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ASSESSMENT, HANDLING AND DISPOSAL OF NORM AND TENORM: HOW GERMANY'S RADIATION PROTECTION AND WASTE MANAGEMENT REGULATIONS WORK TOGETHER TO BENEFIT THE INDUSTRY

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Abstract

This paper starts from a brief account of the occurence of NORM and TENORM in Germany, including special cases such as mining and drinking water treatment. It then summarizes the current situation of assessment, handling and disposal of NORM and TENORM in Germany and focuses in particular on the legislative aspects which allow to dispose of these materials in ordinary and industrial landfills (surface landfills and underground storage), or to recycle them, whatever is preferable ecologically and economically.

Germany's radiation protection legislation allows for a relatively easy and straightforward management of NORM/TENORM from all industrial sources which reduces costs and increases flexibility. The interplay of conventional waste management regulations and radiation protection standards, often complemented by transportation regulations for dangerous and radioactive goods, is outlined and, using a recent case study, demonstrated in its practical application. Our paper shows how the permitting procedure combines radiation protection and waste legislation and how this benefits industrial activities without compromising environmental and radiation protection standards. Examples from diverse industrial areas such as oil and gas production, metallurgy, or drinking water production are used to exemplify this.

Cross-border prospects of NORM/TENORM disposal and recycling are also briefly illuminated, using current projects and developments involving Germany's capacity to dispose of NORM/TENORM from other EU countries.

1. Introduction

Naturally occurring radioactive materials (NORM), and technically enhanced NORM (TENORM) are more frequent in our everyday life than most people outside the radiation protection community are aware of. Industrial activities lead to numerous cases where radioactivity is accumulated to a measurable degree, even though the original materials would usually not be regarded as radioactive. Examples are given in Section 2 below.

As long as the radioactive materials are part of a production process in a well-defined industrial environment, health and safety precautions exist to ensure protection of workers and the public. However, the management of NORM/TENORM becomes a more complex issue as soon as they cross the boundaries of a production facility. For example raw materials containing elevated amounts of radionuclides are often rejected at the gate of a smelter or scrap dealer; if residues such as filter sands from drinking water production are replaced, the spent filter sand which have accumulated radionuclides over several decades of operation must be disposed of.

Then, management of NORM/TENORM becomes a matter of public concern, and very often irrational fears dominate the discussion. A regulatory framework is needed to provide solutions which are legally sound, technically practicable, and simple enough to minimize the administrational effort.

Apart from the radiation protection aspect, the management of NORM/TENORM wastes must take conventional (ordinary) waste management regulations into account. After all, these materials constitute wastes which may have non-radioactive hazardous (e.g., toxic, inflammable) properties which must be considered prior to disposal. Again, the link between conventional waste management and radiation protection must be simple enough to arrive at practicable solutions within limited time, and without one aspect obstructing the other.

We believe the regulatory situation in Germany, despite some imperfections, provides such a simple, practicable and industry-friendly framework.

Our contribution illustrates, from a practitioner's point of view, how the German system of NORM/TENORM waste management and disposal works.

This paper is organised as follows: Section 2 gives a brief overview of the typical occurrences of NORM/TENORM wastes in Germany. Section 3 then gives a rather general overview of possible ways to manage NORM/TENORM residues. Section 4 describes the German regulatory framework which applies to NORM/TENORM disposal. It includes the aspects of both conventional waste and radiation protection legislation, and also touches briefly on the relevant transport regulations. Section 5 exemplifies the general approach by a case study from the natural gas production. Section 6, finally, draws some conclusions.

The authors are bound by several confidentially agreements. Therefore some of the information provided in this paper must remain anonymous.

2. Occurrence of naturally radioactive materials

As stated in the Introduction, there are numerous industrial and civil activities where NORM/TENORM may occur. Fields of particular practical relevance in Germany include, but are not limited to,

- the extraction and treatment of natural gas from some deposits in Northern Germany, which may lead to radioactive incrustations in pipes and sludge from gas purification,
- the processing of mineral resources such as phosphates, flourspar or thorium,
- the use of thorium products such as welding electrodes or gas lamp mantles,
- the active treatment of drinking water containing uranium (according to the new toxicity-based WHO recommendations for U content in drinking water),
- the accumulation of Radium on filter sands in drinking water plants over long time spans or if actively removed from certain mineral waters.

Historically, also uranium-containing paints and glazes, Radium-illuminated hands in watches, aircraft and navigation instruments and wastes from the production of uranium-dyed glass ("Canary glass") play a role.

Certainly the largest amount of NORM/TENORM wastes in Germany must be managed in the context of the East-German uranium mine closure and rehabilitation program, implemented by Wismut. These activities which are subject to a slightly different regulatory framework will not be considered here.

3. Principal ways of NORM/TENORM waste management

The principal ways of NORM/TENORM waste management are the same as those for conventional waste. In general, the hierarchy of waste management options is

- avoidance or minimization (not relevant if wastes have occurred and must now be managed),
- reuse or recycling,
- disposal.

The preferred way to manage a given NORM/TENORM waste stream depends on various factors, including cost, availability of a suitable technology and/or disposal capacity, acceptability by the authorities and the public.

Recycling of waste materials in most cases requires separation of the radioactive components. This is economically justified only in certain cases. For example, cleaned steel gas pipes can be sold as scrap, but this requires the availability of a proven technology which guarantees that the acceptance criteria of the smelter or scrap dealer are met. Experience shows that even if a single pipe still contains elevated contamination the entire truckload is rejected, annihilating the expected revenues. What is possible for straight, regular gas pipes, however, does not work for gas production equipment with a more complex geometry (vessels, containers, valves), often already strongly corroded, which must be directly disposed of.

Another example where treatment may make sense are large quantities of contaminated soil which must be excavated and disposed of at high cost, unless the radioactive components can be leached out (often referred to as "activity separation") so that only a small quantity of radioactive residue remains and must be disposed of, whilst the cleaned soil can be released for use.

Recently, uranium treatment stages have been installed by several German drinking water suppliers, triggered by the new WHO recommendation on uranium in drinking water. The recycling of uranium recovered from the ion exchange resins, which may reaching activity concentrations of several 100 Bq/g of U-238, is an option, but this still requires further discussion.

In most wastes, however, radioactive components cannot be separated at all with reasonable technical effort, so that direct disposal remains the only option. Moreover, the radioactive residues that arise from any cleaning process must be disposed of anyway. Therefore the focus of this paper is on disposal of NORM/TENORM residues, without negating the importance to consider activity separation and recycling options.

4. Legislative framework and regulatory approach

The legislative framework encompasses radiation protection issues, conventional waste legislation and, in certain cases, transport regulations. In the practical management of NORM/TENORM wastes, these fields of legislation are intimately intertwined. The following sub-sections 4.1 and 4.3 treat them individually, whereas sub-section 4.4 shows their interaction in a typical permitting process.

4.1 Radiation protection

The German regulatory framework of radiation protection is based on the EURATOM directive 1996/29. The practically relevant regulations are contained in the Radiation Protection Act of 2001 (Strahlenschutzverordnung or StrlSchV for brevity). The StrlSchV differentiates between Practices, covered by Part 2, in which materials have been produced just because of their radioactive properties (typically nuclear activities, but also the illumination of hands in watches, for example), and Works, covered by Part 3 of the StrlSchV, in which the radioactivity of a material is an unwanted side-effect, such as the production of natural gas or drinking water.

Depending on the radioactivity and intended use of the materials, the StrlSchV generally requires supervision to ensure that neither workers nor the public are unacceptably exposed. However, materials can be released from supervision if it can be demonstrated that the effective dose does not exceed 10 μSv/a ("Part 2" materials) or 1 mSv/a ("Part 3" materials), respectively. This is exactly what is done when disposing of NORM/TENORM wastes in a landfill. It is acceptable to bury

NORM/TENORM wastes in an ordinary or hazardous waste landfill as long as the criterion for release is satisfied. This can be guaranteed in all practical cases.

The waste owner, often assisted by a qualified consultant, must provide radiometric analyses from representative samples and carry out a dose estimate for workers and the general public, taking into account all relevant exposure pathways.

If the effective doses can be shown to stay safely below 1 mSv/a, the competent radiation protection authority on the state level within Germany's federal system issues the release statement.

The dose calculations may be quite cumbersome, and in fact the time and effort required would often be disproportionate in relation to the economic significance of the waste problem itself. Therefore, to make things simpler still for "Part 3" wastes, the German legislation provides derived, secondary criteria for release. They are illustrated in a very simplified manner here (for full details of the conditions see Appendix 12 of the StrlSchV): if the activity concentration of the main nuclide is < 10 Bq/g and the average activity concentration of the landfill is <1 Bq/g, it can be assumed without further detailed dose calculations that the effective dose received by the public is below 1 mSv/a, and consequently disposal in the landfill is permissible. If the wastes are disposed of in a dedicated hazardous waste landfill meeting certain conditions, the activity concentration of the main nuclide can reach 50 Bq/g before dose calculations are required to show compliance with the 1 mSv/a criterion. If the activity concentration exceeds 10 (respectively 50) Bq/g, detailed dose calculations are required, but the number of those cases is very small compared to the simple cases where the secondary criteria are sufficient to permit disposal.

As was mentioned above, the origin of the waste determines whether the dose limit is 1 mSv/a ("Part 3" wastes) or 10 µSv/a ("Part 2" wastes). This leads to the somewhat paradoxical situation that Radium-containing filter sand from a drinking water plant falls under Part 3, whereas Radium-painted watch hands of the same activity concentration are subject to Part 2, and thus the 100-fold lower dose limit of 10 µSv/a must be complied with.

NORM/TENORM wastes from other EU member states can be disposed of in Germany provided a procedure to release them from radiation protection supervision comparable to that in Germany has been followed in the country of origin. For example, NORM wastes from Austria have been disposed in a German industrial landfill according to this procedure.

4.2 Conventional waste management

Apart from their radioactivity, NORM/TENORM wastes must be considered under conventional waste management aspects, as laid down in the Landfill Directive 1999/31/EC and related European waste legislation, as transposed into German law, e.g., by the Landfill Act. In order to be disposed of in a given landfill, wastes must comply with its acceptance criteria, i.e., the usual procedure must be followed:

- characterisation of the wastes according to their origin and classification according to the EU waste code catalogue 2001/218/EC,
- representative sampling and analysis according to the list of physical and chemical parameters relevant for the landfill and comparison with the acceptance criteria,
- possibly additional testwork if some parameters critically exceed the landfill's acceptance criteria.

A waste disposal permit by the competent waste management authority is issued following the statement of acceptance by the landfill.

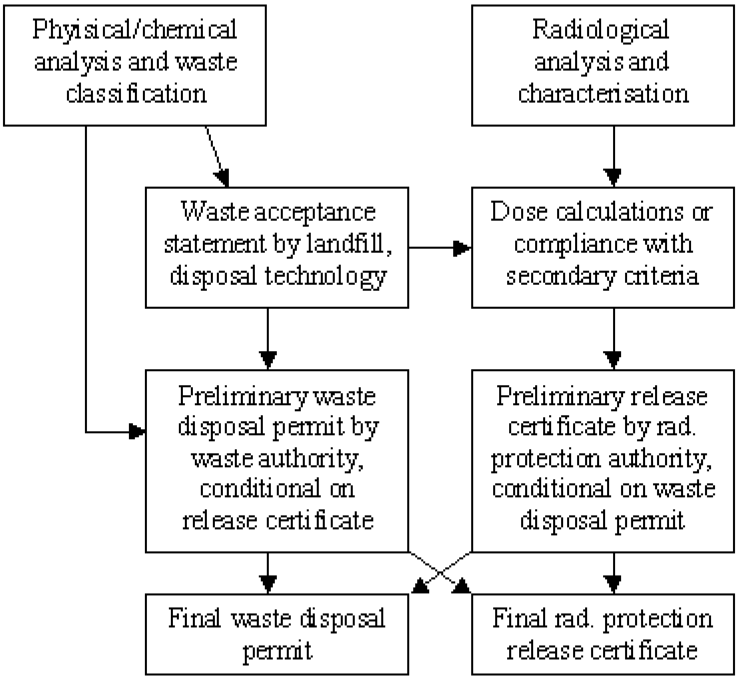
For cross-border waste disposal, a standard notification procedure according to the Directive 1993/259/EC is required.

4.3 Transport regulations

If the thresholds of ADR Class 7 ("Radioactive") are exceeded, the transport vehicles must be labelled accordingly, and the drivers must have received sufficient training. While disposal of NORM/TENORM wastes usually goes unnoticed by the public, labelled vehicles may cause public attention and concerns. This has prompted most landfills to reject ADR Class 7 transports for fear of bad publicity and pressure from their communities. The very few landfills which accept ADR Class 7 transports have experience in communicating the issue and keeping transparent records of all NORM/TENORM wastes which they have received. This pro-active attitude pays off because it enables a landfill to exploit a profitable niche avoided by others.

4.4 Typical permitting process

Waste and radiation protection legislation are closely intertwined, and must be managed at the same time when applying for the disposal of NORM/TENORM wastes. The following scheme shows the typical permitting procedure.



5. Example: pipes from natural gas production

In a gas production field in Northern Germany, a decision on the disposal or recycling of around 5100 pipes of 9 to 12 m length (i.e., a total of around 50 km) had to be taken. The incrustations ("scales") were typical for pipes from gas production drillholes in that region: the contamination was dominated by Ra-226.

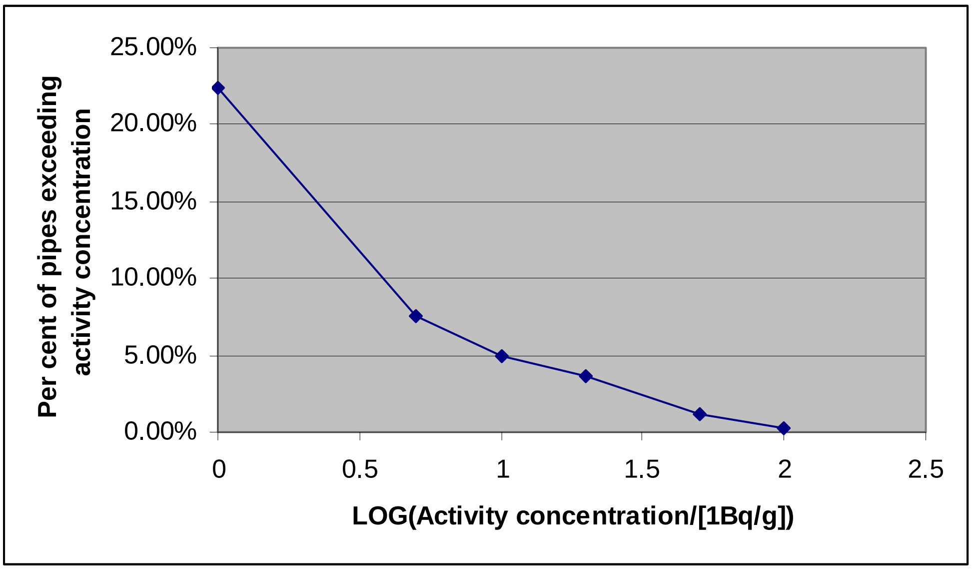
An important aspect was the presence of elemental mercury in the pipes. Rather a conventional waste problem than a radiation protection one, it required additional precautions to protect workers' health and safety.

As this was a pilot project which was viewed as a precedent for the future waste management strategy of the gas company, it was decided to carry out measurements of each individual pipe, and number each pipe in order to enable the authority to randomly check the measurements afterwards. It was also agreed that pipe and incrustation shall be treated as one unit, so that the activity concentration is calculated using the total mass (steel+incrustation).

In a first step, all pipes with an activity concentration below 50 Bq/g had to be separated for immediate disposal in a landfill for hazardous industrial waste. The release from radiation protection supervision was done using the secondary criterion discussed in Section 4.1 above. The EU waste code of the contaminated pipes was 050701* ("wastes containing mercury"). The acceptance certificate from the hazardous waste landfill and the disposal permit from the waste authorities were readily obtained, as the landfill had ample experience with mercury contamination.

A semi-automatic measurement equipment was devised which allowed to measure the activity concentration along the entire length of each pipe in a very short time. The throughput of the equipment was 600-650 pipes per day, which required a seamless work organisation and co-operation of all on-site staff. The pipes were orderly stored on racks, which strongly eased handling. On the other hand, a wide variety of pipe diameters and steel wall thicknesses had to be taken into account when calculating the activity concentration from the count rate of the detector.

These measurement results were an essential basis for any further discussions with the radiation protection authorities. The following diagram shows the distribution of the activity concentration of the 5100 pipes.



The high percentage (98.8 %) of pipes with a specific activity <50 Bq/g that could be transported directly to the landfill without any further dose calculation was overwhelming. Only a very small fraction (1.2 %) was left over which required either a detailed dose calculation or cleaning (to be decided). If the small fraction of pipes were cleaned, the disposal of the cleaning residues whose activity concentration is far larger than 50 Bq/g requires a detailed dose calculation and solidification by an inorganic binder with proven long-term stability to minimize leaching of radionuclides and ensure structural stability.

Although the transport was subject to the ADR Class 7, and the trucks had to be labelled accordingly, no problems were encountered during transport and unloading at the landfill. Questions and concerns from the public were dealt with by a well-organised, transparent information campaign.

6. Conclusions

The German regulatory framework of NORM/TENORM waste management is relatively simple, industry-friendly and practicable. It allows for the disposal of NORM/TENORM wastes in ordinary and hazardous waste landfills if it can be shown that the effective dose to the public does not exceed 1 mSv/a (or 10 µSv/a for some NORM with exceptional origin). This can be shown by a dose calculation taking all relevant exposure pathways into account. To make the procedure simpler still, secondary limits and criteria have been defined which allow to drop dose calculations altogether if the activity concentration is below certain limits, and if the landfill meets some conditions. Conventional waste legislation and, if required, ADR transport regulations must be observed concomitantly with the radiation protection issues. Practically, all NORM/TENORM wastes can be disposed of using this regulatory framework in a short time without excessive effort and cost.

Whether disposal of wastes originating from other EU member states can continue to be disposed of in Germany under this regulatory framework, remains open at the time of writing because of an Amendment to the German Radiation Protection Act, which, in the view of the authors, contradicts the principle of free movement of goods and services in the European Union.