FINAL DISPOSAL OF RADIOACTIVE WASTE IN GERMANY: PLAN APPROVAL PROCESS OF KONRAD MINE AND ACCEPTANCE REQUIREMENTS

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ABSTRACT

Currently no final repository for any type of radioactive waste is operated in Germany. Preliminary Final Storage Acceptance Requirements for radioactive waste packages were published in 1995. Up to now these are the basis for treatment of radioactive waste in Germany. After licensing of the final repository these preliminary waste acceptance requirements are completed with licensing conditions. Some of these conditions affect the preliminary waste acceptance requirements, e. g. behaviour of chemo-toxic substances in case of accidents in the final repository or the allowed maximum concentration of fissile material. The presented examples of radioactive waste conditioning campaigns demonstrate that no difficulties are expected in management, characterization and quality assurance of radioactive wastes due to the licensing conditions.

INTRODUCTION

As there is no final repository for radioactive waste in Germany, the German utilities now store their low and intermediate radioactive waste in nearly 50 locations. These include capacities at the power plants, at two interim storage facilities off-site the power plants, at the major research centres as well as at the collecting depots for industry, medicine and universities. According to the German Atomic Energy Act the final storage of radioactive waste is a public task and therefore a final repository must be erected by the government.

After a long period of scientific exploration and investigation program the former Konrad Iron Ore Mine was considered offering ideal conditions for a final Repository for low and intermediate radioactive waste. So the licensing procedure for the erection and operation of a final Repository were initiated by the German Government on August 31, 1982. Between 1983 and 1990 the safety report “Plan Konrad” was worked out. The plan and additional documents were on view to the public in four cities of Lower Saxony in the vicinity of Konrad Mine for two months in 1991 leading to nearly 290.000 persons, objecting to the project. The objections were reduced to around 1000 topics of different categories. During the public discussion lasting about five months under the direction of the Lower Saxony Ministry of Environment (NMU) all these objections were negotiated.

Finally the licensing resolution was completed up to 2002. This plan approval decision contains about 450 licensing conditions but also draws the conclusion that all necessary provisions against possible effects due to construction and operation of the final repository are made including the aspects of long-term safety. The licence for erection and operation of the final repository at Konrad Mine was granted to the Federal Office of Radiation Protection (BfS) on June, 5th 2002. The licence was published and laid open for public inspections in June 2002.

Following the energy consensus between the Federal Government and the utility companies (June 2000) the request to immediately enforcement of the licence was already withdrawn in July 2000 by BfS. As a consequence it was possible to institute proceedings within a four-week-period up to end of July 2002. Citizens´ initiatives and also private persons instituted proceedings against the licence. Taking into account that these proceedings could last for several years BfS will not start converting the former ore mine into a final repository until court decision will be made.

LICENSING CONDITIONS AND PLAN APPROVAL PROCESS

Nevertheless, the plan to erect and operate the final repository for nuclear waste with negligible heat generation at the site of the former iron ore mine Konrad was approved according to §9b of the German Nuclear Act. The involved offices and institutions will be named in the following.

In Germany the responsibility for the final disposal of radioactive waste is with the federal government: It has charged the Federal Agency for Radiation Protection (BfS) at Salzgitter with the final disposal of radioactive waste. With respect to planning, erection and operation of these installations the BfS is using the services of the German Company for Construction and Operation of Final Repositories (DBE) at Peine as a third party. In Germany, any plan for a final repository has to be approved by the regulator responsible for licensing of nuclear installations in the respective federal state. In Lower Saxony this regulator is the licensing authority (Ministry of Environment - NMU) in Hanover. In the plan approval process for the final repository at the Konrad site NMU had engaged Technical Inspection Agency (TÜV) Hannover/Sachsen-Anhalt e.V. as an independent expert organization for the safety assessment of the repository. An overview of the authorities involved in the licensing process is given in Fig. 1 and described in Table I. Table II shows most of the affected legal fields.

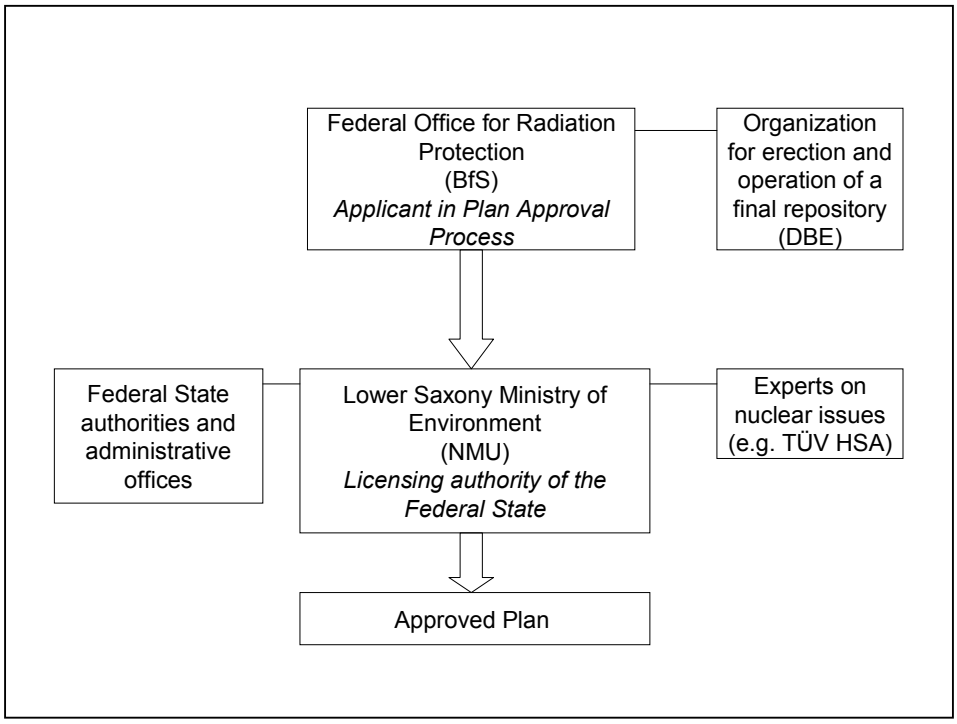

Figure 1: Authorities involved in the licensing process and supervision as well as operation of a final repository in Germany

Table I: Authorities, State Offices and other involved organizations to the plan approval process

Authorities and State Offices	**Abbreviation**
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety – Responsible for nuclear safety and radiation protection, BMU has the competence to issue directions and to supervise the legacy and expediency of the acts of the authorities responsible for enforcing the Atomic Energy Act and the Radiation Protection Ordinance	BMU
Lower Saxony Ministry for Environment – Federal State Licensing Authority	NMU
TÜV Hannover Sachsen/Anhalt e.V. – Independent expert organization for nuclear issues, in case of the plan approval process on behalf of NMU	TÜV
Lower Saxony Office for Soil Science – Federal State Office, in case of the plan approval process working for the NMU	NLfB
Federal Office for Radiation Protection – Federal authority in the portfolio of Federal Ministry of Environment, implements federal administrative tasks in radioactive waste management – In case of the plan approval process for the final repository Konrad the BfS is the applicant	BfS
German Company for Construction and Operation of Waste Repositories – contracted by the BfS as a third party	DBE

Table II: most relevant affected legal fields, acts and ordinances in the plan approval process

Act	**Ordinance**	**Abbreviation**	**Issue**
Act on Peaceful Utilization of Atomic Energy and the Protection Against its Hazards- Atomic Energy Act		AtG	Waste disposal and handling of radioactive material, waste repository construction and operation
	Ordinance on the Protection Against Damage and Injuries caused by Ionising Radiation- Radiological Protection Ordinance	StrlSchV	Radiation protection
	Ordinance on the Procedure for Licensing Facilities under Section 7 of the Atomic Energy Act	AtVfV	Licensing procedure for nuclear facilities
	Several ordinances concerning financial aspects	AtDeckV AtKostV EndlagerVlV	Financial security Cost of licensing Cost for waste disposal
Act on Precautionary Protection of the Population Against Radiation Exposure		StrVG	Supervision of radiation
Federal Mining Act		BBergG	Construction and operation of waste repositories
Act on Transport of Dangerous Goods		GGBefG	Transport
	Ordinance on the Internal and Cross-border Transport of Dangerous Goods by Rail- Dangerous Goods Ordinance Rail	GGVE	Transport
	Ordinance on the Internal and Cross-border Transport of Dangerous Goods by Road- Dangerous Goods Ordinance Road	GGVS	Transport
Act on the Assessment of Environmental Impact- Environmental Impact Assessment Act		UVPG	Environmental impact assessments for waste repositories
	Ordinance on Assessment of Environmental Impact for Mining Projects	UVP-V Bergbau	
	Ordinance for the Protection of Groundwater Against Pollution Caused by Certain Dangerous Substances- Groundwater Ordinance	GrWV	Groundwater protection

After conclusion the licensing process described above the approved plan is encompassing the erection of disposal galleries in the former iron ore mine Konrad approximately 800 to 1300 m below sea level with a maximum storage volume of 303,000 m^3 and the operation of this underground repository. Also the decommissioning of the repository together with including of the disposal galleries, the mine as a whole and the shafts with appropriate material is an issue of the approved plan.

The final repository is foreseen for the disposal of all radioactive waste with negligible heat generation originating from the generation of nuclear energy and the application of radioactive substances for medical, industrial, research and commercial purposes in Germany. To clarify in detail the application for plan approval of Final Repository Konrad dating from the year 1982, BfS and DBE had submitted approximately 500 documents characterizing the aforementioned waste and describing the planned repository. Some of these documents are determining the features relevant for the nuclear licensing decision in the form of specifications. Others are establishing details concerning additional legal aspects and fields affected by the licensing application. In the plan approval decision /1/ the specifications and further requirements are referenced as licensing documents. Additionally, the plan approval document is containing about 190 licensing conditions concerning nuclear safety, radiation protection and the long-term safety of the final repository as well as further conditions referring to other affected legal fields, as e.g. those of civil construction, railway transportation, road transportation, water exploitation.

LICENSING CONDITIONS AND PRELIMINARY ACCEPTANCE REQUIREMENTS

BfS submitted early in the licensing process the Preliminary Final Storage Acceptance Requirements for Final Repository Konrad. As mentioned in the preface /2/ “these requirements were developed on the basis of the results of a site-specific safety assessment. They include general requirements on waste packages as well specific requirements on waste forms and packaging and limitations for activities of individual radio nuclides. Requirements on documentation and delivery of waste packages were additionally included”. The Final Storage Acceptance Requirements were referenced in the plan approval decision as a revision dating from December 1995.

Further, requirements /3/ concerning the necessary quality assurance measures for the radioactive waste have been prescribed in a specification about characterization and verification of waste product properties during and after waste treatment. This was approved by the licensing authority NMU as well.

According to the preliminary waste acceptance requirements any specific waste treatment campaign leading to products for final disposal must be licensed by the BfS. Within the scope of this licensing process a waste specific process schedule plan must be compiled for each waste treatment campaign. All conditioning steps are listed in this plan as well as the respective sheets for documentation. Most of the waste conditioning campaign run in the past already used a process schedule plan ensuring waste treatment and chemical and radiological properties are described in sufficient detail. So far process schedule plans were compiled based on the Preliminary Final Storage Requirements.

With respect to the waste to be disposed off in Final Repository Konrad a number of licensing conditions has to be achieved. These licensing conditions were published with the plan approval and are not fully compatible to the Final Storage Acceptance Requirements. Two of these licensing conditions are exemplified in the following:

BEHAVIOR OF CHEMO-TOXIC SUBSTANCES

One requirement is to identify the potential for the release of chemo-toxic substances due to accidents in the final repository. If necessary, specific precautionary measures during the waste treatment and storage processes can be foreseen. According to the currently valid final storage requirements submitted as supporting document for plan approval the waste packages have to be chemically stable only during normal operation of the repository. There are no requirements concerning their behavior during accidents.

An example for this kind of waste products characterized by a potential for release of chemo-toxic substances only due to accidents in the final repository are products containing oxalic acid or its derivates. These products originate from aqueous oxalate decontamination agents used in nuclear power plants. Such liquid waste with varied concentrations of heavy metal oxalates has already been treated in different waste conditioning campaigns taking into account the applicable requirements for final storage. At temperatures above 100 °C – which could be exceeded under certain accident conditions – dry, oxalate-containing waste will decompose in an exothermic reaction leading to gaseous CO, CO_2 and the respective metal oxides.

Several campaigns with liquid waste containing oxalic acid were run in the past. Investigations of the drying behavior of the liquid waste as well as measurements to detect the lowest waste-specific decomposition temperature were made in each case. Decomposition temperatures were detected above 100 °C by thermo-gravimetric experiments.

One possibility to prevent the formation of chemo-toxic gases is using a special package concept. This ensures that in case of an accident the decomposition temperature characteristic for the specific oxalate-containing waste product will not be exceeded. The liquid waste containing around 10 g oxalic acid per liter was treated by evaporating water at vacuum conditions and temperatures between 60 and 80 °C using the conditioning facility FAVORIT. This facility is operated by the Gesellschaft für Nuklear-Service mbH (GNS) who presented their experience in conditioning of liquid waste using the FAVORIT at WM `99 /4/. For conditioning liquid waste containing oxalic acid, special casks were used. The inner cask was a simple 200-l-drum heated by an electric jacket heating unit. This 200-l-drum including the jacket heating unit was put into a cast iron cask "MOSAIK®" produced by GNS. The jacket heating unit remains in the package for final storage and the space between drum and cast iron cask is filled with an unburnable isolation material.

Certain Accidents which must be considered in a worst case scenario in the final repository will lead to a fire with temperatures at 800 °C lasting half an hour. On the basis of the additional licensing conditions of the approved plan the potential of chemo-toxic substances must be evaluated..

Mathematical calculations were made by the waste owner and assessed by an independent expert organization on behalf of BfS. For waste campaigns leading to waste products for final storage an approval of BfS is required. It was shown that the maximum temperature reached at the outer surface of the waste product in case of fire is still lower than the lowest waste-specific decomposition temperature.

The conditioning campaign using types of heat insulating packages for potential hazardous waste containing oxalic acid as described above was run under the conditions of the Preliminary Final Storage Acceptance Requirements. It has been shown that the starting temperature for exothermic decomposition of the oxalates will not be reached. Therefore the additional requirements of the licensing conditions have also been achieved without any additional conditioning steps.

Alternatively, the oxalate-containing waste can be treated such that the oxalates will already decompose during treatment. So the final waste product to be disposed off will be the corresponding thermally stable oxide. Figure 2 shows an overview of the process of conditioning metal oxalate at the nuclear Power Plant Gundremmingen (KGA).

It is used for conditioning of nearly pure metal oxalate from the recycling process of chemical or electrochemical polishing solvents. The waste product after decomposition of the oxalate in the cone impeller is a fine powder containing almost pure metal oxide.

This conditioning campaign for waste containing oxalic acid was also run under the conditions of the Preliminary Final Storage Acceptance Requirements. As the final waste product is a thermodynamic stable metal oxide the Preliminary Final Storage Acceptance Requirements as well as the additional requirements of the licensing conditions are fulfilled.

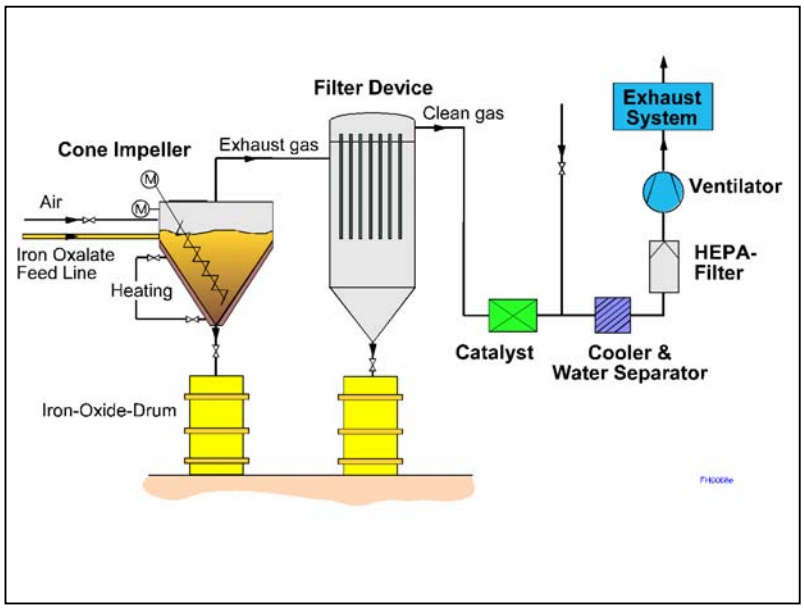

Figure 2: KGA-Process for Decomposition of Metal Oxalates

MAXIMUM CONCENTRATION AND DISTRIBUTION OF FISSILE MATERIAL

Another licensing condition is defining the requirements on the distribution and maximum concentration of fissile material in the waste product. According to this waste packages containing fissile material to an extent of one twentieth of the minimum critical mass for the specific fissile material have to meet special requirements. It has to be ensured that the concentration of fissile material in any arbitrarily selected cubic volume of 100 liters within the package is less than one twentieth of the specific critical mass. On the basis of the Preliminary Final Storage Acceptance Requirements the maximum concentration of fissile material is limited to 50 g per 100 liter waste product volume. The quantitative limitations of the licensing conditions are more restrictive than those of the preliminary final storage requirements.

Certain waste products originating from the nuclear fuel cycle are affected by this restrictive licensing condition. Operational waste from nuclear power plants is characterized by a different nuclide composition thus the restriction has no adverse effect. Owners of radioactive waste with increased fissile material contents will have to plan the respective waste treatment such that the requirements of the aforementioned licensing condition will be achieved.

As mentioned above waste treatment campaigns leading to final storage products must be licensed by the BfS on basis of a process schedule plan listing all conditioning steps as well as the respective sheets for documentation. So far process schedule plans were compiled based on the Preliminary Final Storage Acceptance Requirements.

To fulfill the aforementioned additional licensing condition of the approved plan it is necessary to have a known distribution of the fissile material within the waste package. A suitable technique could be to fix the waste in inner drums (e. g. by cementation) and to determine the distribution of the specific fissile material in each drum. In consideration of the distribution a special package concept can be developed which fulfills the one twentieth criterion as well as that on the compliance with the maximum concentration limitation. All of these waste treatment and characterization steps have to be considered while compiling the campaign specific process schedule plan. Also the special package concept is also approved in licensing of the process schedule plan.

Figure 3 shows a container with ten 200-l-drums containing waste originating from the nuclear fuel cycle and treated according to the described conditioning concept. It is assumed that there are different

but well-known distributions of fissile material in each drum. This assumption has to be verified by special measurements.

Figure 3: Container with fixed drums containing waste with higher concentration of fissile materials

This conditioning campaign for waste containing a higher amount of fissile material was started under the conditions of the Preliminary Final Storage Acceptance Requirements. After the licensing conditions for the final repository were published the waste owner changed the package concept to ensure a homogenous concentration of fissile material as much as possible. With this change documented in the process schedule plan the Preliminary Final Storage Acceptance Requirements as well as the additional requirements of the licensing conditions are attained.

SUMMARY

Also currently no final repository for radioactive waste is operated in Germany, Preliminary Final Storage Acceptance Requirements for the planned final repository Konrad are mandatory for waste conditioning. According to these requirements waste conditioning campaigns for final disposal must be licensed by the BfS. Each conditioning step during a campaign is prescribed in a campaign specific process schedule plan. In the approved plan for the final repository Konrad additional licensing conditions have been published, e. g. concerning the behavior of chemo-toxic substances in case of accidents or the limitation of fissile material in each waste package.

In waste campaigns important waste characteristics are documented on the basis of a specific process schedule plan. In case of conditioning liquid waste containing oxalic acid measurements of the characteristic decomposition temperature were foreseen according to the process schedule plan. The data obtained demonstrated that the additional requirements of the licensing conditions have also been reached without any additional conditioning steps. In case of radioactive waste containing higher concentrations of fissile material the more restrictive requirements of the licensing conditions of the approved plan can also be kept by using special package concepts.

As a result we come to the conclusion that even the additional requirements of Konrad´s licensing conditions do not cause major changes in the treatment of radioactive waste.

REFERENCES

/1/ Bekanntmachung des NMU vom 22.05.2002, Niedersächsisches Ministerialblatt, Hannover, Nds.MBl. Nr. 21/2002, S. 452ff (2002)

/2/ P. Brennecke, BfS-Report ET-IB-79, Salzgitter, December 1995

/3/ K. Kugel/W. Noack/B.-R. Martens/H. Giller/P. Brennecke, BfS-Report ET-IB-45, Salzgitter, August 1996

/4/ W. Hawickhorst, R. Finkbeiner, G. Gestermann (GNS), Liquid Waste Treatment from Source to Final Disposal, Waste Management 1999, Tucson (AZ) (1999)