

**DECOMMISSIONING AND CLOSURE OF THE
MORSLEBEN DEEP GEOLOGICAL REPOSITORY
THE FINAL STEP**

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ABSTRACT

In Germany, a deep geologic repository for low and intermediate-level waste has been in operation since 1971. This repository, which is located in the territory of former Eastern Germany, became a Federal Facility in the wake of German reunification in 1990. Since then, waste from all of Germany was disposed of until a stop ordered by BfS in 1998. The site is now in the process of being decommissioned and later closed down. This process includes updating the concept for guaranteeing appropriate waste isolation for as long as the waste remains a hazard. During the licensing procedure being currently conducted, in line with German requirements for repository sites, the site operator must provide convincing proof of the facility's long-term safety. Thereafter, implementation of the decommissioning and closure concept will follow. It is estimated that the licensing procedure will take until the year 2006. The decommissioning and closure process itself will require about 10 years. Reliable costs estimates are not yet available. This paper briefly covers the history of the Morsleben radioactive waste repository and provides a draft update on the status of the licensing procedure.

INTRODUCTION

In Germany, 19 nuclear power plants with a total generation capacity of 22.3 GW supply some 35% of the electricity delivered to the public power grid. Following a recent change in the country's energy policy, the Federal Government and the electricity utilities entered in 2001 into an agreement to phase out nuclear power use after a transition period lasting until about 2020. The Government is also reconsidering the German waste disposal program. Changes affecting the schedule of repository projects are now effective, among others a moratorium for the development of the Gorleben exploration mine. Other activities are not affected as, e.g., decommissioning of the Morsleben deep geologic repository, on which this paper focus.

The Morsleben repository for radioactive waste was commissioned in 1971 in Eastern Germany, the then German Democratic Republic. This pioneer deep geological disposal facility, second only to the Asse experimental repository in Western Germany that had started receiving waste in 1967, remained in operation for 27 years until October 1998. Pursuant to a decision by the German Federal Government inaugurated in the fall of 1998, this facility will not be further used for waste disposal, and is to be permanently closed down. The original site operation license did not cover all aspects of relevance today for decommissioning under the now valid regulatory framework. Therefore, decommissioning requires a full-scope licensing procedure, which is currently being conducted. Actual decommissioning will immediately follow. In implementing

this final step in the life cycle of a deep geologic repository, a worldwide first-of-a-kind-task, the involved parties are obtaining unique, pioneering experience. In the course of the “plan approval procedure”, (licensing procedure) the site operator must provide convincing proof that the protection objectives laid down in regulations are fully met. These include not only radiological aspects, but also other environmental requirements, as surface protection against subsidence and groundwater protection, which greatly impact the technology to be used in providing long-lasting waste isolation.

WASTE DISPOSAL AT MORSLEBEN – LOOKING BACK

The Morsleben deep geologic repository is located in a salt formation at approximately 500 m depth, in Northern Germany, in the Federal State of Saxony-Anhalt. At the site, potassium was mined until the early twenties of the last century. Thereafter rock salt mining went on until 1969, leaving open cavities with a volume of approx. 8 million m³. In 1970, the nuclear power plant operator of the former German Democratic Republic (East Germany) bought the mine to convert it into a repository for low and intermediate-level radioactive waste, predominantly short-lived. In the wake of German reunification on October 3, 1990, Morsleben became a Federal Facility under the authority of the Bundesamt für Strahlenschutz (BfS, the Federal Office for Radiation Protection). Site operation was assigned to the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE, the German Company for the Construction and Operation of Repositories for Wastes). Figure 1 below shows an aerial view of the surface facilities.



Fig. 1: Morsleben deep geologic repository – Surface facilities

The Morsleben deep geologic repository was licensed and entered into operation in a stepwise procedure lasting several years. First disposal of radioactive waste took place on December 7, 1971, on the basis of a provisional site authorization and a license to deal with radioactive waste as ruled by the Radiation Protection Regulations then in force in East Germany. In a short campaign approximately 500 m³ of waste with a total activity of 1.85 TBq, mainly from the production and use of radionuclides, were disposed of. With this, enough capacity became available at interim storage facilities to cover the period until start of trial operation at industrial scale in 1978.

After collecting operational experience during three years, a first operation license for five years was granted in 1981. A further permanent operation license, issued on April 22, 1986, allowed disposal for unlimited time. Following German reunification on October 3, 1990 an amendment to the Atomic Energy Act of the Federal Republic of Germany declared the continuing validity of the site operation license under the law of Germany until June 30, 2000. A later law extended the validity of the operation license until 2005.

Shortly after German reunification, and pursuant to a court decision, waste disposal was discontinued on February 25, 1991, to allow for a detailed reassurance of the act ruling the continuing validity of the East German license under the law of the Federal Republic of Germany. The Federal Administrative Court finally confirmed the license's legality on June 25, 1992; disposal was reassumed on January 13, 1994.

In this pioneer deep geologic repository, different categories of solid LLW and ILW as well as sealed radiation sources were thereafter routinely disposed of until 1998. The Administrative Court competent for the site ruled on September 25 of that year to stop waste disposal in the new chambers of the so-called eastern field as a temporary measure to protect the rights of one opponent to site operation that had filed suit until her complaint had been resolved by the court. BfS then ordered the suspension of all other disposal operations until a final court ruling reassured the site license status. The last waste disposal operation was carried out on September 28, 1998. The new Federal Government resulting from the federal elections held in October 1998 later decided never to reassume waste disposal. BfS issued a corresponding statement on April 12, 2001. The site will be completely decommissioned and closed down. At present, the licensing procedure before the competent authorities in the mining and nuclear field is under way.

For waste disposal at the Morsleben deep geologic repository the most widely used technology was stacking of LLW packed in drums in chambers by means of a special-purpose fork lift truck with heavy radiation shielding. Figure 2 shows such a disposal chamber in the mentioned eastern field. This single chamber, commissioned in the fall of 1997, had a capacity of about 20,000 m³, i.e. enough to take all the LLW arising in Germany in a period of approximately 7 years. Waste with higher activity content, delivered to the repository in shielding overpacks, was discharged into closed chambers below a drift through shielding lock systems. Waste was disposed of on the basis of contracts between waste producers and the Federal Government. Ownership of the waste passed over to the Federal Government upon delivery, the producers paid a fee to settle all current and future costs.



Fig. 2: Deep Geologic Disposal at Morsleben - Eastern Field

As previously stated, after German reunification in 1990 the legal system of the Federal Republic of Germany was introduced in the former East Germany. Notwithstanding this, disposal at Morsleben continued being carried out under the rules and limits set forth by the original East German license. Among other things, the original waste classification into waste classes and radiation protection groups as defined by the permanent operation license of April 1986 was maintained. This license allowed disposal of waste of three classes, namely:

- Class A1: solid waste
- Class A2: liquid waste
- Class A3: sealed radiation sources

For each such class, waste belonging to some of the six radiation protection groups into which the waste classes had been subdivided was acceptable for disposal. The radiation protection groups defined radiation dose rate limits outside the waste package for solid waste, activity limits for sealed radiation sources, and activity concentrations for liquid waste.

Before German reunification, liquid waste was disposed by in situ immobilization with a hydraulic binder. This practice was discontinued by order of BfS in 1990, in the framework of a revision of the waste acceptance criteria, which introduced additional restrictions. According to the latest valid set of such acceptance criteria only solid waste with a dose rate below 1 Sv/h at 0.1 m distance of the unshielded package surface as well as sealed sources with an activity below 200 GBq were acceptable for disposal. Further requirements on waste products and waste packaging were similar

to usual acceptance criteria for near surface disposal. Worth to be mentioned are an upper limit of 0.4 GBq/m³ for the activity of α -emitters. Furthermore, only packages with a β/γ activity concentration below 40 TBq/m³ were acceptable. Additional activity concentration limits for single nuclides resulted from the updated operational and long-term safety analyses. A detail of waste quantities disposed of at the Morsleben repository between 1971 and 1998 is included in Table I below. Table II provides information about activities and main radionuclides.

Table I. Waste Disposal at Morsleben until October 1998.

Disposal Period	Solid Waste [m ³]	Liquid Waste [m ³]	Radiation Sources [pieces]
1971 – 1990	5,987	8,253	6,200
1990 – 1991	187	4.8	27
1994 – 1998	22,320	-	394
Total 1971 – 1998	28,494	8,258	6,621

Table II. Waste Amounts, Activities, and main Activity Contributors

Disposal Technology	Quantity	β/γ -Activity		α -Activity	
		Bq	Nuclide Vector	Bq	Nuclide Vector
In situ Solidification	8,258 m ³ A2 waste	$8.1 \cdot 10^{13}$	Co-60 36% Cs-137 28% Cs-134 9%	-	
Drum Stacking	26,476 m ³ A1 waste	$9.6 \cdot 10^{13}$	Mn-54 7% Co-58 4% Fe-55 3%	$1.2 \cdot 10^{11}$	Am-241 70% Ra-226 10% PU-239 9%
Discharge into Chambers	2,018 m ³ A1 waste 6,621 sealed sources	$1.6 \cdot 10^{14}$ $4.3 \cdot 10^{13}$	Ni-63 3% Pm-147 2% H-3 2%	$1.1 \cdot 10^{11}$ $8.5 \cdot 10^{10}$	Pu-240 5% Cm-244 4%
Total	36,752 m ³ waste 6,621 sealed sources	$3.4 \cdot 10^{14}$ $4.3 \cdot 10^{13}$	CE-144 1% Sr-90 1% C-14 1%	$2.3 \cdot 10^{11}$ $8.5 \cdot 10^{10}$	

Table II shows that the activity disposed of at Morsleben mainly consist of radionuclides with half-lives of about 30 years and shorter, and even the α -activity, mainly due to Am-241 sealed sources from smoke detectors, is relatively short-lived at 432 years. It is therefore interesting to compare the activity actually disposed of at Morsleben with the activity limit as defined by the license. The data compiled in Table III below clearly shows that the activity in the repository is only a small fraction of the very conservatively determined, acceptable activity limits.

Table III. Acceptable and Actually Disposed of Activity

	β/γ -Activity	α -Activity
Total Acceptable Activity	$1.00 \cdot 10^{16}$ Bq	$1.00 \cdot 10^{13}$ Bq
Disposed of Activity	$3.83 \cdot 10^{14}$ Bq	$3.15 \cdot 10^{11}$ Bq
Percentage of Total Acceptable Activity	3.83 %	3.15%

SITE DECOMMISSIONING AND CLOSURE – THE WAY AHEAD

After the decision by the German Federal Government of never reassuming waste disposal at Morsleben, the final step in the repository lifecycle is site decommissioning and final closure. This is also a pioneering task, for nowhere else in the world a deep geological repository has reached a comparable status. The only site in an analogous condition is the mentioned Asse experimental repository in Germany. But in spite of the technical similarities, the legal status of the Asse is quite different, and this makes decommissioning and closure there from an administrative standpoint rather simple.

The licensing procedure started with filing a corresponding application in May, 1997. Of special importance here is to demonstrate to the authorities the isolation potential of the repository multiple barrier containment system. The site safety assessment was originally based on a preliminary backfilling and sealing concept. More detailed site-specific information later becoming available and respective safety analyses proved this concept not to be the most adequate.

In the framework of the licensing process now under way, convincing proof must be given that the site in its final stage meet all protection objectives. These include:

- Radiological protection
- Protection of the surface against subsidence
- Protection of the groundwater

The long-term radiological protection objectives applicable to the Morsleben repository are similar to the ones considered for the Konrad site, now in the final stage of licensing. Basically, protection to future members of the public shall be the same granted to humans living today, in line with the “*Safety Criteria for the Final Disposal of Waste in a Mine*”, the German regulation stating the protection objectives for final repositories. Said regulation contains no time cut-off, but it is assumed that model computations underlying any safety analysis become increasingly inaccurate with time, so that only a period of up to 1 million years is considered. Such a period is more than sufficient, in view of the activities involved.

Moreover, the “*Federal Mining Act*” and ancillary regulations demand guaranteeing adequate protection of the surface against subsidence. Therefore, underground cavities remaining open must be stabilized to avoid their sudden collapse, which could give rise to severe earthquakes in the site’s

vicinity or even at a regional scale. In addition, groundwater resources are to be protected against the deleterious effects of contamination with salt brines, as demanded by the "*Water Protection Act*".

Salt mines in Germany are usually decommissioned by flooding open cavities in a controlled manner, building sealing constructions whenever required, and by plugging the access shafts. For obvious reasons this cannot be considered for a repository. Thus, three alternative decommissioning concepts are being considered, namely

- Complete backfilling concept
- Pore-spaced gas storage concept
- Waste encapsulation concept

Since the concept evaluation process is not yet finished, sufficient confidence in meeting the safety objectives is still lacking. Consequently, work on this field by BfS, the Governmental body responsible for disposal; DBE, the site operator; BGR, the German Geologic Survey; and other involved parties, is continuing with great intensity. Efforts are focusing on the preparing the licensing documents to be submitted to the competent authority, the Ministry of the Environment of the Federal State Saxony-Anhalt. The target date for finishing all safety related reports is the end of 2002.

A special problem requirement detailed consideration and with great impact onto the decommissioning concept is the generation of gases resulting from microbial decomposition of organic materials and from anaerobic corrosion of metals. Since the host rock salt is virtually tight, gas generation leads in the long-term to a pressure build up in closed disposal chambers. This effect could impair the host rock barrier function, eventually opening pathways for groundwater to enter the disposal areas. For the time being, it seems apparent that a combination of the waste encapsulation concept with a complete backfilling of remaining underground openings is adequate to provide optimal protection.

CONCLUSIONS

The process of decommissioning the Morsleben radioactive waste repository is now entering a crucial phase. The final definition of the concept to be followed to guarantee attaining the protection objectives will be finished in the near future. A first set of corresponding documents was submitted to the licensing authorities in the autumn of 2001. Current planning anticipates submitting all long-term safety related documents during the course of 2002.

In parallel, the planning of technical measures for backfilling and sealing the site by DBE is proceeding to schedule. Notwithstanding this, the licensing process will take some years before a license is obtained; the actual decommissioning work will last well into the next decade. Being a worldwide first-of-a-kind activity, this time schedule seems reasonable and is providing the involved parties, mainly BfS, BGR, and DBE, unique experience that we would like to share with the radioactive waste community.