Note:
This is a translation of the ESK recommendation entitled
“Leitlinie zum sicheren Betrieb eines Endlagers für hochradioaktive Abfälle”
In case of discrepancies between the English translation and the German original, the original shall prevail.

RECOMMENDATION of the Nuclear Waste Management Commission

Guideline on the safe operation of a repository for high-level radioactive waste

CONTENTS

1 General

1.1 Preliminary note

With regard to the future disposal of high-level radioactive waste, the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) issued the Ordinance on Safety Requirements for the Disposal of High-Level Radioactive Waste [1] and the Ordinance on Requirements for the Performance of Preliminary Safety Analyses in the Site Selection Procedure for the Disposal of High-Level Radioactive Waste [2] of 6 December 2020. The ordinances can be concretised by guidelines. This includes this guideline on the safe operation of a repository for high-level radioactive waste ("Guideline on operation"). This guideline replaces the ESK recommendation "Guideline on the safe operation of a disposal facility for in particular heat-generating radioactive waste" of 10 December 2015.

For the disposal of high-level radioactive waste, a site for the construction and operation of a repository is searched for and will be selected within the framework of a legally defined procedure [3]. This Site Selection Act specifies rock salt, claystone and crystalline rock as possible host rocks.

Against this background, the "Guideline on operation" deals with fundamental aspects and issues relevant for the operation of such a repository. The guideline is to be continuously developed in a staged procedure according to the results and progress made in site selection as well as the technical plans for the design and operation of the repository.

1.2 Scope of application

This guideline applies to the operation of a repository for high-level radioactive waste and refers to all processes from the date of the first delivery of disposal packages (i.e. the containers with radioactive waste intended for disposal) to the repository until completion of the emplacement of disposal packages in the repository and the subsequent backfilling and sealing measures. This includes a possible retrieval of the waste as a planned technical option during the operational phase according to [3]. Upstream work such as the planning, construction and commissioning of the repository, the demonstration of long-term safety and the protection of the near-surface groundwater as well as the dismantling of the surface facilities and the possible recovery of the waste as an emergency measure up to 500 years after the closure of the repository are not part of the "Guideline on operation".

All surface and underground facilities at the site that are required for the operational phase of the repository are considered. Facilities for storage, conditioning and product control may be located at the repository site and are not subject of this guideline. Possible interactions with these facilities must be considered separately.

The high-level waste to be disposed of in accordance with this guideline is spent fuel and high-level waste from the reprocessing of spent fuel as well as, if applicable, small quantities of low- and intermediate-level radioactive waste whose volume is significantly smaller than the volume of high-level waste to be emplaced at the same site [1, § 21(3)].

The disposal of low- and intermediate-level radioactive waste at the site to be selected is permissible provided that the same best possible safety of the site is ensured as for the sole disposal of high-level radioactive waste [3, § 1(6)]. Disposal of this waste has to take place in a separate disposal mine [1, § 21(2)] and is not the subject of this guideline.

The operation of the repository for high-level radioactive waste comprises two areas of requirements:

- The first area includes the assurance of operational safety. To this end, processes are to be defined and measures taken to ensure the protection of the operating staff as well as the technical installations in terms of occupational safety and radiation protection.

- The second area includes the safe handling and emplacement of the disposal packages. It must be ensured that radionuclides do not enter the mine and the environment of the facility, via exhaust air, to an inadmissible level during the entire operational phase until safe closure of the repository. As for the open access routes to the surface during the entire operational phase, special attention must be paid to this requirement in order to also protect the people and the environment.

These two areas of requirements are already to be considered during the site selection procedure [3], in particular for the preliminary safety concept and the preliminary repository design [2, § 6] as well as for the presentation of the general possibility of safe operation [2, § 7(6)] and for the operational safety analysis [2, § 8]. As a first step, this "Guideline on operation" presents, in general terms, the safety-related boundary conditions and thus the requirements and prerequisites that are to be fulfilled to ensure the protection of the operating staff, the population and the vicinity of the facility. Thus, the basic requirements for the safe operation of the repository specify requirements for the development of future technical concepts.

1.3 Protection goals

With regard to the technical design and operation of the repository for high-level radioactive waste, it is required

- to avoid any unnecessary exposure or contamination of the people and the environment (§ 8(1) of the Radiation Protection Act (StrlSchG) [4]), and

- to minimise any exposure or contamination of the people and the environment, even if below the respective level, taking into consideration the state of the art in science and technology and taking into account all circumstances of the individual case [4, § 8(2)].

The planning of structural or other engineered protection measures against design-basis accidents is to be based on the requirements of § 104 of the Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation (Radiation Protection Ordinance) (Strahlenschutzverordnung – StrlSchV) [5]).

Consequently, for the disposal packages, the technical installations of the surface and underground facilities as well as the geotechnical barriers, the following main protection goals result:

- confinement of radioactive material,
- safe removal of decay heat,
- maintenance of subcriticality,
- avoidance of unnecessary exposure, limitation and control of exposure of the operating staff and the general public,

as well as the requirements derived from these:

- shielding of ionising radiation in surface and underground facilities,
- avoidance of accumulation of ignitable gas mixtures, especially hydrogen,
- design and construction of the facilities such as to enable operation and maintenance,
- safety-oriented organisation and performance of operation,
- safe handling and safe transport of the disposal packages,
- design against accidents,
- measures to mitigate the consequences of beyond-design-basis accidents, and
- handleability of the disposal packages until the start of repository closure in order to generally enable the retrieval of the disposal packages [1, § 13].

In addition to the protection goals listed above, the technical design and operation of the repository for high-level radioactive waste have to comply with the protection goals of the mining industry. Accordingly, pursuant to the Federal Mining Act (Bundesberggesetz – BBergG) [6],

- the safety of operation and the staff is to be ensured, and

- prevention against dangers arising from mining activities for life, health and third-party property is to be strengthened and compensation for unavoidable damage is to be improved,

and the requirements pursuant to the Federal Mining Ordinance (Allgemeine Bundesbergverordnung – ABBergV) [7] derived from this are to be fulfilled:

- workplaces are to be designed, constructed, equipped, commissioned, operated and maintained in such a way that workers can perform the work assigned to them without endangering their safety and health or those of others,

- When workers are present, the operation of workplaces have to take place under the supervision of a person in charge, and

- work involving a special risk is to be entrusted only to competent staff and carried out in accordance with the instructions given.

Proof is to be provided by facility-specific safety analyses that the necessary precautions have been taken according to the state of the art in science and technology to prevent damage resulting from the operation of the repository; the results of these analyses are to be considered in the design of the repository. For the safety

case, care must be taken to ensure sufficient robustness. Moreover, for the operational phase, graded measures are to be planned according to the four levels of defence in depth, i.e. normal operation, abnormal operation (failures), design-basis accidents and beyond-design-basis events [1, § 17 (1)]. The safety concept has to outline and justify the potential operational failures and accidents that could occur during operation of the repository. For this purpose, the facility-specific deterministic and probabilistic safety analyses required for the operational phase of the repository are to be conducted. A probabilistic safety analysis and, if necessary, extension of the probabilistic database required for it are to be carried out in parallel to the development of the repository concept [8]. In this way, the safety design of a repository can be optimised in an iterative process already in the planning phase, and the database can be continuously improved and expanded.

Additional requirements not dealt with here exist with regard to the liability for damage and the control of fissile material according to international agreements (safeguards) as well as with regard to physical protection (protection against malevolent disruptive acts or other third-party intervention, IT security).

2 Repository operation

2.1 Principles of operation

The repository is to be operated such that the precautions against damage have been taken according to the state of the art in science and technology. All modifications to the facility or its operation intended during operation are also to be examined with regard to their potential impact on long-term safety. Negative impacts are to be minimised.

According to [4, § 8], any unnecessary exposure or contamination of the people and the environment is to be avoided (Chapter 1.3) and any exposure or contamination of the people and the environment is to be minimised, even if below the respective threshold, taking into consideration the state of the art in science and technology as well as all circumstances of the individual case. To this end, largely automated or remote-controlled operational processes are to be aimed at.

For the operation of the repository, an appropriate radiation protection organisation is to be planned and implemented and a radiation protection instruction which has to specify the protective measures to be considered during operation, is to be issued. This may include, for example, the establishment of an organisational plan for radiation protection, the control of operational processes that are essential for radiation protection, the measurements provided for determining the effective dose, as well as provisions regarding the prevention, investigation and reporting of incidents. Maintenance work is to be planned and carried out under radiation protection aspects, taking into account work permit procedures.

In the repository, radiation protection areas (monitored areas, controlled areas and, where required, restricted areas pursuant to [5, § 52]) are to be provided in accordance with the exposure conditions and marked accordingly. In the radiation protection areas, the local dose or the local dose rate is to be measured and documented to the required extent. In working areas where contamination may occur, the room air is to be monitored for control purposes, e.g. by mobile air sample collectors. Circulation areas, persons, workplaces, traffic routes and movable objects are to be checked for contamination in an appropriate manner. A concept

is to be developed for eliminating the effects and consequences of operational occurrences and accidents above ground and underground and thus for restoring the operational safety of the repository. This concept must include, in particular, appropriate measures for the management of contamination occurred and decontamination. For decontamination, organisational provisions are to be specified and adequate means provided or they must be procurable in the short term.

The body dose of persons staying in a radiation protection area is to be determined by means of appropriate official dosimeters in accordance with the requirements in [4] and [5] and documented. For the performance of work, additional dosimeters whose results can be read at any time are to be used. The radiation measuring devices used and kept available are to be checked for their functional performance and serviced regularly.

The health and safety documents for occupational safety are to be drawn up in accordance with the provisions in [7, § 3]. In addition to the development of safety instructions for all groups of staff in an appropriate and comprehensible manner, this also includes the provision of adequate first aid facilities and the performance of necessary safety exercises at regular intervals.

A fire protection concept is to be drawn up and integrated into an emergency plan. All fire alarms (fire above ground and underground, including incipient fires) are to be recorded and evaluated in a fire alarm panel from which the necessary measures are to be initiated and monitored. Stationary and mobile fire-fighting systems and equipment are to be provided, as required, throughout the repository to fight fires (incipient fires included), also considering temporary fire loads. The operating staff must be trained in fighting fires. Training and exercises are to be repeated regularly.

For operational safety, the experience gained in repositories worldwide is to be taken into account and the accidents that have occurred there must be evaluated and, if applicable, taken into account in the operating rules.

In particular, the following operational processes are to be planned and considered for the operation of the repository:

- Above ground
  - delivery of the disposal packages to the repository,
  - acceptance and handling of the disposal packages in the reception area,
  - incoming inspection of the disposal packages,
  - preparation for transport of the disposal packages to underground, and
  - handling of retrieved waste/disposal packages.

  Only those disposal packages may be emplaced that meet the disposal conditions. Measures are to be taken for dealing with disposal packages that do not meet the disposal conditions.

- Underground
  - excavation of emplacement areas and other infrastructure,
  - transport of the disposal packages to underground (ramp or shaft),

- underground transport of the disposal packages,
- emplacement of the disposal packages,
- backfilling and sealing of the emplacement areas,
- closure of the repository, and
- retrieval of the disposal packages, in particular keeping the necessary technical installations available during the operational phase.

For safe performance of the operational processes, the entire operation is to be structured and organised appropriately. For this purpose, the following requirements are to be observed:

- the operational processes are to be described,
- interdependencies between the individual operational processes are to be considered,
- automated emplacement of disposal packages is to be aimed at,
- the positions (x, y, z) of the disposal packages must be traceable at least for the period required for possible recovery [3, § 26],
- the parameters relevant for operation are to be specified in the mine book / operating manual,
- only qualified staff may be deployed for operation, and
- persons are to be assigned to the operational processes who are authorised accordingly.

Moreover, the necessary administrative prerequisites relating to personnel, organisation and safety are to be established, maintained and documented. For the operating states normal operation, abnormal operation, design-basis accidents, beyond-design-basis events as well as their management, clear instructions are to be drawn up for the mine book / operating manual. In the mine book / operating manual, experience from other facilities are to be considered and the mine book / operating manual is to be updated at regular intervals or in case of a reportable event, as specified in the Nuclear Safety Officer and Reporting Ordinance (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV [9].

The organisational structure of the repository operator must show defined responsibilities, competencies, powers and communication channels. It must ensure that during operation, the necessary operating staff with the required skills, abilities and experience will be available. To this end, appropriate instructions, training/advanced training courses, regular exercises and a predictive planning of human resources are to be provided.

An integrated management system (IMS) is to be implemented that includes, under the priority of safety, in particular the following areas:

- Safety

  Strategies and processes are to be defined that ensure reliable implementation of safety requirements and continuous improvement of the safety level of the repository. In this context, the safety standards achieved also have to be continuously monitored and concrete processes for continuous improvement are to be initiated.

All structural modifications intended during operation are to be reviewed in terms of their potential impact on the safety level of the repository and – depending on the evaluation of the results of the review – adapted accordingly. Further explanations can be found in the Guideline on safety management in waste management organisations [10].

- Quality

  It must be ensured that the process and product qualities necessary for the operation of the repository can be continuously checked and improved in the course of the operation of the repository. Depending on the defined operating states and the resulting processes, appropriate QM measures are to be derived and specified.

- Environmental protection

  Measures for the protection of the environment are to be integrated into the operational processes.

- Occupational health and safety

  Measures, means and methods to protect staff from work-related safety and health hazards are to be defined.

- Documentation and archiving

  During the operational phase of the repository, all information and proofs that demonstrate the operation of the facility and compliance with the requirements of radiation protection and mining law are to be documented. The documentation on the disposal containers and the radioactive inventory contained therein (disposal package documentation) are to be treated separately from the documentation on operation. All documentation has to be stored separately, both spatially as well as by means of fire protection, at least at two different suitable locations. The operator is free to choose a suitable storage medium (analogue, digital). Appropriate documentation concepts are to be developed and agreed with the supervisory authority for the storage, preservation, maintenance and accessibility of the documentation of the repository. The documentation concepts must take into account that the documentation has to remain accessible and readable in the long term. Furthermore, ageing of the storage medium/material and external damaging influences must also be taken into account.

- Ageing

  Ageing management comprises the measures to be carried out by the operator to control ageing that is relevant for the safety of the repository. This applies in particular to the safety-relevant structures, systems and components specified within the framework of the plan approval procedure. On the one hand, the physical and chemical ageing of materials and, on the other hand, the continued technological development of materials and machines/constructions are to be taken into account.

According to [11, § 9h], the operator of the repository is required to conduct a safety review for the facility every ten years. In this respect, it is not only required to present and evaluate the adaptations to the state of the art in science and technology that may be necessary but also to take account of experience from the operation of the own and other comparable facilities and/or parts thereof. The results of the safety review and assessment are to be submitted to the supervisory authority.

All installations of the repository, such as cranes above ground, accesses to the underground area with the respective conveyor systems or mechanical equipment underground (including vehicles) that require inspections, maintenance or repair have to be readily accessible or have to be made readily accessible by technical means, taking into account radiation protection requirements. The spatial conditions have to be such that there is sufficient space available for inspections, maintenance and repair. This also involves the requirement that shielding, which might become necessary for reasons of radiation protection, can be installed and used temporarily. For the preparation, performance and documentation of this work, a maintenance and repair concept is to be developed whose specifications and provisions are to be included in the mine book / operating manual.

According to [1, § 16], the operation of the repository is to be successfully tested before radioactive waste is accepted for disposal for the first time. Within the framework of an overall acceptance test, the proper emplacement process is to be demonstrated with an inactive and subsequently with an active disposal package.

2.2 Requirements for facilities above ground

The facilities above ground necessary for the operation of the repository as well as all the facilities and buildings for acceptance of the disposal packages are referred to as surface facilities

For the surface facilities, the safety-related design requirements according to the ESK guidelines for storage [12, 13] and on the protection of disposal facilities against flooding [14] are to be applied. The shafts and conveyor systems are to be designed such that accidents (e.g. cage crash, crash of transport units, collision of the conveyor frame with shaft fittings) can be excluded or, in the event of a crash, exposure of workers and the public beyond permissible limits can be excluded, taking into account the properties of the disposal packages. In addition, an appropriate environmental monitoring programme is to be provided.

When dimensioning the repository site, reserves are to be considered for a potential retrieval of the disposal packages in accordance with the retrieval concept. These are to be plausibly derived depending on the emplacement volume.

2.3 Requirements for surface-to-underground access

For the operation of the repository, appropriate accesses from the surface to the underground are to be provided to ensure the transport of the disposal packages as well as the hoisting of persons and materials and ventilation. Moreover, the accesses are used for the removal of mining debris heaps that may be produced. The accesses must be designed such that all tasks can be fulfilled safely and reliably in accordance with the legal requirements.

2.4 Requirements for underground facilities

The underground work is to be planned and organised in accordance with the provisions in [6] and [11] and the respective substatutory regulations. In this respect, a distinction is to be drawn between two operating areas:

- area where the underground cavities are driven to build the emplacement areas (excavation areas), and
- area for the emplacement of the disposal packages, i.e. the area for emplacement operation.

Here, it has to be taken into account, that the purely conventional mining activities are to be separated from the activities relevant in terms of radiation protection. Depending on the waste container concept and other boundary conditions, it is to be examined where radiation protection areas (controlled and supervised areas) must be established in accordance with [5].

Underground cavities are to be driven in a manner designed to minimise any damage to the host rock. When conducting excavation and mine support work, it should be ensured that the barrier effectiveness of later sealing structures is not affected by, for example, damage to the rock. During the operational phase, it must be ensured that the integrity of the containment-providing rock zone and of the essential engineered and geotechnical barriers already constructed is given.

Drifts, infrastructure facilities and underground side chambers have to be planned, built and maintained such that their usability is ensured throughout their service life. This also includes the shaft landing.

Layout and design of emplacement areas and backfilling of their residual cavities must be such that the disposal packages are safely contained and the decay heat is effectively removed. Any measures to establish long-term monitoring must not lead to inadmissible changes in the proven safety level of the repository.

The traffic control and routing of the transport vehicles must ensure that the transport routes for emplacement cannot be used in both directions at the same time to avoid accidents. Vehicles used must be equipped with on-board automatic fire protection systems. It is to be examined whether from a safety point of view, technical devices for automated collision avoidance have also to be implemented on the vehicles.

Size and equipment of infrastructure facilities must ensure that all work necessary for operation can be performed. Due to the required establishment of monitored and controlled areas in the mine workings, it is to be defined at an early planning stage whether individual facilities (e.g. workshops) have to be provided separately for each area. This also applies to the establishment of appropriate areas within the framework of retrieval of disposal packages.

The fire loads in the repository (i.e. structural and operational fire loads) are to be minimised in order to limit heat release and thermal impact, for example on the mine support, and to limit the risks for the operating staff associated with smoke release to an acceptable level in the event of fire. Preference is to be given to the use of non-combustible or at least flame-retardant materials. Combustible materials may only be kept in storage if these are stored in a condition in which their ignition can be ruled out. Individual areas are to be protected with automatic fire detection and extinguishing systems where required. The design of the fire protection measures has to comply with DIN 4102 [15].

Underground mine ventilation

There have to be stable ventilation conditions throughout the mine workings at any time. This means that the volumes of air currents must not be significantly changed by operational processes (e.g. actuation of air locks, cage winding) or by disruptions in the ventilation system. The supply of sufficient fresh air must be ensured. In addition, it is to be taken into account that larger amounts of airborne hydrogen may have to be expected and the ventilation has to be adapted accordingly.

When defining the number and design of the underground escape and rescue routes, the regulations and provisions under mining law are to be observed on the basis of the layout and ventilation of the mine workings. An escape route concept is to be developed which, during the operational phase, is to be compared with the changing actual underground situation and updated at regular intervals. The escape route concept also has to take into account escape or rescue chambers. For the purification of combustion gases, appropriate devices are to be provided in the ventilation system (e.g. filters for the retention of radioactive substances). The intervention forces, usually a mine rescue team, must have additional training in accordance with the fire brigade-specific contents for operations involving hazards from radioactive substances.

For the ventilation of the mine workings, exhaust ventilation should be provided with installation of the main mine fan above ground. Due to the negative pressure, all contaminants removed from the mine workings are discharged into the free atmosphere via the main mine fan in a controllable manner or can be led to a possibly required filtering device. Depending on the results of the accident analysis, it is to be checked whether and, if so, where in the exhaust air flow a filtering device is to be provided that can filter all the potentially contaminated air in the event of a release of radioactive substances within the repository.

For ventilation during the excavation of the emplacement areas, blowing auxiliary ventilation is to be provided with installation of the mine fan in the continuously ventilated main drift. During emplacement of disposal packages, ventilation is to be switched to exhaust ventilation.

The ventilation system must ensure that the air flow is directed from the excavation area to the emplacement area in order to only supply fresh air to the working area. The return air of the emplacement area may have to be led directly to the emplacement shaft/ramps (i.e. to the air exhaust shaft) via a filtering device without getting into contact with other mine openings.

Emplacement operation

To increase operational safety, emplacement of the disposal packages should be automated or remote-controlled as far as possible. The packages are to be emplaced shortly after excavation of the emplacement areas [1], and the emplacement areas are then to be backfilled and sealed in the near term. The final position of a disposal package in an emplacement field, an emplacement drift or an emplacement chamber is to be recorded and documented.

A concept is to be developed for handling and treatment of radioactive operational waste.

3 References

[1] Verordnung über Sicherheitsanforderungen an die Endlagerung hochradioaktiver Abfälle vom 06. Oktober 2020 (BGBI IS. 2094)

[2] Verordnung über Anforderungen an die Durchführung der vorläufigen Sicherheitsuntersuchungen im Standortauswahlverfahren für die Endlagerung hochradioaktiver Abfälle vom 06. Oktober 2020 (BGBI. I S. 2094, 2103)

[3] Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für hochradioaktive Abfälle (Standortauswahlgesetz – StandAG) vom 5. Mai 2017 (BGBl I S. 1074), das zuletzt durch Artikel 1 des Gesetzes vom 07. Dezember 2020 (BGBl. I S 2760) geändert worden ist

[4] Gesetz zum Schutz vor der schädlichen Wirkung ionisierender Strahlung (Strahlenschutzgesetz – StrlSchG) vom 27. Juni 2017 (BGBl. I S. 1966), zuletzt geändert durch die Bekanntmachung vom 3. Januar 2022 (BGBl. I S. 15)

[5] Verordnung zum Schutz vor der schädlichen Wirkung ionisierender Strahlung (Strahlenschutzverordnung – StrlSchV) vom 29. November 2018 (BGBl. I S.2034, 2036), zuletzt geändert durch Artikel 1 der Verordnung vom 8. Oktober 2021 (BGBl. I S. 4645)

[6] Bundesberggesetz (BBergG) vom 13. August 1980 (BGBl. I S. 1310), das zuletzt durch Artikel 1 des Gesetzes vom 14. Juni 2021 (BGBl. I S. 1760) geändert worden ist

[7] Allgemeine Bundesbergverordnung (ABBergV) vom 23. Oktober 1995 (BGBl. I S. 1466), die zuletzt durch Artikel 4 der Verordnung vom 18. Oktober 2017 (BGBl. I S. 3584) geändert worden ist

[8] Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, TÜV SÜD Industrie Service GmbH: Überprüfung von Risikokonzepten zur Bewertung der Sicherheit in der Betriebsphase eines Endlagers, Abschlussbericht zum BfS-Vorhaben SR 2572, Februar 2009

[9] Verordnung über den kerntechnischen Sicherheitsbeauftragten über die Meldung von Störfällen und sonstigen Ereignissen (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV) vom 14. Oktober 1992 (BGBl. I S. 1766), die zuletzt durch Artikel 18 V v. 29.11.2018 (BGBl. I S. 2034; 2021 S. 5261) geändert worden ist

[10] Empfehlung der Entsorgungskommission (ESK): Leitlinie zum Sicherheitsmanagement in Endlagerorganisationen vom 01.09.2021

[11] Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz – AtG) in der Fassung der Bekanntmachung vom 15. Juli 1985 (BGBl. I S. 1565), das zuletzt durch die Bekanntmachung vom 03. Januar 2022 (BGBl. I S. 14) geändert worden ist

[12] Empfehlung der Entsorgungskommission (ESK): Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnde radioaktive Abfälle in Behältern (Revidierte Fassung vom 10.06.2013)

[13] Empfehlung der Entsorgungskommission (ESK): Leitlinien für die Zwischenlagerung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung (Revidierte Fassung vom 09.12.2021)

[14] Empfehlung der Entsorgungskommission (ESK): Leitlinie zum Schutz von Endlagern gegen Hochwasser vom 06.12.2018

[15] DIN 4102, Brandverhalten von Baustoffen und Bauteilen, Teile 1 - 4 (Teil 1: Fassung 05/98; Teil 2: Fassung 09/77; Teil 3: Fassung 09/77; Teil 4: Fassung 03/94, Änderung 06/2014), Beuth Verlag, Berlin