

Realization of Requirements on Non-Radioactive Waste Package Constituents - 11441

Peter Brennecke* / Karin Kugel* / Stefan Steyer*
Wilma Boetsch** / Detlef Gruendler** / Claudia Haider**

* Bundesamt für Strahlenschutz, Salzgitter, Germany
** Institut für Sicherheitstechnologie, Cologne, Germany

ABSTRACT

Within the licensing procedure for the Konrad repository, i.e. a disposal mine in deep geological formations for short-lived and long-lived low-level and intermediate-level radioactive waste, the possible impact of non-radioactive waste package constituents such as cadmium, lead and mercury on the near-surface groundwater was investigated. This investigation completed the site-specific radiological safety assessment for the post-closure phase. The Konrad license issued on May 22, 2002, comprises limitations on the radiological inventory (i.e., maximum permissible activities) as well as on the non-radioactive chemical/chemotoxic inventory. As to this, the licensing authority particularly imposed limitations on the permissible masses of 94 elements and organic/inorganic compounds. In order to transfer these requirements into practicable measures for the waste generators and conditioners as well as for Bundesamt für Strahlenschutz (BfS - Federal Office for Radiation Protection) being the licensee and operator of the Konrad repository, the concept of material vectors has been developed and implemented. Comprehensive model calculations were performed taking assumptions into account on the distribution of those 94 elements and organic/inorganic compounds within all radioactive waste envisaged to be disposed of in the Konrad repository. Thus, the fulfillment of the requirements imposed by the licensing authority could be demonstrated. Principal results are included in an amendment (draft) of the Konrad waste acceptance requirements as of October 2010. At present, the assumptions used are more and more amended and/or replaced by actual data supplied by the waste generators.

INTRODUCTION

In the Federal Republic of Germany, solid or solidified radioactive waste with negligible heat generation (i.e., low-level and intermediate-level waste (LLW and ILW)) containing short-lived and long-lived radionuclides will be disposed of in the Konrad repository at an emplacement depth of approx. 800 m. This facility is located in the northern part of Germany near Salzgitter-Bleckenstedt, federal state of Lower Saxony. The Konrad repository is under construction since May 2007 starting with the establishment of the Konrad project group within BfS and comprehensive preparatory planning work. Construction works are anticipated to last for about 10 years.

Waste packages to be disposed of mainly consist of non-radioactive organic and inorganic substances including, e.g., chemotoxic constituents such as cadmium, lead or mercury. The chemical composition of such substances is of importance from the groundwater pollution perspective. Attention must be paid to the chemical composition of the radioactive waste, the immobilization material (if used) and the waste containers/packagings. Thus, as part of the Konrad post-closure safety assessment, the radiological long-term effects (radionuclide-specific radiation exposures) as well as the potential pollution of the near-surface groundwater by non-radioactive organic and inorganic waste package constituents had to be investigated and evaluated.

During the licensing procedure the Konrad waste acceptance requirements were prepared and published as draft, focusing on radiological requirements. Even in their preliminary form these requirements were successfully used giving guidance to the waste generators with respect to LLW and ILW conditioning [1].

KONRAD WATER LAW PERMIT

The investigation and evaluation of a potential pollution of the near-surface groundwater was performed within the Konrad licensing procedure. The results served as basis for the requisite allowance according to water law [2, 3]. Procedures and selected results of this investigation of concern are given in [4, 5]. The allowance according to water law is given in Annex 4 to the Konrad license issued on May 22, 2002 [6].

Maximum Masses of Harmful Substances

The allowance quantitatively stipulates the maximum masses of 94 non-radioactive harmful substances (elements and organic/inorganic compounds) to be disposed of in the Konrad repository. These masses are indicated in comprehensive tables classified by

- substances referring to the lists I and II in the annex of the Groundwater Ordinance [3], and
- other substances which may cause a potential pollution of the groundwater in terms of Section 137 of the Niedersächsisches Wassergesetz (NWG - Water Act of Lower Saxony) [2].

Emplacement of such substances in addition to the radiological inventory is only admissible if explicitly mentioned in the permit, and if the maximum masses are not exceeded.

It must be pointed out that the maximum masses of all 94 harmful substances as imposed by the competent licensing authority in Annex 4 to the Konrad license (allowance according to water law) result from an inquiry into the chemical composition of radioactive waste intended for disposal in the Konrad repository. The data supplied by the waste generators and conditioners were used as input data for the safety-related investigations performed within the licensing procedure [5]. Thus, the maximum masses specified in the permit do not represent results of those investigations. From a safety point of view much higher masses could be accepted without any fear of a harmful pollution of the near-surface groundwater or a detrimental change of its characteristics.

In addition to the maximum masses of harmful substances, the Konrad allowance according to water law comprises further requirements to be dealt with [6]. The permit states that BfS shall monitor radioactive waste intended for disposal with respect to its chemical composition. The actually emplaced radionuclides as well as the emplaced non-radioactive harmful substances must continuously be registered and balanced.

Specification of Requirements

The basic requirement on permissible masses of non-radioactive harmful substances (i.e., waste package constituents) is defined more precisely in the Konrad water law permit:

- A chemical analysis of the waste package contents is not required for monitoring, registering and balancing the harmful substances.
- Trace impurities may be left unconsidered for the determination of the amounts and balance of harmful substances. Trace impurities may include substances mentioned in the permit as well as other substances whose amounts cannot be quantified. Trace impurities must only occur in such amounts not causing detrimental changes to the near-surface groundwater.

- A quantitative registration is impossible for already existing conditioned waste. From radiation protection perspective it is inadvisable to open waste containers and analyse their content. In these cases, an estimation of the mass of harmful substances must be a sufficient basis.

The basic requirement only addresses the harmful substances and the mass limitations, respectively. There is no information given on the chemical/chemotoxic composition of LLW and ILW to be disposed of in the Konrad repository.

Thus, there are two important aspects given in the Konrad water law permit as well as the lacking information on the composition of waste packages that must be considered when realizing and transferring these requirements into practicable measures serving the waste generators/conditioners and Bundesamt für Strahlenschutz (BfS - Federal Office for Radiation Protection) being the licensee and operator of the Konrad repository. These aspects are:

- Limitation of the masses of 94 elements and organic/inorganic substances.
- Allowance to exceed these limitations or to dispose of harmful substances not given or limited in the Konrad water law permit but only in such masses that a harmful pollution of the near-surface groundwater or another detrimental modification of its characteristics is not to be feared (i.e., that the protection goal of the water law is met).
- No specific information on the presence and allocation/spreading as well as on the chemical form of 94 elements and organic/inorganic substances in the waste packages available.

IMPLEMENTATION OF THE KONRAD WATER LAW REQUIREMENTS

Basic Concept

The transfer of the requirements imposed in the Konrad water law permit has been based on the concept of so-called material vectors [7]. The concept is based on the idea that, in general, the waste forms, immobilization materials (if used) and waste containers/packages (i.e., the materials of all waste packages intended for disposal in the Konrad repository) must chemically only once be characterized. For this purpose data on non-radioactive harmful substances contained in a waste stream (e.g., ion exchange resins), waste form, waste container, waste package or charge of waste packages including, if applicable, immobilization material and material used to fill up residual voids, are to be compiled in a comprehensive materials list. In addition, data on waste containers/packages including interior linings are to be described and quantified in the containers list. Thus, the materials list and the containers list being available, it is sufficient to refer to those data being applicable when radioactive waste is registered for disposal in the Konrad facility. On the basis of these data, BfS will easily register and balance the masses of non-radioactive harmful substances. Further details on the concept chosen are given in [8, 9].

Following the basic concept, the non-radioactive harmful substances which are contained in radioactive waste with negligible heat generation must be registered and described according to their type and amount. The waste generators are responsible for supplying the information and data needed. To this end, all waste package constituents exceeding the relevant description threshold values have to be indicated. These values describe the fraction of a non-radioactive harmful substance contained, e.g., in a waste form, waste container, waste package or charge of waste packages, which must be indicated with respect to the chemical composition. The description threshold value thus defines how accurately non-radioactive substances must be described.

While the waste generator has to describe harmful waste portions only above the description threshold value, BfS operating the Konrad repository has to declare harmful waste portions arising above the declaration threshold value. The declaration threshold value defines the percentage mass fraction of a harmful substance which, if exceeded, must be balanced. Both the description threshold values and the declaration threshold values are included in the materials list and, in extracts, as in the October 2010 draft of the Konrad waste acceptance requirements [10]. If the declaration threshold values are exceeded, respective masses are balanced. Masses of harmful substances not exceeding the threshold values are neither to be indicated nor to be balanced (trace impurities).

Model Calculations

As already pointed out, no specific information on the presence and allocation/spreading as well as on the chemical form of 94 elements and organic/inorganic substances in the waste packages was available. Unfortunately, the waste generators and conditioners only supplied very few comments on the items originally compiled in the material and container lists. As a consequence, numerous and comprehensive model calculations including assumptions and model data must be used. These extended investigations are rather complicated, especially with respect to the appearance of harmful substances in the radioactive waste and the assessment of the respective chemical compounds. As input data those calculations substantially comprised:

- Limited masses of 94 elements and organic/inorganic substances as given in the Konrad water law permit [6] including in addition the radioactive uranium and thorium inventories.
- Concentration limitations as given in water law-relevant rules and regulations (e.g., Ordinance on Drinking Water).
- Allocation/spreading of non-radioactive harmful substances in the radioactive waste to be disposed of in the Konrad repository.
- Chemical form of the harmful waste package constituents.
- Solubilities.

Nevertheless, the calculations and examinations resulted in a confirmation of the approach pursued by BfS. In addition, a distinct procedure was developed for the description, examination, and approval of waste data set entries into the materials and container list [11]. According to this procedure, an examination of the BfS concept with respect to its applicability by the waste generators and conditioners is in progress. More and more information and data on individual material vectors (e.g., on radioactive waste originating from nuclear power plant operation or from decommissioning and dismantling of nuclear power plants and fuel element fabrication facilities) are supplied by the waste generators.

Validation of the Implementation

The implementation of the chosen concept as described so far represents a tool easily to be applied by both the waste generators and conditioners, as well as by the operator of the Konrad repository. However, prior and, as far as necessary, in parallel to the repository's operation, the procedure has to be validated with respect to the numerous model calculations that have had to be carried out due to lacking information on the appearance of non-radioactive harmful substances in the radioactive waste and the assessment of the allocation/spreading of the respective chemical compounds in a waste stream, waste form or waste package. Thus, information and data already or in future to be supplied by the waste generators will allow for a validation of the concept. In this way model items and assumptions are replaced in a step-by-step

procedure with waste generator - specific (real) data. Nevertheless, it cannot be excluded that the validation of the concept for transferring the requirements given in the Konrad allowance according to the water law, i.e. the repetition of the former model calculations with real data, may result in newly determined description and/or declaration threshold values.

MATERIAL WASTE PACKAGE QUALITY ASSURANCE / QUALITY CONTROL

According to the Konrad water law permit the material waste package quality assurance/quality control is to be prepared and implemented in addition to the existing radiological waste package quality control. These measures serve to demonstrate the compliance of waste packages to be disposed of with the Konrad waste acceptance requirements.

To minimize efforts and radiation exposures, the control measures on non-radioactive waste package constituents are embedded in the well-established and successfully performed radiological waste package quality control. Thus, adequate protection of the near-surface groundwater can be assured by appropriate control measures to be performed in parallel to the radiological control measures. According to this procedure, there are no new quality control principles to be introduced. The existing options process qualification, sampling and waste container examination are appropriately to be extended and enlarged due to the aspects being of relevance for non-radioactive harmful substances. Nevertheless, this approach offers the opportunity to use existing information on the chemical composition, e. g., results of analyses being performed within the scope of the radiological waste package quality control, thus reducing additional expenditures and proofs.

These steps can also be used as a basis to check the chemical composition of the waste forms and, with this, of the whole waste packages. For example, evaporation concentrates have already to be characterized to ensure the fulfillment of respective conditions of a chosen conditioning process. These chemical analyses can also be used as basis for chemical characterization purposes once a suitable materials vector is approved for the respective waste form and is verified on basis of the analysis which are carried out during the conditioning process as a standard. The same procedure is to be applied to, e.g., miscellaneous waste taking existing instructions on sorting of the different constituents/components of this type of waste into account.

Thus, in general, already performed analyses, checks, and the documentation of the fulfillment of working instructions (e.g., sorting instructions for solid low-level radioactive waste originating from the operation of nuclear facilities) can be very useful in order to verify the applicability and suitability of already approved material vectors. Therefore, no general changes in the conditioning processes and the quality assurance/quality control procedures are to be expected - the additional measures do not comprise comprehensive and/or detailed checks and examinations.

CONCLUSION

The Konrad water law permit addresses chemical/chemotoxic safety-related requirements on radioactive waste disposal. Thus, BfS has faced the challenge to develop and to implement practicable measures for the transfer of the limitations and requirements given in this permit. Although the final implementation of the concept is still pending, more and more waste generators submit information and data on waste streams, waste forms, and waste packages envisaged for disposal in the Konrad repository, namely for gaining experience in the application of the system developed by BfS. According to the current status, an implementation including the revised Konrad waste acceptance requirements and the measures for waste package quality assurance/quality control may be expected in spring 2011.

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