Approval of Existent Waste Packages and New Package Designs in Preparation for the KONRAD Repository - 8092

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ABSTRACT

Low and intermediate level radioactive waste from German nuclear and other industries, research facilities and increasingly decommissioned nuclear installations is handled and prepared for interim storage and later disposal in the licensed KONRAD repository.

This paper presents aspects, experiences and perspectives of container design testing and qualification procedures. Several new container designs, in particular different types of steel plate containers, have been tested and licensed; some are handled at present or just applied. Examples from typical qualification procedures including drop tests from 0.8 and 5 m height with prototype containers are presented.

On the other hand several thousand waste packages are currently stored in interim storage facilities, many of them for more than 10 or 15 years. Based on existing package documentations applications and safety assessments for KONRAD are prepared and have to be evaluated. The paper discusses aspects, difficulties and strategies to demonstrate sufficient compliance to the current KONRAD repository requirements for the large number of existent waste packages.

INTRODUCTION

During the last decades low and intermediate level wastes have been prepared for their long term interim storage in view of the planned KONRAD repository (Fig. 1.). Meanwhile the Morsleben repository was opened again between 1994 and 1998 after the German reunification and a limited waste volume of about 22.300 m^3 could be disposed off there. But Morsleben was finally closed thereafter and on October 8, 2003, backfilling selected cavities as a measure to prevent mining hazards started. The purpose of the backfilling measures is to ensure the stability of the mine for the long term. The measures should be completed in 2010.

With the final federal court decision from March 26, 2007 the given license for the German KONRAD repository was confirmed to satisfy all legal requirements. Now, further steps for the technical preparation of the former iron ore mine are en route to start operation of the repository preferably until 2013/14. Against this background German waste producers substantiated their plans for waste conditioning directly for KONRAD as well as qualification of legacy waste packages from so far interim storage facilities. Both ways represent a large number of containers of different designs to carry the manifold waste products fulfilling the well specified KONRAD requirements for containers and waste products. Therefore, the number of applications for container qualification is always increasing.

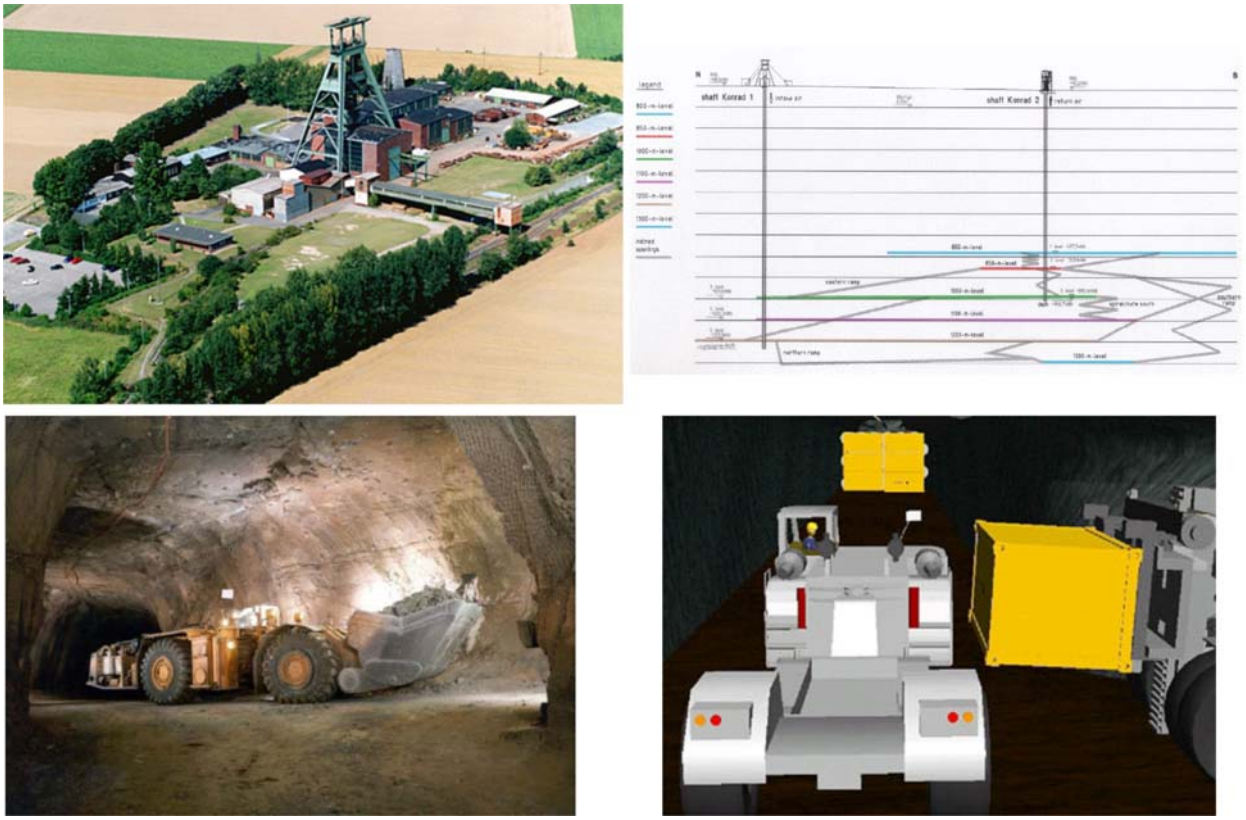

Figure 1. KONRAD repository (http://www.dbe.de/en/sites/konrad/1/index.php)

THE KONRAD CONTAINER QUALIFICATION PROCESS

Applications for KONRAD licenses have to consider the KONRAD requirements published by BfS, the Federal Institute for Radiation Protection [1, 2]. Former publications have explained requirements and container classification in detail [3, 4, 5].

Relevant Regulations for Container Design and Evaluation

Generally, waste conditioning and packaging must comply with the legal requirements from transport, storage and disposal and must be certified by state authorities for interim storage and the authority for disposal, the Federal Office for Radiation Protection (BfS). Basic regulations in that field are:

- German Atomic Act,
- German Radiation Protection Ordinance
- National Transport Regulations for Dangerous Goods based on the international IAEA Regulations,
- German guideline on radioactive waste monitoring (“Abfallkontrollrichtlinie”),
- Recommendations by the German Reactor Safety Commission (RSK) for long term interim storage
- Interim storage licenses with their specific waste and package acceptance criteria

and
- KONRAD requirements [1, 2].

Qualification procedures, technical and safety requirements for containers are given by the above mentioned documents in detail. Because of only low and intermediate waste activity levels most containers have to fulfil Industrial Package (IP) or Type A transport requirements and only in limited cases Type B requirements. The certification of the waste containers for interim storage at the respective storage facility is carried out on basis of the transport qualification with additional requirements as a result of the site specific safety analyses. Since closure of Morsleben in 1998 the so far preliminary KONRAD requirements were mostly considered as well to ensure if possible later acceptance by that repository.

KONRAD Requirements for Containers

With respect to container qualification the KONRAD requirements define different acceptable container types and sizes. They contain box-shaped and cylindrical types and can be made of steel, cast iron or concrete. The total gross mass is limited to 20 metric tons.
The KONRAD repository acceptance criteria [1, 2] define two package categories, called Waste Container Class I (ABK I) for lower activity levels and Waste Container Class II (ABK II) for higher activity levels. The corresponding activity limits are nuclide and waste product specific following from the safety analyses of the repository.

All container types have to fulfil basic requirements like shape, volume, gross mass, 6 m stacking height, if necessary a specified leakage rate, corrosion protection, no mechanical and corrosion damages, consideration of ISO standards for container handling corners.
Additionally, ABK I containers have to demonstrate integrity after a collision with a velocity of 4 m/s, respectively a 0.8 m drop, so that in a following accident fire (1h, 800°C) waste products with a melting point >300°C do not burn in an open fire.

In addition to the basic requirements, ABK II containers have to demonstrate a leakage rate $\leq 10^{-4}$ Pa·m³/s after a 5 m drop onto the real ground of the repository and a following accident fire (1h, 800°C). This guarantees a defined limitation of gas and activity release. Alternatively, demonstration of sufficient thermal insulation by the container walls due to a heat conduction resistance of <0.1 m^2K/W with a limitation of waste product temperatures to < 80°C is appropriate.

Both container classes can be used in combination with an accident safe packaging of the waste products. This makes container class requirements change in some aspects. In case of ABK I containers the waste must be fixed in stable form or must be packed in inner packages like drums which are themselves fixed in stable form. The fixing has to demonstrate its stability in case of a 5 m drop or the inner packages must stay integer. In case of ABK II containers the waste must be fixed in stable form and must be packed in inner packages which are themselves fixed in stable form. After a 5 m drop, the integrity of the inner packages has to be demonstrated or the leakage rate of the container has to be $\leq 10^{-4}$ Pa·m³/s. With respect to a following accident fire (1h, 800°C) demonstration of a stable thermal insulation of the container walls is sufficient or it has to be proven that no radiological relevant activity release occurs.

Responsibilities during the Qualification Process

Transport regulations require approvals by the competent authority BfS only in case of Type B packages. Type A and IP-2, IP-3 packages demonstrate their qualification by the manufacturer and only the quality assurance systems has to be evaluated by BAM.

Interim storage qualification is evaluated by the German state authorities who are supported by technical supervision organisations (TÜV's). The approval is given by the responsible state authority. Usually, container transport qualification is a basis also for interim storage qualification because all packages have to be shipped at least to the central repository in the future. For that same reason, also disposal requirements are commonly considered if possible.

BfS is the competent authority for the KONRAD container and packaging qualification processes. Container design testing and safety evaluation including quality assurance system and measures are performed by BAM as regulated by a co-operation contract with BfS. Application and safety assessments must be arranged as defined by the KONRAD requirements. Safety assessments from transport and interim storage qualification can be applied and are accepted if appropriate.

TESTING OF NEW CONTAINER DESIGNS

Container design testing is based upon complete application documents do demonstrate compliance with the KONRAD requirements. In terms of container design essential items are:

- Material qualification,
- Dimensions and masses,
- Container handling corners,
- Leakage rate requirements,
- Corrosion protection,
- Mechanical design considering normal operation and accident loads
- Thermal design considering KONRAD test scenario.

In case of a new container designs without transferable safety assessments and prototype tests of similar designs a prototype test program is required considering the following test conditions:

- Selection of a representative test container
- Stacking test,
- Lifting test,
- Drop test(s),
- Thermal test
- Leak-tightness.

Test results have to be recorded and evaluated in a comprehensive test report.

Examples of former BAM design testing of steel, ductile cast iron and concrete containers including some pictures can be found in (4). In the recent past many more container designs, mostly steel containers of different types, have been tested at the new BAM drop test facility, because drop testing is commonly the most severe test scenario for a container design. Fig. 2. shows a steel container of KONRAD Type V (3.20 m length, 2,00 m breadth and 1,70 m height;

volume = 10.9 m^3) in a 80 cm drop test onto the unyielding BAM IAEA foundation as a conservative test condition. The container category is ABK I without fixed content. The test container was loaded with larger pieces of scrap metal and filled up with gravel as a representative loading option. The most critical drop orientation was found to be an edge drop with the container lid down, which results in maximum forces of the loose contents onto the lid fixing system during the impact. The test criteria are preservation of container integrity without discharge of any contents (gravel). Fig. 2. shows only little deformations of the container after the test without any critical damages.

Fig. 3. shows a steel container of KONRAD Type V in a 5 m drop test. The container is classified as ABK I and II with accident safe packaging of waste products. This means, the waste is fixed in eighteen 200 liter drums which are themselves fixed in the container with concrete. In this case a flat drop onto the side wall of the container with a very hard impact was chosen and again the conservative unyielding BAM IAEA foundation was used. Test results showed preservation of the stable waste fixing and Integrity of the inner packages (drums).

Fig. 2. Steel container KONRAD Type V drop test; ABK I; 80 cm drop height.

Fig. 3. Steel container KONRAD Type V drop test; ABK I+II with accident safe waste packaging; 5.0 m drop height.

QUALITY ASSURANCE FOR CONTAINER FABRICATION AND LOADING

Quality assurance measures for package fabrication and operation are obligatory for transport, interim storage and disposal. The basic guideline, primarily issued for transport packages but also applied in the field of storage, is given by the German technical rule TRV 006 [6]. The container manufacturer has to demonstrate that he has a certified quality management system and that his fabrication works on an appropriate quality assurance program. Finally, each container type must be fabricated on the basis of certified “Inspection and Test Plans”. With a KONRAD container type approval given by BfS the applicant manufactures containers on the basis of certified fabrication and test plans. Finished and compliant containers are then ready for use.

According to the German Radiation Protection Ordinance all waste treatment and conditioning processes must be approved with respect to disposal by BfS since 2002. Treatment and conditioning processes for interim storage approved by BfS with respect to disposal are required in most cases since 1996. Examples and further details of waste conditioning and treatment campaigns were presented in [5].

Due to the fact that the KONRAD container approval is carried out independently from any waste conditioning procedure but considers specific mechanical and/or thermal waste properties with potential relevance to the former container design testing, interactions between container and waste products have to be checked within the waste specific treatment and conditioning campaign evaluation. Typical cases are mechanical and thermal waste product properties with relevance to the design testing conditions. If there are limitations in the test certificate and approval additional safety assessments would be necessary. Another aspect is corrosion protection especially at the inner container surfaces. It has to be assured, if necessary by additional handling requirements, that waste products do not damage corrosion protection coating during the loading procedure. Because different parties are involved in container design testing (BAM), design approval (BfS), waste specific treatment and conditioning campaign evaluation (TÜV) it was obvi-

ous that a co-operation is useful especially in difficult cases, primarily with regard to waste product conditions and properties.

The most important waste conditioning campaign was the packaging of waste from decommissioning the Siemens fuel fabrication plant in Hanau. More than 1,000 steel containers of different KONRAD types, all with a preliminary KONRAD approval, were loaded with MOX- and uranium waste, construction waste and larger metallic components. The campaign was finished in December 2003 and the containers are stored in an interim storage building until they can be delivered to the KONRAD repository.

Due to some more years until the KONRAD repository is expected to start operation BfS, BAM and TÜV are planning a data based container documentation including waste data and waste conditioning campaigns in connection with container fabrication documentation. First benefits are expected when used for future waste conditioning campaigns. Authorities and technical experts are able to check container certification easily including possible limitations for waste products. On the other hand, several thousand packages will exist until 2013/14 and such data based documentation allows quick investigation of container documentations in connection with the belonging waste campaign characteristics. Benefits are expected in any case of later discussion of package properties and especially when delivery campaigns to KONRAD are planned.

SAFETY ASSESSMENT AND QUALITY ASSURANCE FOR EXISTING PACKAGES

Due to the continuous need of conditioning radioactive waste also in the past some thousand waste packages do exist in German interim storage facilities. Analyses performed show that in many cases Packages contain waste products, which are conditioned based on an approved treatment and conditioning process. But containers are only qualified and approved for interim storage by the respective authority.
On the other hand a large number of legacy packages (most of them conditioned before 1988) exist, where neither a detailed description of the conditioning process nor a detailed documentation of the containers exist.

Fig. 4. Existing Waste Packages in the Storage Facility of the Karlsruhe Research Centre

For such predictable situations the KONRAD requirements contain special paragraphs defining test requirements for existing containers. Documentation, design testing and quality assurance measures are also for such containers the main assessment goals. Generally, the equivalence of container safety assessments and the manufacturing documentations in comparison to a new container design testing procedure has to be evaluated. Possible strategies are reference to comparable objects/containers and additional investigations to demonstrate sufficient compliance with the KONRAD requirements. In addition to containers waste products have to be evaluated as well. If documentations are not sufficient additional investigations might be necessary to determine required physical, chemical and nuclear waste properties. Currently, first applications were made and evaluation procedures for containers of a wide range of fabrication time and documentation quality have started. The strategy agreed between BAM, BfS and the applicants is to start with the latest containers showing least differences in documentation and to move step by step to the older containers with poorer documentation status.

CONCLUSIONS

With the final court decision of 2007 confirming the KONRAD license further steps for the technical preparation of the former iron ore mine are en route to start operation of the repository preferably until 2013/14. Technical requirements for containers and waste products are now widely mandatory and container design qualification as well as waste conditioning and treatment campaigns are increasing tasks.

BAM has performed several container design evaluations on the so far preliminary and now mandatory KONRAD requirements including drop tests with different container design of different applicants. More evaluation procedures and design tests are expected for the future.

Another important topic is the evaluation and approval of several thousand existing waste containers and packages. Minor effort is expected for packages conditioned on basis of design and waste conditioning and treatment campaign approvals for interim storage considering the KONRAD requirements if possible. Higher effort is expected for legacy packages with poorer documentation status. There it might be necessary to perform additional investigations to determine the requested container and material properties as well as waste properties. Evaluation procedures in the field of package and container qualification have started now and strategies between BfS, BAM and TÜV have been discussed.

REFERENCES

1. P. BRENNECKE, „Anforderungen an endzulagernde radioaktive Abfälle (Endlagerungsbedingungen, Stand: September 1995) – Schachtanlage KONRAD – *(Radioactive waste disposal requirements – KONRAD mine –)*“, Bericht ET-3/90-REV-3, Bundesamt für Strahlenschutz (BfS), Salzgitter (1995).

2. B.-R. MARTENS, „Produktkontrolle radioaktiver Abfälle – Schachtanlage KONRAD – (Stand: September 1995) *(Quality assurance of radioactive waste products – KONRAD mine –)*“, Bericht ET-IB-45-REV-2, Bundesamt für Strahlenschutz (BfS), Salzgitter (1995).

3. P. BRENNECKE, S. STEYER, G. BANDT, „Management of Radioactive Waste in Germany: Quality Assurance of waste packages with respect to IAEA Recommendations”, Waste Management Conference WM ´04, Tucson, AZ (2004).

4. H. VÖLZKE, U. ZENCKER, G. BANDT, „Qualification and Design Testing of Packages for Transport, Interim Storage and Disposal of Low and Intermediate Level Waste in Germany”, Waste Management Conference WM ´05 (WM-5400), Tucson, AZ (2005).

5. G. BANDT, H. VÖLZKE, P. BRENNECKE , S. STEYER, H. GRUNAU, „Waste Products and Containers - Qualification Procedures for Interim Storage and Disposal”, Waste Management Conference WM ´05 (WM-5399), Tucson, AZ (2005).

6. Der Bundesminister für Verkehr (Federal Ministry of Transport), “Technische Richtlinie über Maßnahmen zur Qualitätssicherung (QM) und –überwachung (QÜ) für Verpackungen zur Beförderung radioaktiver Stoffe (TRV 006)“, Verkehrsblatt Amtlicher Teil, 45. Jahrgang 1991 Heft 4, S. 233 ff. (1991)