The German Final Repository Konrad for Low and Intermediate Level Waste with Negligible Heat Generation - Water Law Issues - 9381

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ABSTRACT
A survey on the conceptual realization of the requirements due to water law aspects within the license the KONRAD repository for radioactive waste with negligible heat generation in Germany is given [1]. The regulatory decision for the implementation and operation of the repository KONRAD includes, among other things, water law issues. In particular, the KONRAD license includes waste requirements concerning non-radioactive hazardous material (waste package constituents) which have to be considered producing KONRAD waste packages. The intended philosophy of waste acceptance and waste package quality assurance measures to be considered by the KONRAD site operator as well as by the waste producer will be presented. It will demonstrate the selected procedure of the waste declaration and acceptance and describe the structure and logic of tools and aids to comply with the legal requirements of the license and its collateral clause issued under water law.

INTRODUCTION
In addition to the radiological hazards arising from the radionuclide inventory radioactive waste packages may contain non-radioactive substances that might be harmful to the groundwater. Therefore the licence of the KONRAD repository for radioactive waste with negligible heat generation according to the atomic energy act is complemented by the permission for the emplacement of non-radioactive harmful substances contained in the radioactive waste packages ("water law permission").

In complementation of the waste acceptance requirements for KONRAD limitations for 10 radionuclides, 2 groups of radionuclides and 94 substances and materials relevant for water protection issues are stipulated. This leads to regulations concerning the assignment of tasks and responsibilities in the field of conditioning and disposal of radioactive waste for the KONRAD repository. Thus, the operator (The German Federal Office for Radiation Protection, BfS) has particularly to fulfill the following:

- Monitoring the composition of the radioactive waste to be disposed of.
- Monitoring and recording of all non-radioactive hazardous substances being harmful to the groundwater.
- Estimation and recording of waste package composition of legacy waste.
- Verification of the inventory of harmful substances declared by the waste producers.
- Annual reports on the non-radioactive hazardous waste contents being disposed of in the KONRAD repository.

The identification of harmful portions of radioactive wastes is an ambitious challenge considering the fact that a complete analysis of waste packages should be avoided as far as possible. For this reason a standardized procedure of waste description and declaration was developed. While the waste producer has to describe harmful waste portions only above the description threshold value the operator of the repository site follows his task to declare harmful waste portions arising above the declaration threshold value. As tools compilations of materials and containers were generated to simplify and standardize the waste producer´s description of radioactive waste package constituents, e. g. concrete, steel, tissue, paint, etc. and to allow the operator the evaluation of the reported waste compounds concerning their hazardous contents.

The selected concept is still under examination by the competent authority, the final approval is still pending.

THE BASIC CONCEPT

The identification of the content and therefore the description of the waste package constituents are of pivotal importance for the declaration and balance of harmful substances. This process follows the logic shown in Fig. 1 below.

Radioactive waste which harmful components are to be described, recorded and balanced, is composed of the radioactive waste by itself, the waste container, and the immobilization material (if required) as well as shielding material. Following the basic concept each waste package has to be described by its components which supplies sufficient information about the harmful substances which are to be monitored referring to the water law permission of the license for the KONRAD repository. The description of, e.g., the KONRAD Container Type IV results in the chemical composition of this container and also in the identification of its harmful components. Using the intermediate information "container made of steel and alloys" a quantitative description of the amount of iron, nickel and similar steel additives can be achieved. Only the harmful components have to be balanced, declared and monitored in form of written documents or digitally as set of data in a database.

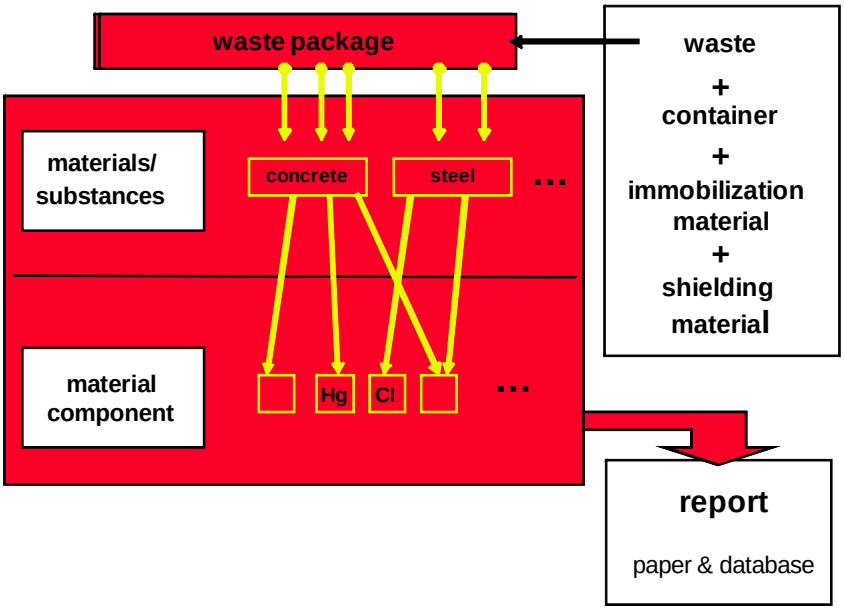

Fig. 1. Basic concept for the qualification and quantification of waste package constituents

Performing the legal requirements of the license and its collateral clause issued under water law, a multi-level procedure of description, examination, recording and balancing of non-radioactive harmful waste components was developed. Within this procedure the material composition of the radioactive waste has to be described at first, referring to Fig. 2. As basic tools a material-list and a container-list were generated to provide all achievable information necessary for the evaluation of substances regarding to their potential hazard to water.

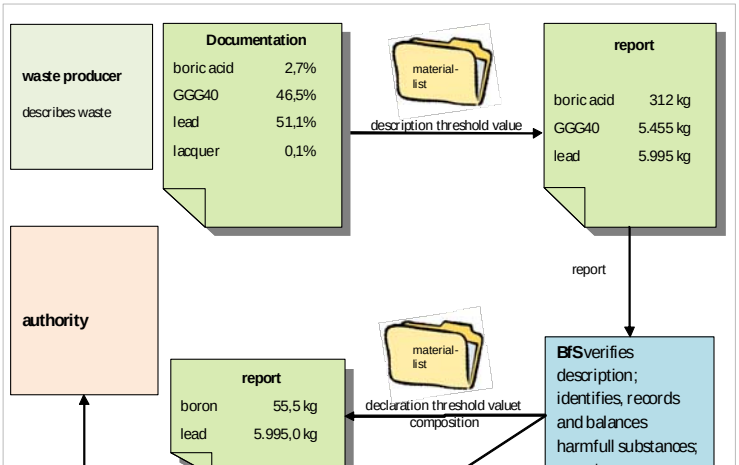

Fig. 2. Basic concept of material declaration

The material description of the radioactive waste to be disposed of is to be performed by the waste producers. The precision of the description of each substance is specified through the description threshold values and results from the material-list.

The BfS as the operator of the KONRAD repository has to verify the waste descriptions of the waste compositions and records and balances the contending harmful waste components. The classification is done comparably to the non-radioactive waste legislation on the base of declaration threshold values. According to the water law permission being part of the KONRAD license the BfS will have to report about the non-radioactive hazardous waste contents being annually disposed of.

MATERIAL COMPOSITION DESCRIPTION

The waste producer describes the waste by naming the material components or materials as such in relation to their gross mass fraction of the total gross mass. Reference values can be the waste package or a waste batch or even a waste stream. As a next step the waste producer has to identify each waste component in the material-list or the container-list to compare the mass portion of each material with its related description threshold value in the list. As a general rule the description threshold value is generally defined to be 1 % for new radioactive wastes and 5 % for legacy radioactive wastes. For materials with hazardous effects on the groundwater the description threshold values were defined according to the respective hazardous properties of each material component. Only materials with mass fractions above the description threshold value have to be mentioned within the description of the waste composition.

Materials not mentioned in the material-list and, thus, without an assigned threshold value can be added to the list which is designed as a living document. The waste producer must apply for the admittance of such waste component at BfS.
All waste containers (also inner containers) have to be named according to the codes and names in the container-list. Containers used by the waste producers which are not listed in the container-list have to be added by application (similar to the procedure described above).
Then the complete resulting material description as well as the rest of the waste documentation is handed in at BfS and checked within the frame of the regular waste package quality assurance / quality control process.

Reference values for the description of radioactive wastes

As a rule, the gross package mass is defined as the reference value for the description of materials in waste packages. But also alternative values are possible:

a) Batch of primary wastes or intermediate conditioned wastes:
In cases of one batch of primary wastes which will result in several waste packages or inner packages the waste description is allowed to be formulated for the whole batch. Example wastes could be large amounts of rubble from the same building section or ashes resulting from large incineration batches. Only waste batch components have to be described which description threshold values are exceeded referring to the gross mass of the waste package.

b) Batch of waste drums:
For waste drums resulting from a similar treatment or conditioning process with similar primary wastes or intermediate wastes, the description of the material composition can be done with an average composition description for the complete batch. This could be applied to the description of dried concentrates or cemented ashes. This leads to material vectors. The composition of a single waste package results from the product of each waste package gross mass and the portion of the batch material vector.

c) Batch of waste packages:
Waste packages resulting from the same conditioning process with similar primary wastes or intermediate conditioned wastes can be described with an average description of the composition of the total batch. This also leads to material vectors. As already mentioned under b) the composition of a single waste package results from the product of each waste package gross mass and the portion of the batch material vector.
This procedure might cause slight mistakes for the single waste package which appears to be negligible for the total batch.

Definition of the description threshold value

The water law permission names masses for 94 elements and substances and also defines boundary conditions for the implementation of a procedure for the declaration of harmful substances in radioactive waste packages, such as:

- In general no complete analysis of the waste packages should be necessary.
- The waste producers have to declare the inventory of harmful substances.
- The declaration has to be checked by the BfS.
- Impurities that do not harm the groundwater are not recorded.

It must be kept in mind that the masses for the 94 substances result from an inquiry to the waste producers. These figures do not represent the results of a site-specific safety analysis. On the one hand, the masses for the 94 elements and substances are very low in some cases. Taking into account that due to the water law permission traces of substances may be neglected, these limitations do require a very exact declaration of the chemical composition of the respective waste package constituents. On the other hand, the water law permission points out that in general a complete analysis of the waste packages should be avoided in order to avoid an additional radiation exposure.

These conditions lead to the necessity to develop reliable tools for the description of the composition of wastes. A compromise between the best achievable description accuracy and a reasonable data collection effort had to be found regarding to the protection aims of the license of the KONRAD repository and its water law permission.

To model these requirements the description threshold value was set to 1 % for new and 5 % for legacy wastes. For materials with harmful components the description threshold value is set in dependence to the harmfulness for the groundwater.
Taking into account the above mentioned masses, a procedure is suggested refering to the well established waste legislation for non-radioactive wastes. According to that, the harmfulness of a material can be classified by the use of the hazardous properties and risk phrases. The following Table I gives a short overview on t the hazardous properties of materials which can be harmful to the groundwater.

Table I. Hazardous properties with related concentration limits which can possibly be harmful to the groundwater

Hazardous property	**Concentration limits**	**Symbol**
very toxic	Total concentration ≥ 0,1 % of one or several materials	H6
toxic	Total concentration ≥ 0,3 % of one or several materials	H6
harmful to health	Total concentration ≥ 25 % of one or several materials	H5
Corrosive (R35)	Total concentration ≥ 1 % of one or several materials	H8
Corrosive (R34)	Total concentration ≥ 5 % of one or several materials	H8
Irritant (R41)	Total concentration ≥ 10 % of one or several materials	H4
Irritant (R36, R37, R38)	Total concentration ≥ 20 % of one or several materials	H4
Carcinogenic (Cat.1 or 2)	Total concentration ≥ 0,1 % of one or several materials	H7
Carcinogenic (Cat.3)	Total concentration ≥ 1 % of one or several materials	H7
Mutagenic (Cat.1 or 2, R 60, R61)	Total concentration ≥ 0,5 % of one or several materials	H10
Mutagenic (Cat.3, R 62, R63)	Total concentration ≥ 5 % of one or several materials	H10
Teratogenic (Cat. 1 or 2, R 46)	Total concentration ≥ 0,1 % of one or several materials	H11
Teratogenic (Cat. 3, R 40)	Total concentration ≥ 1 % of one or several materials	H11
R 50-53	Total concentration ≥ 0,25 % of one or several materials classified as hazardous to the environment (R50-53)	H14
R 51-53	Total concentration ≥ 2,5 % of one or several materials classified as hazardous to the environment (R51-53)	H14
R 52-53	Total concentration ≥ 25 % of one or several materials classified as hazardous to the environment (R52-53)	H14

There are no specific water-related regulations for repositories in Germany. Thus, the chosen procedure follows the advices of the *Guidelines on the Application of the Waste Catalogue Ordinance* published by

the German *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety* giving notice of the guidelines for the application of the Waste Catalogue Ordinance (Abfallverzeichnis-Verordnung - AVV) of 10 December 2001. This ordinance assigns hazardous material properties to harmful effects on the quality of the near-surface groundwater which puts the material waste legislation on the equal level of water protection legislation.

With the properties listed above all properties are covered which could possibly cause harmful effects on the quality of the near-surface groundwater. Analogue to the existing non-radioactive waste legislation it is assumed that materials with masses below the concentration limits do not cause harmful effects on the water. In reverse, all materials exceeding the concentration limits are claimed to be harmful.

In the case that more than one hazardous property can be linked to a material, the most restrictive value will be chosen. The classification of hazardous properties can also be based on facts in material safety data sheets.

As mentioned above the description threshold value for new wastes differs from the description threshold value for legacy waste. The reason for this can be found in deficient access to already conditioned or packed radioactive waste. The radiation exposure for the staff appears to be unreasonable high as compared to the possible gain of information. This aspect is literally considered in the water law permission of the KONRAD license allowing the reasonable estimation of harmful components in already existing waste packages (legacy waste). This requirement is met by the description threshold value for legacy wastes on a five times higher level than for new wastes.

Using this procedure of description threshold values it must be taken into account that the amount of substances, which are not harmful by definition, may be higher than the limitation of the water law permission within one waste package. For these elements and substances lower threshold values were determined. All thresholds are proofed to cause no harm to the near surface groundwater.

RECORDING AND MONITORING OF NON-RADIOACTIVE HARMFUL WASTE COMPONENTS

Due to the license BfS as operator of the KONRAD repository has to

- monitor the composition of the radioactive waste disposed of,
- record all substances that are harmful to the groundwater,
- verify the inventory of harmful substances declared by the waste producers,
- prepare annual reports on the amount of harmful substances emplaced in the repository for the competent authority.

Non-radioactive harmful waste components described by the waste producer have to be identified, recorded and balanced by the use of the declaration threshold value. The declaration threshold value is the mass fraction which is able to cause harmful effects on near-surface groundwater.

Definition of the declaration threshold value

This requirement is realized due to the use of the declaration threshold value which claims conformity with the non-radioactive waste legislation procedure. European and German legislation, especially the *first directive on classification, packaging and labeling of dangerous substances* [2] *(Council Directive 67/548/EEC)*, defines the hazardous property of a material with the concentration of its presence. The classification of hazardous properties is related with concentration limits. Contrary to the definition of the description threshold value the declaration threshold value is not limited to an upper bound, which means,

that concentration limits were transferred from the non-radioactive waste legislation directly without adaption.

Materials without hazardous properties or concentration limits have to be classified by the self-rating system following a German water protection directive [3]. The resulting water hazard classification allows 3 classes which can be related to the hazardous properties and risk phrases of the material legislation as shown in Table II. The relation of water hazard classes to hazard properties and risk phrases of materials enables the adaption of the concentration limits of the material classification.

Table II: Correlation between water hazard classes and concentration limits via risk phrases

Water hazard class	**Analogue risk phrase**	**Effects of risk phrase**	**Concentration limit**
WGK 1	R 52-53	**Harmful** to aquatic organisms, may cause long-term adverse effects in the aquatic environment	25 %
WGK 2	R51-53	**Toxic** to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	2.5 %
WGK 3	R50-53	**Very toxic** to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	0.25 %

Examples for recording and balancing of waste packages

Not-immobilized rubble in a KONRAD container Type V:

The waste producer has reported 16,780 kg standard concrete (hardened) and 2,023 kg of steel (Type S235JR). Both materials have no properties relevant to water hazards and therefore do not need to be recorded and balanced. This information is to be taken from the material-list with its risk phrases and hazardous properties of each waste material.

Ashes in pellets in a KONRAD container Type V:

The waste producer reported 8,030 kg of ashes, 3,364 kg of steel D235JR, 7,700 kg of standard concrete (hardened) and 91 kg of lacquer to the operator BfS. Related to material component only “ashes” is relevant in the means of water protection. Only “ashes” shows a declaration threshold value over 100 %.

Miscellaneous waste

Miscellaneous waste as an important waste stream can not be sorted or processed into mono-fractions. Regarding to the production process the composition of that waste arising from a definite procedure can be averaged over long periods of time. The declaration threshold value of miscellaneous waste can be defined due to the components and the rating of the declaration threshold values for each component according to their portion in the total waste.

The calculation of the declaration threshold value results in the following equation (eq. 1):

$$DS = \frac{DS_i}{\xi_i} \cdot 100 \qquad \text{(eq. 1)}$$

with

DS declaration threshold value of the material

DS_i declaration threshold value of the material component

ξ_I mass portion for the material component of the total material mass

MATERIAL WASTE PACKAGE QUALITY ASSURANCE

The material waste package quality assurance / quality control is, according to the KONRAD license, to be additionally introduced to the already existing radiological waste package quality assurance. It implies organizational and administrative regulations in order to define the responsibilities, tasks and operations of the involved parties. The BfS as the operator of the repository assures the quality of the waste packages and containers as well as the compliance with the waste acceptance requirements.

BfS is allowed to use subcontractors with the execution of the necessary control measures which are to be added to the already existing control measures for the radiological quality assurance. Radiation protection aims as well as the reasonability of measures to gain the best achievable accuracy are the principal components of the material waste package quality assurance.

The control measures should therefore be possibly reduced to

- Non-destructive testing
- Visual testing
- Plausibility checks
- Transfer of generic data
- Already existing analysis results.

The principles of the material waste package quality assurance are:

1) The material waste package quality assurance has to assure the avoidance of harmful effects on the groundwater. For this the integral and total impact of harmful substances into the repository has to be monitored.
2) The material waste package quality assurance is supposed to give the best realistic, but not the best covering material description.
3) Investigations of specific harmful substances or materials with low declaration threshold values have to be executed only with reasonable suspicion.
4) Complete analysis for the generation of material data are not to be demanded.
5) The material waste package quality assurance has to be executed together with the radiological waste package quality assurance.
6) Common principles of radiation protection have to be considered.

By using these principles the material waste package quality assurance ensures a sufficient safety level for the protection of the near surface groundwater.

REFERENCES

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