Treatment of (TE)NORM residues in the Netherlands

J.Welbergen[a], R. Wiegers[b]

[a]Central Organisation for Radioactive Waste (COVRA)
Vlissingen

[b]Ingenieursbureau Bindmiddelen en Reststoffen (IBR Consult BV)
Healen

The Netherlands

Abstract. In the Netherlands, different types of (TE)NORM materials coming from the various industries are produced. These materials are partly waste and partly capable for recycling. If the NORM material is considered waste, there are two options available; treatment and storage as radioactive waste or disposal as hazardous substances. In case recycling is foreseen, there are specific demands on the process and use. A summary of the current types and amounts of (TE)NORM wastes and materials is given. The relevant legislation and the opportunities for the NORM industry are discussed and treatment options that COVRA has developed for the conditioning prior to long-term storage are shown. An overview of the conditions under which the hazardous waste depositories are allowed to process specific NORM wastes is given.

1. Introduction

As in many other countries, in the Netherlands there is a wide variety of (TE)NORM materials generated by industries. Some of these materials are considered waste and are intended for disposal and some of these materials are suitable for recycling or recovery. As far NORM materials are considered waste there are two options available: treatment and storage by the Central Organisation for Radioactive Waste (COVRA) or by a specified waste depository for hazardous wastes. In this paper a short overview of the current situation concerning types and amounts of (TE)NORM wastes is described. Recovery of materials as well as treatment processes are presented. Furthermore, the relevant legislation and the opportunities for the NORM industry are discussed. Specific attention is given to the treatment options COVRA has developed for the conditioning of the (TE)NORM prior to long-term storage. An overview of the conditions under which the hazardous waste depositories are allowed to process specific NORM wastes is also given. Last (but not least), some alternative options which are available and/or under development for the recovery of NORM materials is dealt with.

2. Description of scenarios

2.1. Recycling and recovery

The option of recycling or recovery is explicitly mentioned in regulations and as far as the application in infrastructural works is concerned there is a specific demand that NORM material is diluted to such a level that the produced material is no longer considered radioactive waste. The general approach for this option is first to see whether a product can be developed out of NORM waste (considering technical, economical and environmental aspects). Second an overall safety assessment of the radiological implications for a given process and application is developed to see whether any major threats could occur. Potential threats do occur during processing of the waste and during the life cycle of the product. In the latter case the leachability of radionuclides and subsequent dose limits and contamination levels are aspects which have to be taken into consideration. In case both criteria are met, the technical development and processing of NORM material can proceed.

As far as marketing aspects are considered the NORM requirements are just one set of aspects determining the feasibility of recycling or recovery. Other aspects including economics, market principles and customer perception are far more restrictive and the most appropriate way to assure that the product is no longer a NORM material is paramount (even for those applications where it is not formally required).

An example of a recycling or recovery of NORM material in infrastructural works is the development of a granulate on the basis of mixing the NORM sludge with binders. This process of granulating by a rotating disc technology seems to be most promising for large quantities of low level NORM wastes. A special option is given by the treatment of NORM-contaminated steel scrap which can either be cleaned (in case recovery is considered and cleaning is possible) or melted in the Siempelkamp (D) facility for recycling.

2.2. Waste treatment

COVRA is the Central Organisation for Radioactive Waste in the Netherlands. Its statutory task is to take care of all the radioactive waste produced. COVRA collects and transports the waste from the producers to its facilities where it is treated if necessary and deposited in storage buildings (Photo 1). COVRA has a monopoly position: in the Netherlands, working with radioactive substances is only allowed when licensed under the Nuclear Energy Act. This act stipulates that a licensee can only dispose of radioactive waste (including (TE)NORM waste) by handing it over to an authorised organisation. As far as high(er) level waste is concerned, only COVRA is authorised. Although COVRA is also authorized for accepting low level wastes there is an alternative option formed by specific hazardous wastes depositories. All activities with radioactive substances, excluding shipments, have to comply with the rules laid down in the Radiation Protection Decree, which is part of the Nuclear Energy Act. In the decree, a definition is given for radioactive waste:

> *Radioactive waste: a substance can be considered to be waste, if for this substance no use, reuse or recycling is foreseen, and the substance is not to be discharged.*

In the decree, limits are also given for exemption and clearance of radioactive materials. The limits are based on the Council Directive 96/26 of the European Commission. In the Netherlands, the choice has been made to use the same levels for exemption and clearance. However, for work activities up to a tenfold higher level, a notification procedure is required instead of a licensing procedure.

Complications for the safe and cost-effective processing and storage of the radioactive waste are:

i) Heterogeneous waste supply: In the Netherlands, there are some 200 producers of radioactive waste varying from nuclear power plants and research establishments to all sorts of industries and hospitals. Most of them generate only small volumes of low and medium level waste. Some nuclear processing industries generate big volumes of solid low-level radioactive material (TENORM material). Some processing industries generate larger volumes of solid very low-level radioactive material (NORM waste). The nuclear power plant(s) and research reactors produce waste with a high level of activity, however only in small volumes.

ii) Single final product: It is estimated that roughly two-thirds of the waste stored at the COVRA site will be disposed of in a geological repository. This implies that the wide range of wastes must be processed into a single (or a few) final product(s), compatible with the specifications of the envisaged repository, and easy to handle and maintain.

iii) Predictability of costs: Radioactive waste must isolated from the environment, controlled and monitored over very long periods of time. The polluter-pays principle is a leading principle in waste management. According to this principle, the fees levied when the waste is collected must cover all costs of treatment, storage and final disposal. Once the waste is accepted, all liabilities are taken over by COVRA. COVRA takes full title, because some wastes may have to be managed over longer periods of time than the waste producers exist. Consequently, the fee must cover all present costs and the discounted value of all future costs.

iv) Industrial activity: Radioactive waste treatment and storage are considered normal industrial activities. As a consequence COVRA is located at an industrial area in the south-west corner of the Netherlands, close to NPP Borssele (see Fig. 1). This puts additional demands on safety compared to dedicated sites in more secluded surroundings.

This explains why simple processing, versatile production equipment and passive safety are central in the design and operation of the COVRA facilities. For example, all storage buildings are modular, which provides flexibility to adapt to changes in waste supply. The radioactive waste is immobilised in a form that is physically and chemically stable, and stored in a way, which minimises the need for control and safety systems, maintenance, monitoring and human intervention.

Photo 1: Aerial photo of the COVRA site *FIG.1: Map of the Netherlands*

1. Office building and exhibition centre;
2. Building for the treatment of low and medium level waste (AVG);
3. Storage building for conditioned low and medium level waste (LOG);
4. Storage building for high level waste (HABOG);
5. Storage building for low level NORM waste from the ore processing industry (COG);
6. Storage building for low level TENORM material from the enrichment industry (VOG);

The waste is stored in discrete packages which are resistant to degradation and hazards, and which can be inspected and retrieved for final disposal. Finally, application of passive safety principles also leads to more predictable costs: because it minimises the need for control and safety systems, maintenance, monitoring and human intervention, the costs are largely determined by the investments (equipment, buildings etc.). In the sections below, this approach is explained in more detail for the different types of waste processed and stored at the COVRA site.

2.2.1. Low and intermediate level radioactive waste

The Dutch hospitals, research industry and NPP produce approximately 200 t of solid low and medium level waste (LLW) per year as well as 1000 t of (TE)NORM coming form a wide range of industries. There are a few industries which produces large quantities of very low level wastes (VLLW) up to some 10 000 t or more per year (e.g. phosphate and TiO_2-pigment industries). These quantities are too large to be handled by COVRA. Hence, an alternative was developed by which, under certain conditions, depositories for hazardous wastes are allowed to accept these types of NORM wastes. As a result the small amounts of (TE)NORM wastes (scales, insulation wool, filters etc.) are treated using the same technologies as for LLW.

Treatment of this type of waste by supercompaction starts in 100 L drums. This requires that the wastes are dry and sludges have to be dried or stabilized (by addition of e.g. cement). As the cost of the disposal is dependent on the volume, the main object of treatment of waste is to reduce the size of the drum (supercompaction by a 1500 t press; see Photo 2). Subsequently all supercompacted waste is conditioned with cement in relatively small drums. 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 L makes it easy to handle the units for repair. In order to keep the dose rate in the storage areas low, the 200 L drums with conditioned waste and having a surface dose rate in excess of 0.2 mSv/h are put in shielding containers of 1000 L. The shielding is removed when the dose rate has dropped.

Photo 2. Treatment of LLW (AVG)

In a storage building (Photo 3), conditioned waste packages are placed in blocks 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. 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 of conditioned waste. A reception bay connects the three storage units. A fourth unit will be built in 2007 and connected to the central reception bay. 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 the mobile equipment (construction dryers) humidity in the building is kept at a low level (50 % on average) in order to prevent condensation of air moisture on the packages and thus corrosion. All waste in the storage building is well contained. The storage area is a contamination free area.

Photo 3. Storage building for LLW (LOG)

2.2.2. NORM waste

Waste from phosphorus production is produced in larger quantities and generally as a stable and solid product (calcinate). For this NORM waste with radionuclides ^{210}Pb, ^{210}Po and ^{210}Bi, a tailor-made solution was developed. The calcinate resulting as waste from the production of phosphorus in a dry, high temperature process 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 cost of the solution (storage). Moreover, as activity decays to levels below exemption/free release (clearance) levels in about 150 years, conditioning is also undesirable because it would increase the cost of disposing of the waste as conventional waste. The calcinate produced at the phosphorus plant is dried at the plant and collected in a specially designed '20 foot' 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 lid. A big polyethylene bag serves as a liner. The inside and outside of the container are preserved with high quality paint. The container can be filled with 30 t of material. This higher payload required recertification of the container. These containers are stacked four high in the container storage building (Photo 4). The containers are stored in blocks of two row containers, which leave open corridors for inspection. The container storage building is a steel construction frame with insulation panels. High quality criteria were set for the construction and for the materials used in order to meet at least the 100 year lifetime (^{210}Pb: t½ = 22.3 a) with practical maintenance. Technical provisions in the building are minimal. There is no mechanical ventilation and the concrete floors are provided with a fluid tight top layer of epoxy. With mobile equipment the average air humidity in the storage building is kept below 50 % in order to prevent condensation of air moisture on the packages and corrosion.

Photo 4. Storage building for calcinate (COG)

2.2.3. TENORM material

For depleted uranium oxide tails a solution similar to the one for calcinate has been chosen: storage of this unconditioned TENORM in larger containers (3.5 m^3 boxes). The depleted uranium oxide (DUO) is produced as UF_6. This is not a stable product suitable for long term storage and therefore this depleted UF_6 is converted in the very stable U_3O_8. This is done in the uranium conversion plant of AREVA (France). Recovery of DUO for economic reasons (feed for enrichment) is possible at any time. The construction of the first storage building (one storage unit and a reception bay) started in 2003. The building was finished in March 2004 and operational in august 2004. Five more modules are permitted in COVRA's licence and two modules will be constructed in 2008.The containers with DUO are stacked three high in the container storage building (Photo 5). The containers are stored in blocks, which leave open corridors for inspection. The building with a concrete structure can be expanded modularly and per storage module an overhead crane is present. There is no mechanical ventilation. The concrete floors are provided with a fluid tight top layer. With mobile equipment the average air humidity in the storage building is kept below 50 % in order to prevent condensation of air moisture n the packages, and thus corrosion.

Photo 5. Storage building for depleted uranium tails (VOG)

Filters

Another source of NORM wastes is the enrichment of the radionuclides in the processing of all kinds of ores. In several cases the enrichment takes place in the waste stream in which all impurities of the ores are concentrated. Depending on the processes used this can generate scales in certain parts of the installation or form solid waste (e.g. sludges) which has to be treated and can be processed (depending on its radionuclide content) by COVRA or other specified repositories. NORM is also collected in filter bags used in the treatment of sludges (e.g. dewatering). Because sludge contains precipitates of radium (and some cases thorium) the filter bags will be contaminated with those scales and become a (TE)NORM waste once they are exchanged (removed) from the filter press. Because they contain relatively high amounts of radionuclides (up to several thousand Bq/g) they are not allowed to be treated by the hazardous wastes depositories and therefore have to be treated by COVRA. COVRA has developed a method for processing these filter bags into the system as described above (compaction, immobilisation and storage). This treatment consists of the use of two shredders which are placed at an angle of 90^0 to each other in order to process these filter bags into small flakes with the size of a few centimetres. This approach reduces both the exposure during handling (it prevents manual folding and cutting) of the filter bags in order to make them fit for 100 litre drums. In addition it reduces the storage cost by better utilization of the volume of the drum.

Photo 6. Shredding of filters in AVG

Sludges

In some cases sludges contain levels of radionuclides that are too high to be accepted by the hazardous waste repositories. The sludges from the oil and gas industry not only contain (high amounts of) water but also mercury and organic compounds. These components make drying and/or stabilization of the sludge with cement very difficult. Therefore an alternative treatment path was developed by the supplier in cooperation with COVRA. This treatment consists of a drying step in a dedicated installation (by which not only the water is evaporated but also certain quantities of mercury are collected). This step generates a dry material containing all the nuclides which can be treated according to one of the available routes at the COVRA facility. One complicating factor in this treatment route is that the intermediate treatment takes place in Germany which involves also a lot of extra legislative and regulatory requirements.

Photo 7. Packaging of sludges

2.3 Disposal at hazardous waste depositories

As already mentioned, COVRA cannot supply a solution for large quantities of (very low level) NORM wastes . For this reason repositories which are allowed to process hazardous chemical waste may accept these NORM wastes on condition that they make a radiological assessment of the processing of the NORM wastes. Subsequently they have to inform the authorities and implement the basic requirements as given in the legislation as well as customized measures based on additional legal requirements and radiological assessment. Based upon the first experiences it seems that extra measures for the processing of NORM wastes have been limited to minor adjustments. The measures taken in order to process hazardous wastes are already providing a high standard of protection for both workers and public. Just a basic adjustment of the waste administration, informing the workers and employing a specialized health physics specialist is enough to transform a 'conventional' hazardous waste depository into a NORM waste depository.

3. Conclusions

Some NORM wastes are produced in quantities too large to allow processing through the standard radioactive waste routes at COVRA (available processing capacity, costs of processing) or have an activity too low to justify these routes. In the Netherlands, legislation allows the development of tailor made solutions for all kinds of (TE)NORM residues. Alternative routes at COVRA where developed for the bulk calcinate and uranium oxide, as well as the different options of waste treatment of sludges and filters. For NORM immobilised by calcinations or converted into a chemical stable oxide, an ordinary container is sufficient to prevent non-controllable release of radioactivity. To prevent corrosion of the container a storage building with humidity control is used. Corridors between the blocks of containers allow for inspection of degradation and other hazards. For large quantities of VLLW, disposal at a hazardous waste depository is allowed after a safety assessment and subsequent (minor) adjustments.

Photo 8. Disposal of large quantities of NORM

Due to cooperation of COVRA with (TE)NORM waste generators, cost optimized solutions are developed. Treatment of the waste outside the country (Germany, France) is arranged under the restriction that as far as radioactive waste is concerned (according to national legislation) this radioactive waste has to be returned to COVRA.

Finally, application of passive safety principles also leads to more predictable costs: because it minimises the need for control and safety systems, maintenance, monitoring and human intervention, the costs are largely determined by the investments (equipment, buildings etc.).

As a result there are no (TE)NORM residues which cannot be dealt with in the Netherlands.

REFERENCES

[1] ROELOFS, L., WIEGERS, R., Immobilization of natural radionuclides as a solution for large volume wastes from NORM industries, NORM I, Amsterdam, the Netherlands, 1997.

[2] CODÉE, H.D.K., Radioactive waste management in the Netherlands: a practical solution in full operation. IAEA Conference on the safety of Radioactive Waste Management, Cordoba, Spain, March 13-17, 2000.

[3] ROELOFS, L., WIEGERS, R., " New approaches for the Treatment of Naturally Occurring Radioactive Materials, NATO Science series, 1, Disarmament Technologies – Vol 28, 2000.

[4] CODÉE, H.D.K., Long-term storage of radioactive waste and norm waste practical experience from the Netherlands, KONTEC, Symposium Conditioning of Radioactive Operation and Decommissioning, Berlin, March 28-30, 2001.

[5] CODÉE, H.D.K., Practical solution for the management of TENORM waste in the Netherlands**,** IBC Conference, London, April 22-23, 2002.

[6] WIEGERS, R., Treatment and possible use of NORM (waste) materials, Seminar NORM Arbeitsschutz, Grundwasserschutz, Reststoffmanagement, Bonn, 2004.

[7] WELBERGEN, J., VERHOEF, E.V., BERNTSEN, M.B.T.M., CODÉE, H.D.K., Passive safety in the treatment and storage of radioactive waste at COVRA (Netherlands), 10th ICEM, Glasgow, Scotland, September 4-8, 2005.

[8] http://www.covra.nl.