according to then applicable standards.

High level waste

All the spent fuel of the Dodewaard plant will be reprocessed by BNFL in the United Kingdom while that of the Borsele plant will be reprocessed by Cogéma in France. The resulting reprocessing waste will be sent back to the Netherlands. The vitrified residues, cemented or compacted hulls and endcaps and other high level cemented waste will be stored in a storage vault that is now under construction. A distinction is made between heat and non-heat generating waste, since the former category requires cooling.
Also the high and low enriched spent fuel from the research reactors and some other high level waste from research activities will be stored in this building.

At this moment some spent fuel from the research reactor at Petten is stored in Castor MTR2 containers in the storage building for low and medium level waste. This is an interim solution, needed because the storage capacity at the research reactor is used completely and because the facility for high level waste at COVRA is still under construction.

A summary of the total waste quantities that are licensed to be stored at the facility is given in table I.

	waste volume after 100 years	
High-level waste		
- spent fuel elements form research reactors	40	m^3
- vitrified reprocessing waste	70	m^3
- other reprocessing wastes	810	m^3
- decommissioning	2,000	m^3
- other	120	m^3
Subtotal	3,040	m^3
Low- and medium-level waste		
- operational wastes	60,000	m^3
- reprocessing	2,000	m^3
- decommissioning	18,000	m^3
- Depleted uranium and radioactive waste from Ore-processing industries	108,000	m^3
Subtotal	188,000	m^3
Total of all waste categories	191,040	m^3

Table I. Estimated total volume of waste collected after 100 years and licensed for the COVRA site.

HOW IS THE RADIOACTIVE WASTE MANAGED?

In The Netherlands working with radioactive substances, including TENORM, is only allowed when licensed under the Nuclear Energy Act. This Act stipulates that a licensee can only dispose of his waste by handing it over to an authorised organisation. As such, only COVRA is authorised in The Netherlands. In practice this means that COVRA has a monopoly position. COVRA collects the waste at the producers and ships it to the COVRA facilities where it is treated, if needed, and put into storage buildings.

In waste management the ‘polluter pays’ principle is generally seen as a basic principle. All costs of COVRA have to be covered by the fees paid for when the waste is transferred to COVRA. At the same time all liabilities are taken over by COVRA: COVRA becomes the owner of the waste and takes full title. This creates a clear situation because some of the waste will have to be managed over long periods of time during which the original waste producer can disappear. Consequently, in the fee for the waste the discounted value for all future costs have to be included.

At COVRA all wastes will be stored for a period of at least 100 years. This has to be taken into account in the design of the storage.

Low and medium level waste

All waste is conditioned in cement in relatively small units. Cement is a very stable product and creates an alkaline environment for the waste materials. This will prevent or slow down the degradation of the waste materials. Producing relatively small units of 200 or 1000 litre makes it easy to handle the units for repair.

In order to keep the dose rate in the storage areas low, the 200 litre drums with conditioned waste and a surface dose rate in excess of 0.2 mSv/hr are put in shielding containers of 1000 litre. The shielding is removed when the dose rate has dropped.

In storage blocks of waste packages are placed in rows, which leave open corridors for inspection. Lower dose rate packages are stored along the outer walls of the modules, and on the top layers in order to provide additional shielding for higher dose rate packages at the interior (see figure 2).

The storage buildings are of a modular design. At the moment COVRA operates three storage units, each unit has a capacity for approximately 5000 m^3 conditioned waste. A reception bay connects the three storage units. A fourth unit can be built and connected with the central reception bay when needed in future. In total 16 storage units can be constructed at the site.

The storage building is a simple concrete building; there is no mechanical ventilation. With mobile equipment humidity in the building is kept at a low level in order to prevent condensation of air moisture on the packages.

All waste in the storage building is well contained. The storage area is a contamination free area.

Fig. 2. Storage of low and medium level waste

TENORM

Calcinate is a stable product that does not need to be conditioned to assure safe storage. Any additional conditioning would most likely enlarge the volume and would certainly add to the costs of the solution proposed.

The calcinate produced at the phosphor-plant is dried at the plant and collected in a specially designed 20-ft container. The container has the dimensions and properties of a standardised ISO-container (ISO-668 type 1CC). There are no doors in the container but there are three filling positions in the roof of the container that can be closed with a sealed lid. Inside the container a big polyethylene bag is present that serves as a liner. The inside and outside of the container is preserved with high quality paint. The container can be filled with up to 30 tonnes of material. The containers are stacked four high in the container storage building (see figure 3).

The container storage building is a steel construction frame with steel insulation panels. High quality criteria were set for the construction and for the type of materials used in order to meet the 150 years lifetime with practical maintenance. The building can modularly be expanded and per storage module an overhead crane is present. As a start two modules were constructed, having a capacity to store some 12,000 tonnes of calcinate. Five more modules are permitted in COVRA's licence.

Technical provisions inside the building are minimal. With mobile equipment the air humidity in the storage building is kept between 60 and 70%.

All containers must be free of outside contamination, so inside the building contamination should not be present.

Fig. 3. The storage of radioactive calcinate from phosphor production.

In 2002 the construction of a storage building for depleted U_3O_8 will start. This will be a concrete building with minimal fixed installations or equipment, comparable to the store for low and medium level waste.

The depleted U_3O_8 is a stable product to store. Because of its potential future use the material will not be conditioned in a fixed matrix. When judged necessary in the future, for instance when the material is brought into a geologic disposal facility, then this can be done according to applicable standards at that time. Money for this treatment and for the final disposal will be set aside in a capital growth fund in the same way as is done for all other waste stored at COVRA.

High level waste

Because of the long term storage requirement a system was chosen that is as passive as possible and where precautions are taken to prevent degradation of the waste packages. The heat generating waste is stored in an inert noble gas atmosphere and cooled by natural convection. In the design of the storage vault all accidents with a frequency of occurrence larger than once per million years were taken into account. The design must be such that these accidents do not cause radiological damage to the environment.

The non-heat generating waste is, remotely controlled, stacked in well-shielded storage areas. The heat generating waste such as the vitrified residues will be put into vertical storage wells cooled by natural ventilation. This method is proven technology in the storage facilities of BNFL at Sellafield and of Cogéma at La Hague.

The spent fuel elements of the research reactors are delivered to COVRA in a cask containing a basket with circa 30 elements. The basket with elements is removed from the cask and placed in a steel canister, which is welded tight and filled with an inert gas. These sealed canisters are placed in wells, in the same way as the vitrified residues (see figure 4). The wells will be filled with an inert gas to prevent corrosion of canisters with spent fuel elements or vitrified waste.

The construction of the storage vault started in 1999 and it will be commissioned in 2003.

Fig. 4. Emplacement of the wells during construction.

WHY IS THECHOSEN MANAGEMENT OPTION A DEDICATED SOLUTION?

As indicated in the Introduction, radioactive waste must be contained and controlled. This can be done by storage in buildings and control by society. Also this can be done by shallow land burial and control of society, or by deep geologic disposal and control of society. For the three options mentioned the degree of societal control is the highest for storage in buildings and the lowest for deep disposal. When containment is required over periods of time longer than the existence of society doubt may raise on the capacity of society to fulfil the control requirement.

The Netherlands is a small country, 41,000 km^2, populated by 16 million inhabitants and it has a very high ground water table. Actually a large proportion of the country lies below sea level and is protected by manmade dikes and natural dunes. The ground water level must be regulated mechanically by a system of pumps and discharge canals. Under such circumstances shallow land burial is not acceptable for the low and medium level waste. Ground water contamination is a potential risk that is judged to be too high. As a consequence for all waste categories deep geologic disposal will be required as ultimate solution.

Fortunately, deep lying, large salt formations with a good potential as disposal site, as well as deep clay formations, are available in our country. Unfortunately however public acceptance for deep disposal is lacking. Some comfort can be given when the disposal is retrievable; this is a requirement for The Netherlands.

Also it should be realised that the waste volume that is actually present right now is only a few thousand m^3 and for such a small volume it is not economically feasible to construct a deep geologic disposal facility. The waste volume collected in a period of 100 years can be judged as large enough to make a disposal facility viable. So a period of at least 100 years of storage in buildings will be required. This creates at least six positive effects:

1. Public acceptance is quite high for long term storage. The general public has more confidence in physical control by today's society than in long-term risk calculations for repositories even when the outcome of the latter is a negligible risk.
2. There is a period of 100 years available to allow the money in the capital growth fund to grow to the desired level. This brings the financial burden for today's waste to an acceptable level.
3. During the next 100 years an international or regional solution may become available. For most countries the total volume of radioactive waste is small. Co-operation creates financial benefits, could result in a higher safety standard and a more reliable control.
4. In the period of 100 years the heat generating waste will cool down to a situation where cooling is no longer required.
5. A substantial volume of the waste will decay to a non-radioactive level in 100 years.
6. A little bit more than 100 years ago, mankind was not even aware of the existence of radioactivity. In 100 years from now new techniques or management options can become available.

In conclusion it can be stated that a dedicated solution for The Netherlands is to store the waste in buildings for a period of at least 100 years <u>and</u> to prepare financially, technically and socially the deep disposal during this period in such a way that it can really be implemented after the storage period. Of course at that time again society has the freedom of choice between a continuation of the storage for another 100 years or to realise the final disposal. Controlled containment can be achieved accordingly to the wishes of society!

REFERENCES

1. Jan Kastelein, Hans D.K. Codée. Commissioning a new Facility for the Treatment and Storage of Low and Medium Level Waste in The Netherlands. Spectrum ’96, Seattle, USA, 1996

2. Hans D.K. Codée. Radioactive Waste Management in The Netherlands; A Practical Solution in Full Operation. IAEA International Conference on the Safety of Radioactive Waste Management. Cordoba, Spain, 2000.

3. Hans D.K. Codée, Marcel T.B. Berntsen, Jan Hengst, Harry Lagerwerf. Incineration of Radioactive Organic Liquids; Five Years of Experience in The Netherlands. International Conference on Incineration. Portland, Oregon, USA 2000.

4. Cees Kalverboer, Edwin A. Bach, R. Gattegno, J. Delgrande. HABOG: A new Safe and Economic Multipurpose Storage Facility. Topseal ’99, Antwerp, Belgium 1999.