Optimized Planning of the Disposal of radioactive Waste Packages exceeding the German Waste Acceptance Criteria Limits for Fissile Material Content and for Heat Generation - 10450

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Abstract

The waste producers in Germany are preparing the disposal of radioactive waste in the Konrad repository, an abandoned iron ore mine. To minimize the waste volume they are optimizing the content of their waste packages up to the limits of the waste acceptance requirements for the Konrad repository. Therefore, the limits of heat production or of fissile material for a single container can be exceeded. By placing other containers with smaller inventories of heat producing nuclides or fissile material around these containers the overall safety criteria for the repository are met. The paper describes the cooperation of different waste producers with the aim of reducing the amount of waste packages. It will give some examples of the paperwork to be done and the planning of the logistics for the transportation and the disposal of the packages.

Introduction

Due to the German Atomic Law the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit - BMU) is supported by the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz - BfS) in performing its federal supervision in all matters concerning nuclear safety and radiation protection. The responsibility for the disposal of radioactive waste lies with the Federal Government and BfS is the legally responsible authority. Therefore, all methods for the treatment of radioactive waste and for the conditioning of waste packages for disposal have to be approved by BfS. Complementary the waste treatment has to be qualified for disposal due to the German Radiation Protection Ordinance by BfS. The evaluation of reports for the qualification of waste treatment processes for storage and disposal is done by experts of TUV EnSys Hannover on behalf of BfS.

The radioactive waste disposal policy in Germany has been based on the decision that all types of radioactive waste are to be disposed of in deep geological formations. Near-surface disposal or shallow land burial is not practiced in Germany because of the high population density and climatic conditions; furthermore, appropriate deep geological formations for hosting a repository exist.

In 1982 an application was submitted to dispose of non-heat generating waste at the Konrad mine, i.e., an abandoned iron ore mine. The license was issued on 22 May 2002 for 303,000 m^3 low- and medium-level radioactive waste at maximum. However, the decision was not legally valid since objections had been filed. After the final court decision in 2007 confirming the license and the

decision of the Federal Government it will take several years until the emplacement of radioactive waste in the Konrad repository can start. In parallel to the licensing procedure the Konrad waste acceptance requirements and, pertinent to these requirements, the Konrad radioactive waste quality control measures are successfully applied. Nevertheless, final improvements on the waste package disposability are still to be made.

The German Konrad repository for disposal of radioactive waste packages with negligible heat generation is envisaged to start its operation in 2014. The revised waste acceptance requirements will be available in 2010. These requirements for the Konrad repository consist of different limits. The upper limits for the radionuclide-specific activity content due to the safety assessment of assumed incidents are limits relating to single waste packages. It is not allowed for the content of each container to exceed these activity limits.

Limits of the fissile material content of the waste package can be exceeded if the neighboring containers in storage and disposal facilities are free or are only containing small amounts of fissile material. For these waste packages exceeding the limits for the fissile material content an approval by BfS is required prior to delivery to the Konrad repository.

Additionally the heat production of the waste packages due to the decay of the radioactive isotopes in the waste is limited so that the maximal heat transfer to the geological formation will not result in heating up the host rock more than three Kelvin. It is possible to fulfill this requirement by limiting the isotope content of every container or by positioning containers with higher heat production in the repository in the vicinity of containers with rather low heat production. For waste packages exceeding the permitted heat production an approval by BfS is required prior to delivery to the Konrad repository.

The waste producers in Germany are preparing the documentation of their existing waste packages and starting to plan arrangements for the waste emplacement campaigns. If a waste producer possesses radioactive waste packages exceeding the limits for heat generation and/or for the content of fissile material, he can co-operate with other waste producers and demonstrate that his waste can be compensated by waste packages with lesser inventories. Several waste producers are co-operating and organizing their disposal campaigns together for an efficient use of the waste acceptance requirements for the German Konrad repository.

Radioactive waste from a fuel factory for MTR and gas cooled reactors

In 1960 the NUKEM company was founded in Hanau as a fuel factory for MTR and gas cooled reactors. The facility was situated in an industrial region, surrounded by diverse industry buildings, e. g., for the chemical industry. The plant was located on an area of ca. 11,500 m^2 (3 acres). In 1988 it was decided to empty the fuel content of the facility, to close down the fabrication and to demolish the plant and the buildings. After a long phase of planning and licensing the decommissioning and dismantling started in 1980. In 2000 the respective license was granted. Except for the cleaning of the water from traces of thorium and uranium the decommissioning was finished in 2006. The cleaning of

the groundwater will last some further years. With the exception of 1,000 m^2 the area is now released from the atomic law.

Most of the material was very low contaminated and an exemption of atomic law was possible. An amount of 98,000 m^3 was sent to a waste repository for non-nuclear hazardous waste, situated in a former salt mine. Approximately 700 m^3 of radioactive waste had to be treated for an interim storage facility and for the disposal in the Konrad repository. At first this waste from the dismantling phase was packed in 2,100 200-l-drums. Additionally 2,600 200-l-drums from the operational phase had to be treated. At first these drums were stored on the NUKEM site. However, these drums were not suitable for a longer interim storage period. To achieve a good volume reduction for the interim and final storage of the waste products the following methods for the pretreatment were chosen:

Packaging,
Super compaction,
Incineration and super compaction of the ashes, and
Cementation of slurries in rectangular containers.

The pretreated waste products, like the pellets from the super compaction, were filled in new certified 200-l-drums. 1,114 drums and ten containers with cemented slurries were produced. For disposal the drums are packed in rectangular containers. The waste stream from the operation and the dismantling of the NUKEM fuel factory consists of approximately 100 packages. From the cleaning of the area and the demolishing of the buildings more than 2,000 drums with soil and rubble were produced being not suitable for an exemption from the atomic law. Therefore, these materials had also to be treated as radioactive waste.

The radionuclides contaminating the waste were in general only thorium and uranium isotopes. Due to the high enrichment of the uranium, a blending had to be practiced to fulfill legal requirements for the transport, the treatment and the interim storage. However, this blending does not fulfill all requirements of the waste acceptance requirements of the Konrad repository. Therefore, most of the enriched uranium in these waste packages has still to be looked at as fissile material.

To achieve a good volume reduction the packaging of the drums and the filling of the void volume in the containers with contaminated rubble, soil and debris from the demolishing was optimized. Figure 1 demonstrates the filling of a container with 200-l-drums and shredded contaminated debris.

Figure 1: Filling of containers with drums and debris

Some of the containers exceeded the allowed content of fissile material by the Konrad waste acceptance requirements. Therefore, a certain number of containers with very low content of fissile material are needed to be placed around some containers with NUKEM waste.

Figure 2 shows radioactive waste packages of the NUKEM waste in an interim storage facility at Hanau. These containers are ready for disposal in the Konrad repository, only minor adjustments have to be made to the documentation for the declaration of certain non-radioactive hazardous material.

Figure 2: Interim storage of containers filled with radioactive waste

Waste from the dismantling of a MOX fuel factory

In 1965 the Siemens mixed-oxide (MOX) fuel factory, located in Hanau, Germany, formerly operated by ALKEM GmbH, started operation. Approximately 8,500 kg of plutonium in form of mixed oxide have been processed to fabricate MOX fuel rods and assemblies. In 1991 the facility was shut down for political reasons. In 1997 a cleaning process was started to process the remaining fissile material into rods and storage-assemblies suitable for long-term storage. In September 2001 this process ended and the decommissioning of the facility started.

Several dismantling techniques have been developed and established to perform the decommissioning. The residuals have been estimated to about 80 kg of Plutonium. Therefore, plutonium-contaminated wastes with a high content of fissile material had to be treated.

The equipment was dismantled, e.g., by cutting the different items into pieces of different sizes. This waste was cemented into 200-l-drums after determination of the Plutonium content.

The method of waste cementation was used since 1984. The drums had been stored at the Siemens site in Hanau. All the drums had not suffered any corrosion during their storage period of up to 20 years and, judging from this experience, corrosion is not expected during the next 10 or 20 years either. However, since interim storage may have to be prolonged for further years and the waste drums are not designed for a long interim storage period, other steps had to be taken to ensure safe long-term interim storage. The concept was to create a waste package which needs no maintenance over a long period of storage, incorporates state-of-the-art technology and will probably not require any further treatment of the waste containers.

The implemented quality assurance and quality control system for radioactive waste in Germany has proven to be effective for disposal as well as interim storage at various sites. For non-heat generating radioactive waste such a set of requirements has already been defined. Technical solutions for meeting the respective requirements for those waste packages are well established.

Decommissioning the MOX plant in Hanau all these aspects had been observed. During all steps of the decommissioning procedure of the MOX fuel fabrication plant of Siemens Power Generation in Hanau, from the termination of fabrication until final waste conditioning measures, the fissile material inventories and the long-term-behavior of the waste product itself are well known. Approved and new developed detection systems as well as standard calculation methods and developed codes were used for this purpose.

Due to the methods used the observance of mass limits and criticality safety was guaranteed in every state of the decommissioning process. The above described measurement systems for small packages, 200-l-drums and larger components originating from decommissioning of the Hanau MOX facility were qualified by BfS. All the waste was cemented after quantifying the total fissile content of the individual waste packages. As the measurement precision on measurements of cemented components is rather low, all measurements had to be carried out prior to cementation. Experts commissioned by German authorities monitored all steps.

All the waste properties were well documented. Approval for disposal after completion of waste treatment was given only after TUV ENSYS experts have verified compliance of the waste properties with the Konrad waste acceptance requirements. The waste product is well known and suitable for long-term- intermediate storage, too.

The conditioning started in 200-l-drums and was completed in July 2005 with the end of the decommissioning of the MOX-plant. More than 1,100 containers have been produced by Siemens Power Generation and are stored in an interim storage facility at Hanau until the Konrad repository will start its operation. From the dismantling of a MOX fuel factory radioactive waste was generated exceeding the upper limits for fissile material. Additionally, some containers exceed the limit for heat production of the Konrad waste acceptance requirements due to their high alpha content. These containers may only be disposed of together with waste packages with rather low heat generation and fissile material content.

A certain number of these waste containers were transferred in the responsibility of the owners of those nuclear power plants who received MOX fuel elements from the Siemens factory. Therefore, RD Hanau is responsible for the disposal of 57 containers produced by Siemens Power Generation with waste from the operation and decommissioning of the MOX plant.

Nuclear power plant waste

For compensation of the fissile material and the high activity contents the waste producers of these two waste streams were searching for waste originating from the operation and the dismantling of a nuclear power plant. The dismantling of a light water reactor generates a sufficient amount of low active waste with practically no fissile materials. Therefore, the high fissile content in the waste and the high content of heat producing radionuclides from dismantling of the fuel element facilities can be compensated. Such waste originates from the operation and dismantling of the Kahl experimental nuclear power station (VAK).

The Kahl experimental nuclear power station (VAK), the first German nuclear power plant, was decommissioned after 25 years of operation (1961 to 1985). The BWR plant generated approx. 2 million kWh of electricity in 150,000 hours of operation at a gross power of 16 MWe. After the operator, VAK GmbH, had filed an application for decommissioning, the first of four decommissioning permits was issued in 1988. The plant is to be demolished completely so that the site will no longer be within the scope of atomic law. At the end of 2008, the demolition work was finished.

Dismantled material was subjected to radiological testing under the supervision of the expert appointed by the regulatory authority and allocated to different waste categories. The waste arising was packaged in accordance with its classification, and was removed into interim storage facilities or managed in the conventional way. A part of this material was designated for storage as radioactive waste. The remaining material was approved to be utilized at a landfill site by the regulatory authority.

Planning the campaign of the three waste streams

Approximately 150 containers of low-level radioactive waste are needed; the volume of all the waste packages will be about 2,000 m³. The radioactive waste packages from the two fuel element facilities were already documented and the data of the waste products are checked by independent experts on behalf of BfS. Only the inventories of certain non-radioactive hazardous material have still to be documented for the waste packages originating from the demolishment of the fuel factories.

The waste from the decommissioning of the nuclear power plant is already packed in 200-l-drums and in containers. The drums have to be packed also in containers and the resulting containers have to be documented. After the checking of the documentation by independent experts on behalf of BfS, the planning of a possible dilution of the waste containers with higher activity content can be made in detail. Figure 3 shows a possible configuration of the waste containers in the Konrad repository.

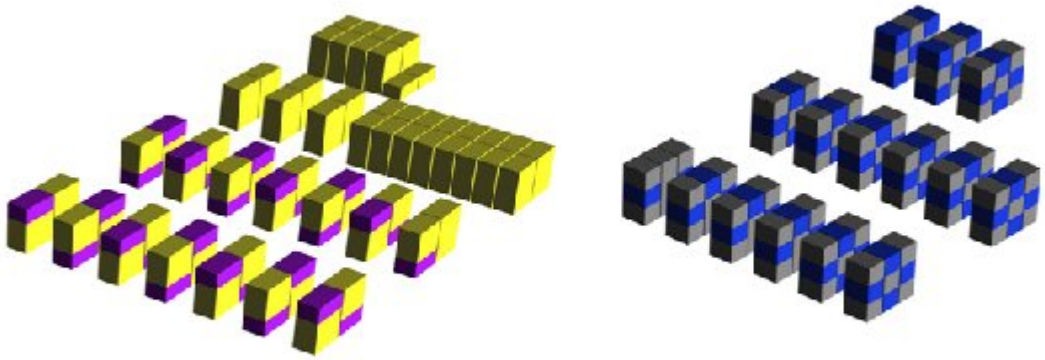

Figure 3: Possible configuration of waste containers with different activity content in the Konrad repository

Conclusion

Radioactive waste packages from three different waste producers will be assembled in one disposal campaign so that all the containers can be disposed of without violation of the Konrad waste acceptance requirements. Some containers are violating the limits of these acceptance requirements. However, their emplacement in combination with other waste containers with lower activity content is possible.