Note:
This is a translation of the ESK recommendation entitled
“Leitlinien für die Zwischenlagerung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung”.
In case of discrepancies between the English translation and the German original, the original shall prevail.

RECOMMENDATION of the Nuclear Waste Management Commission (Entsorgungskommission – ESK)

Guidelines for the storage of radioactive waste with negligible heat generation

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1 General

1.1 Scope of the guidelines

These guidelines apply to the storage of radioactive waste with negligible heat generation that is subject to licensing according to §§ 6, 7, 9 of the Atomic Energy Act (Atomgesetz – AtG) [1] or § 12(1)3 of the Radiation Protection Act (Strahlenschutzgesetz – StrlSchG) [2]. For the purpose of these guidelines, radioactive waste with negligible heat generation is defined as all types of radioactive waste with the exception of spent fuel and vitrified radioactive waste canisters from reprocessing. The radioactive waste considered originates from the operation and dismantling of nuclear installations (according to §§ 6, 7 AtG) or facilities (according to § 9 AtG) as well as from other uses of radioactive material, such as in industry, medicine, research, and at the Federal Armed Forces. It is either stored in central storage facilities, in decentralised storage facilities at the sites of nuclear installations or facilities, in these nuclear installations or facilities themselves, or in public or private collection facilities.

The objective of these guidelines is to formulate all safety-relevant requirements for the storage of radioactive waste with negligible heat generation. These are, on the one hand, requirements for the storage facilities and their operation and, on the other hand, requirements for the radioactive waste over the entire period of storage. The requirements are to be observed regardless of whether emplacement in a repository or subsequent clearance is envisaged.

These guidelines formulate requirements for safe storage without knowing yet the precise time period for the necessary storage until transfer to a repository. Currently, storage periods of up to several decades can be assumed. Therefore, the long-term inherent stability of the radioactive waste and waste forms in combination with the containers under the operational boundary conditions of the storage facility is of great importance.

For the storage of relatively small amounts of radioactive waste with negligible heat generation, e.g. for research laboratories or medical facilities, the requirements to be imposed on storage facilities and their operation according to these guidelines are not appropriate in every case. However, the requirements regarding the properties of the radioactive waste must always be observed.

For the storage of radioactive raw waste and intermediate products, the requirements specified in these guidelines shall be met mutatis mutandis.

In addition to the storage of radioactive waste with the objective of emplacement in a repository, the decay storage of residual radioactive material, such as large components, also plays a role. For this longer-term decay storage with the objective of clearance or subsequent conditioning for disposal under more favourable radiological conditions, the same safety requirements are to be applied – as far as transferable – as for the storage of radioactive waste with the objective of subsequent disposal.

Decay storage for clearance of radioactive material for a non-hazardous reuse or conventional waste management of less than five years [3] is not dealt with here.

Definitions of terms used in these guidelines are given in Annex 3.

1.2 Protection goals

When storing radioactive waste with negligible heat generation,

1 any unnecessary exposure or contamination of man and the environment shall be avoided (§ 8(1) StrlSchG [2]), and

2 any exposure or contamination of man and the environment shall be kept as low as possible even where values are below the authorised limits, taking due account of the state of the art in science and technology and of the circumstances of the individual case (§ 8(2) StrlSchG [2]).

The planning of structural or other engineered protection measures against design basis accidents is to be based on the requirements of § 104 in conjunction with § 194 of the Radiation Protection Ordinance (Strahlenschutzverordnung – StrlSchV) [4].

Based on this, the following general protection goals are derived for the stored radioactive waste, the storage facility with its technical installations and the operation of the storage facility:

- confinement of radioactive material,
- avoidance of unnecessary exposure, limitation and control of occupational and public exposures,

  where applicable, for special waste also

- maintaining subcriticality,

as well as the following derived requirements:

- shielding of ionising radiation,
- design and implementation of installations in compliance with the requirements for operation and maintenance,
- safety-oriented organisation and implementation of operation,
- safe handling, safe transport and safe storage of the radioactive material,
- design against accidents, and
- as far as required due to the release potential, measures to mitigate the consequences of beyond design basis events.

Storage facilities for radioactive waste with negligible heat generation should be equipped with passive safety systems to the largest possible extent. Active safety systems shall only be used as a substitute if adequate passive safety systems are not practically feasible.

There are additional requirements, not dealt with here, regarding liability, protection against malicious acts and, in the individual case, the control of fissile material under international agreements.

2 Confinement of radioactive material

Confinement of radioactive material is to be ensured by a system of engineered barriers and complementary measures during the entire storage period. Immobilisation in a waste matrix, confinement in waste containers or, if applicable, the barrier function of building and ventilation with retention devices can contribute to it. Large components can confine their radioactive material, for example during their decay storage, even without overpacks. Overall, confinement can be achieved technically, depending on the concept chosen, by a sole barrier or the interaction of several barriers.

According to the requirement to give preference to passive safety systems over active safety systems, the maintenance-free storage of the packaged radioactive waste as well as of the large components has largely to be ensured. This results in different requirements for waste forms, containers and large components, some of which are more restrictive than the requirements for disposal.

2.1 Waste forms and packages

The waste acceptance criteria and the product control requirements for the Konrad repository [5 – 7] result in safety requirements for waste packages concerning the radioactive inventory, the chemical, physical and biological characteristics of the waste forms and the packaging of the radioactive waste. Characteristics relevant for disposal derived from these relate to the radioactive waste, the waste forms and the waste containers/packaging.

Fundamentally, these characteristics are also relevant for storage. For this purpose, proof can be provided that a substantial part of the requirements for the storage of radioactive waste is fulfilled if it has been conditioned to meet the requirements for disposal according to a process authorised by the BGE within the frame of the process qualification (§ 3(2) of the Nuclear Waste Management Ordinance (Atomrechtliche Entsorgungsverordnung – AtEV [8])). Likewise, already provided proof that waste requirements for storage have been met can be used for disposal qualification.

For storage, waste forms and waste containers must be chemically/physically sufficiently stable over the period of storage until their disposal. This is to be ensured by appropriate conditioning procedures, i.e. changes in the waste form properties and the waste container properties are to be kept to a harmless minimum under the operational boundary conditions during storage (see [9] Annex 2). The compatibility between waste, fixing agent or waste matrix, and container material is of particular importance for storage. Thus, for the assessment of waste form properties with regard to storage, potential changes in the properties of the packaged radioactive waste that may result from reactions between the radioactive waste and the fixing agent or between the waste

form and waste container are to be considered in addition to the basic requirements and the waste properties relevant for disposal for the duration of storage.

By producing chemically/physically stable waste forms in qualified containers suitable for disposal and by their transparent documentation in combination with inspection and, if necessary, maintenance measures during storage, it can be assumed that the packaged radioactive waste can be safely handled even after storage until it is emplaced in the repository.

2.2 Waste containers and large components

Requirements for waste containers and, where applicable, large components result from the safety analyses of a storage facility and a repository. For storage of packaged radioactive waste and large components, the long-term stability of the materials of the waste containers and large components is to be demonstrated in particular so that the requirements are met during storage. Apart from additional requirements derived from the safety analyses for the repository, these requirements also apply to containers used only for storage.

Qualified waste containers must be certified for storage and ideally also for disposal. The requirements are specified in the acceptance criteria of the storage facilities as well as in the waste acceptance criteria and the product control requirements for the Konrad repository, respectively [5, 6]. Furthermore, the requirements according to the applicable dangerous goods regulations [10 – 13] for the transport of radioactive material also have to be observed. If storage takes place in waste containers that are not qualified in accordance with the requirements of the dangerous goods regulations, the requirements under dangerous goods law are to be fulfilled after an additional packaging step, e.g. by means of an additional qualified outer packaging. The design of the waste containers has to be suitable in a way that they can also be handled during and after storage. The boundary conditions on which the qualification certificates are based and which have an impact on conditioning are to be observed.

Analogous considerations apply to the storage of large components.

If waste containers or large components are not unequivocally suitable for the entire period of storage due to their design (such as e.g. thick-walled concrete or cast containers), due to the properties of their contents or due to the atmospheric conditions in the storage facility, recurrent controls of the waste containers and large components are to be performed in the storage facility by non-destructive tests such as e.g. visual inspections (Chapter 10.6).

2.3 Storage building

During specified normal operation, the storage building usually only has the function of shielding from the environment and of weather protection for the stored radioactive waste and the technical installations of the storage facility.

Requirements for the design of the building for the control of accidents are described in Chapters 8.1 and 8.2.

A design of the building for the storage of radioactive waste which may lead to emissions of radioactive material is admissible, but with regard to the emission of radioactive material through air and water, such a design necessitates additional technical efforts for a controlled air flow as well as measuring and recording the emissions [4].

3 Criticality safety

When storing radioactive waste, subcriticality is to be ensured. If the concentration and mass limits for fissile material are complied with in accordance with the Konrad waste acceptance criteria and the product control requirements [5, 6], no special measures for criticality control are required. If it is intended to store radioactive waste with a higher fissile material content than specified in the waste acceptance criteria of the Konrad repository and the product control requirements [5, 6] or with mixtures of fissile material and substances influencing the neutron balance (such as e.g. graphite), an examination by the competent authority is to be carried out in each individual case.

4 Shielding of ionising radiation

During storage of radioactive waste with negligible heat generation, the shielding of ionising radiation for the protection of the general public and occupationally exposed persons is to be ensured by the design of the waste forms/waste containers/waste packages and/or storage areas, the storage concept and the storage building. Additional measures may be provided for large components if needed.

For the operation of a storage facility, the dose rate limits for the packaged radioactive waste or large components to be stored must be specified in such a way to ensure that the provisions of § 77 and 78 StrlSchG [2] regarding the limits for occupationally exposed persons will be observed.

In order to provide proof of the necessary shielding of the packaged radioactive waste or large components and the storage facilities or storage rooms, the gamma radiation and, where required, the neutron radiation, including any occurring scattered radiation and secondary radiation, are to be taken into account when calculating the exposure in the environment (pursuant to the relevant general administrative provision (Allgemeine Verwaltungsvorschrift zur Ermittlung der Exposition von Einzelpersonen der Bevölkerung durch genehmigungs- oder anzeigebedürftige Tätigkeiten – AVV Tätigkeiten) [14], taking § 102(2) StrlSchV [4] into consideration) and on the premises.

Regarding the placement and positioning of the packaged radioactive waste and large components in the storage facility, the mutual self-shielding effect is to be taken into account. When determining the positioning, aspects of accessibility and controllability of the packaged radioactive waste and large components are also to be taken into consideration.

The shielding function of movable shields is to be maintained as far as possible, e.g. gates with shielding function are to be kept closed where possible.

In the design of the storage building, the aspect of shielding is to be taken into account, in particular with regard to the design of air vents, doors and expansion joints.

5 Radiation protection

5.1 Principles

According to § 8 StrlSchG [2], any unnecessary exposure or contamination of man and the environment shall be avoided. In this context, any exposure or contamination of man and the environment shall be kept as low as possible, even below the respective limits, taking into account all circumstances of the individual case and the state of the art in science and technology. Consequently, radioactive waste is to be stored in such a way that handling and monitoring measures performed by the staff in the storage area can also be minimised to the largest possible extent.

According to § 45 StrlSchV [4], the radiation protection executive of the storage facility has to ensure that a radiation protection instruction is issued in which the protective measures to be observed in the facility are specified. This may include, for example, the establishment of an organisational plan for radiation protection, the control of operational procedures that are essential for radiation protection, the measurements provided for determining the body dose, as well as provisions regarding the prevention, investigation and notification of incidents.

Planning and execution of maintenance, controls and repairs are to be regulated in a work permit procedure under radiation protection aspects. The required equipment and installations must be available or procurable within a reasonable period of time. The persons working in the storage facility must regularly be instructed in accordance with the requirements of § 63 StrlSchV.

5.2 Radiation monitoring in the storage facility

Storage facilities are to be divided into radiation protection areas as specified in § 52 StrlSchV [4] and labelled (§ 53 StrlSchV). In radiation protection areas, the local dose or local dose rate shall be measured and documented in the event of changes in the storage occupancy and at regular intervals in accordance with § 56 StrlSchV. These measurements are to be performed at representative measuring points. The gamma dose rate and, where required, the neutron dose rate are to be recorded. A sufficient number of mobile measuring devices is to be kept available.

The room air in working areas where contamination may occur is to be monitored for control purposes at regular intervals according to § 39 StrlSchV, e.g. by means of mobile air samplers. When storing packaged radioactive waste with significant activities of volatile radioactive material (e.g. H-3 and C-14), the potential emissions are to be assessed regarding compliance with the requirements of the Radiation Protection Ordinance and, where necessary, room air monitoring measures are to be provided.

Circulation areas within the storage area, persons, workplaces, transport paths and mobile objects are to be checked for contamination in an appropriate manner and the results to be documented (§ 56 StrlSchV). For decontamination, organisational provisions are to be specified and adequate means are to be provided or to be procurable in the short term.

The body dose of persons staying in a radiation protection area is to be determined and documented for gamma radiation and, where required, neutron radiation by means of appropriate official dosimeters in accordance with the provisions of the Radiation Protection Act [2] and §§ 64 to 66 StrlSchV. In addition to the official dosimeters, dosimeters that can be read at any time are to be used for activities in the storage facilities. When setting up workplaces, protection of occupationally exposed persons against external and internal exposure shall be ensured primarily by structural and technical means or by appropriate working procedures (§ 75 StrlSchV). In order to further optimise radiation protection, the radiation protection executive shall furthermore ensure that within six months after the commencement of an activity it is checked and documented whether the establishment of dose constraints (§ 72 StrlSchV) for occupationally exposed persons is a suitable instrument for this purpose.

According to § 90 StrlSchV, the radiation measuring devices used and kept available shall meet the requirements of the measurement purpose and be tested for their functional performance as well as serviced at regular intervals. The measuring devices shall be available in sufficient numbers.

5.3 Environmental radiation monitoring

For storage facilities, the local dose is to be determined at representative measuring points, e.g. at the fence, with regard to compliance with the limits of § 80 StrlSchG [2]. The Guideline concerning Emission and Immission Monitoring of Nuclear Installations (Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen – REI) [15] is to be applied to storage facilities with licences under the Atomic Energy Act and mutatis mutandis for dose measurement in storage facilities with licences under the Radiation Protection Act.

More extensive monitoring measures are to be provided if discharge of radioactive material during specified normal operation (§ 99 StrlSchV [4]) has to be postulated. If the retention capability of the waste containers cannot be ensured with regard to volatile radioactive material (e.g. H-3 and C 14), the resulting emissions are to be determined and assessed for compliance with the limits of § 99 StrlSchV and taking § 100 StrlSchV (determination of the expected exposure to members of the public) into consideration.

5.4 Clearance/removal of material

Material produced in the storage facility not being subject to the scope of § 58(2) StrlSchV [4] (“bringing out of controlled areas”) is to be radiologically assessed prior to the permanent release from being subject to the Atomic Energy Act [1] or the Radiation Protection Act [2]. Material for which contamination can be excluded, may be removed. Radioactive material for which this cannot be excluded are subject to a clearance procedure according to §§ 31 to 42 StrlSchV. The procedures for removal and clearance are to be laid down in the operating rules and regulations.

6 Structural requirements for storage buildings

The requirements listed in this chapter apply to all storage buildings to be newly constructed. They also apply mutatis mutandis to storage buildings that are subject to structural changes resulting from retrofitting, refurbishment or upgrading measures.

The structural parts of the storage facility are to be built in accordance with the respective building code of the Land and in compliance with the generally recognised engineering rules. Insofar as not covered thereby, additional design requirements may result from the safety analyses of the specified normal operation of the storage facility until the end of the scheduled operating life:

- For the design of the storage building, the space required for carrying out inspections of the stored packaged radioactive waste (and repairs of e.g. paint damage), the technical installations and the storage building itself is to be taken into account.

- For the design of the storage building, the intended duration of use is to be considered with regard to durability and functional performance of the building material.

- The floor of the storage building shall have an adequate compressive strength and wear resistance.

- The base plate of the storage building must be designed for driving on with transport vehicles and for container loads in accordance with the intended occupancy plan. Here, partial occupancy conditions also have to be considered.

- The design of the storage building also has to consider impact loads during transport processes unless these are excluded by other measures. Crane loads and loads of other heavy plant components, e.g. shieldings, and special loads from internal hazards (Chapter 8.1) as well as external hazards (Chapter 8.2) are also to be taken into account.

- The materials used for the storage building must generally be *non-combustible* (building material class A according to DIN 4102, Part 1 [19]). If *non-combustible* building materials are not available for the intended use (e.g. decontamination coatings), *flame-retardant* building materials (building material class B1 according to DIN 4102, Part 2 [16]) can be used (Chapter 7.4).

- The design of the storage building shall ensure stability for the load case of a fire in accordance with DIN 4102, Part 2 to 4 [16].

- The storage building is to be equipped with grounding and lightning protection systems in accordance with the conventional rules and regulations. Higher requirements only have to be considered where monitoring and protection functions may be affected; in this case, additional lightning protection measures are to be taken.

- The top edge of the floor has to be above the water level for the 100-year flood. Apart from that, structural measures are to be taken to prevent the ingress of water. Temporary measures are to be

provided for the 10,000-year flood. When determining the relevant water level, the state of the art in science and technology is to be taken into account.

- For the determination of the type of seismic design of the storage building, it is to be examined site-specifically whether postulated damage caused by an earthquake – e.g. collapse of the storage building, crash of heavy loads, dropping down or tipping over of packaged radioactive waste, respectively, or fire – may lead to exposure due to the release of radioactive material into the environment exceeding the planning levels of § 104 StrlSchV [4]. If this is the case, the structural parts of the storage building are to be designed against earthquakes in accordance with safety standard KTA 2201, Part 1 of the Nuclear Safety Standards Commission (Kerntechnischer Ausschuss – KTA) [17].

7 Technical installations

The requirements listed in this chapter apply to all storage facilities to be newly constructed. They also apply mutatis mutandis to storage facilities that are subject to structural and/or technical changes resulting from retrofitting, refurbishment or upgrading measures in the following areas.

7.1 Lifting equipment and other transport equipment

The technical design of the lifting equipment used for the handling of the packaged radioactive waste, containers and large components is based on the results of the analysis of events during specified normal operation and during accidents (Chapter 8). They must comply with the general safety provisions and requirements. The lifting equipment and the relevant installations must be designed in a way that the packaged radioactive waste, containers and large components can be handled safely during storage. For this purpose, maintenance work and inspections are to be carried out at regular intervals. If the lifting and transport equipment is not used over a longer period of time, these regular measures can be replaced by tests prior to return to service. The maintenance and test intervals are to be adjusted to the use of the equipment and the required operational readiness. If, in the event of failure of lifting or transport equipment, there is a risk of internal exposure exceeding 1 mSv or external exposure exceeding 5 mSv, additional measures are to be taken.

Also after having completed emplacement in the storage facility, it is to be ensured that all necessary lifting and transport equipment is available on-site or can be procured and used at short notice.

7.2 Room air requirements

For the storage of sheet steel containers without corrosion protection measures and radioactive waste exposed to the atmosphere in the storage hall, a sufficient limitation of the relative humidity of the room air is to be ensured so that the integrity and transportability of the packaged radioactive waste is maintained and not endangered by corrosion processes. For this purpose, room air conditioning of the storage hall may be necessary. Here, dehumidifiers or (underfloor) heating systems may be used. If necessary, measures are to be taken that allow sufficient ventilation of the stacked packaged radioactive waste at floor level. For this purpose, the packaged radioactive waste can be placed, for example, on grates.

7.3 Electrical installations

The electrical installations are to be designed for the scheduled storage period if they are only accessible with considerable radiation protection efforts due to the radioactive wastes stored there. The maintenance and test intervals are to be adjusted to the use of the installations and the required operational readiness.

7.4 Fire protection and fire protection equipment, explosion protection

A fire protection concept is to be prepared for the storage facility, which describes the individual measures of preventive fire protection by structural and engineered measures, of organisational (operational) fire protection and of fire suppression. The individual components and their coupling are to be described concerning the radiological protection objectives, taking into account the facility operation, the fire risk and the expected extent of damage.

For the entire storage period envisaged, measures are to be established for the avoidance of fire loads and ignition sources, for timely detection and for effective fire-fighting. If the formation of explosive gas mixtures due to a release from the stored radioactive waste is to be postulated, adequate preventive measures are to be taken.

The confinement of the radioactive waste in the stored waste containers must also be ensured with regard to fire protection by demonstrating the integrity of the packaged radioactive waste throughout the storage period, since a loss of confinement of the radioactive waste may also lead to an increase of the fire load in the storage facility.

8 Safety analyses

The safety analyses are to be based on a spectrum of events that covers all potentially occurring events. For all events listed in Chapters 8.1 and 8.2, the impacts on systems, safety-relevant installations and measures, buildings, etc., are to be investigated. The source term for radiologically relevant events is to be determined and the resulting radiological effects must be identified unless it can be demonstrated that the respective event type can be excluded. Furthermore, it is to be examined whether there are other potential events that are not covered by the events listed in chapters 8.1 and 8.2. If this is the case, such events must also be considered.

In the safety analyses, the specific technical conditions and processes of the facility are to be analysed systematically and experience from comparable facilities and projects is to be taken into account. When analysing potential causes of incidents and accidents, human error is to be taken into account.

As far as credit is taken from protective measures, i.e. the function of safety-relevant installations or administrative measures, it is to be ensured that the functions assumed will be available with the postulated effectiveness and reliability.

For the operational incidents assigned to specified normal operation, it is to be demonstrated within the scope of an event analysis that, taking into account discharges during specified normal operation, the limits of § 80

StrlSchG [2] and § 99 StrlSchV and the maximum permissible discharges pursuant to § 102 StrlSchV [4] are complied with.

If a particular event is to be classified as design basis accident, compliance with the planning levels of § 104 StrlSchV [2] in conjunction with § 194 StrlSchV is to be demonstrated within the scope of an accident analysis.

8.1 Internal hazards

For the storage of radioactive waste with negligible heat generation, the following three groups of internal events are generally to be considered:

1 Mechanical impacts
such as e.g.

- drop of a container with radioactive waste or waste forms, or a large component from the maximum credible height, in the impact orientation with the greatest damaging effect,

- drop of the maximum credible load onto the containers with radioactive waste or waste forms or large components in the most damaging impact orientation,

- impact of loads, e.g. collision of a transport vehicle with a wall.

2 Thermal impacts

These include fire impacts on the packaged radioactive waste, taking into account the maximum stationary and temporary fire loads in the storage facility. In addition to the demonstration of the retention capacity of the packaged radioactive waste, possible fires in the storage facility with potential activity releases are to be analysed. Regarding the release of radioactive material from packaged radioactive waste, fire duration and temperature are decisive for the maximum heat input into the waste.

Even if the waste container itself is non-flammable, radionuclide release can occur when exposed to fire. The release mechanisms of pyrolysis, evaporation and sublimation are also to be considered. The limitation of the maximum radioactive inventory of the stored radioactive waste is to be taken into account when analysing the release of radioactive material into the environment.

Radioactive waste in thick-walled cast iron containers and concrete containers does not contribute to the fire load. This also applies to sheet steel containers with all-around non-flammable thick-walled lining (e.g. concrete or steel).

Radioactive waste in other containers, e.g. sheet steel containers or 20' containers, is to be classified as non-flammable for the safety analyses if all of the following prerequisites are met:

- The radioactive waste is stored in sealed waste containers made of non-flammable materials.

- There are no self-igniting or explosive substances in the packaged radioactive waste.

- There are no fire loads in the storage area that could release heat in case of fire to an extent which might impair the confinement function of the waste containers.

3 Failure of safety-relevant installations

Here, events are to be taken into consideration such as

- loss of the electricity supply,
- failure of instrumentation and control equipment, and
- failure of lifting equipment and transport devices.

8.2 External hazards

For the storage of radioactive waste with negligible heat generation, the following external hazards are generally to be included in the analysis of the potential consequences, whereby the load assumptions for the site-specific conditions are to be defined conservatively:

- Natural external hazards, such as storm, rain, snowfall, freeze, lightning, flood and earthquakes.

- Man-made external hazards, such as impacts caused by external explosion, external fire and accidental aircraft crash.

- As far as these events are categorised as beyond design basis events, adequate mitigation is assumed if the radiological consequences determined under realistic boundary conditions do not necessitate major disaster control measures [18].

- An aircraft crash and a blast wave are, in general, beyond design basis accidents. In this respect, damage reduction measures in case of an aircraft crash and blast waves with impact from outside are to be considered on the basis of the load assumptions from the Reactor Safety Commission (Reaktor-Sicherheitskommission – RSK) guidelines for pressurised water reactors for aircraft crash [19] and the guideline of the Federal Ministry of the Interior (Bundesministerium des Innern – BMI) on the protection of nuclear power plants against blast waves [20] as well as from site-specific specifications, the emplaced radionuclide inventories and their release behaviour. The aspect of reducing the damage extent has been adequately taken into account if the radiological consequences determined under realistic boundary conditions do not require major disaster control measures also for these events. The reduction of the consequences in the case of aircraft crash and blast waves can be achieved either by the containers with radioactive waste or waste forms alone or by combination with the storage building.

- Possible interactions with neighbouring nuclear installations or facilities (e.g. collapse of the stack or other structural parts, turbine failure, failure of containers with high-energy contents) are additionally to

be considered, if necessary.

9 Quality assurance

For quality assurance in the field of radioactive waste management, above all, the requirements for waste forms and waste packages are to be verifiably fulfilled, product controls are to be carried out, conditioning methods and waste containers are to be subjected to qualification or post-qualification, and a quality-assured documentation is to be established. The corresponding procedures for the qualification of waste packages and waste forms as well as the resulting requirements are dealt with in the ESK guidelines for the conditioning of radioactive waste with negligible heat generation (conditioning guidelines) [9].

The aim of quality assurance during storage is to maintain the condition and quality of the stored radioactive waste, large components and other residual radioactive material as well as their documentation throughout the entire storage period. In addition, requirements from the steps following storage are also to be taken into account:

- requirements from handling and transport, including the requirements from keeping waste available for transport and transport to the repository after the storage period,
- requirements resulting from the disposal following storage, and
- requirements resulting from provisions of the waste owner regarding radioactive waste management, e.g. the implementation of further conditioning steps at the end or in the event of an interruption of storage.

Detailed specifications for quality assurance during conditioning into waste forms and waste packages suitable for storage are presented in the conditioning guidelines [9].

The following sub-chapters present additional requirements resulting from storage facility operation.

9.1 Qualification and quality maintenance of packaged radioactive waste for storage

During storage, specific requirements apply to waste forms and waste containers with regard to maintaining their condition and quality, taking into account any changes in this respect. Requirements regarding the quality of the waste forms and criteria for assessing their stability during storage are presented in the conditioning guidelines [9].

Compliance with the requirements for waste containers or packaging under consideration of the conditioning guidelines and the respective acceptance criteria for storage is verified for each container type within the framework of verification procedures for its suitability and certified by the competent authority. In addition to the determination of the safety-relevant properties and quality of all series samples of a container type, these requirements also include the manufacturing of the containers on the basis of an appropriate quality management system of the manufacturer and type-specific quality assurance programmes (e.g. in the form of approved manufacturing and test and inspection sequence plans). Specifications for carrying out inspections

during manufacturing by in-house specialists or by independent experts and for implementation and review of quality-assuring measures and controls during manufacturing, loading and storage of the waste containers, are laid down in the product control regulations [6] complementing the waste acceptance criteria of the repository [5]. These specifications are to be taken into account in the waste acceptance criteria of the respective storage facilities. Proofs already provided for the transport or on the suitability for disposal can be used to demonstrate suitability for storage.

With regard to the long-term stability of the waste container materials, specifications for the waste package are to be made in the quality management system, specifically in the acceptance criteria of the storage facilities. These specifications have to take into account the compatibility between the container and the waste form, ensure the stability of the waste packages for the entire period of storage and allow for subsequent use (further conditioning, disposal, clearance measurement after decay storage). Criteria for assessing the stability of the waste forms and packages on the basis of gas formation rates can be found in Annex 2 of the conditioning guidelines [9]. Storage-specific monitoring concepts (see Chapter 10.6) are to be defined for identifying any impairment of the storage capability of the waste packages at an early stage.

The above-mentioned quality assurance requirements for waste packages also apply mutatis mutandis to waste forms and packages in storage facilities that are to be subjected to post-qualification or to waste forms and packages for which conditioning has been interrupted.

9.2 Documentation of the radioactive waste

The waste owner is responsible for the documentation of the respective radioactive waste. The documentation for storage in a storage facility has to include the relevant data on the radioactive waste, the waste origin and also the purpose of further use, i.e. disposal or subsequent clearance. Insofar as data to be recorded pursuant to § 2(1) AtEV [8] are concerned, they shall be entered in electronic accounting systems pursuant to § 2(2) AtEV [8] so that they can be made available immediately to the competent authority upon request. The accounting systems require the approval of the competent authority.

The requirements for the documentation of radioactive waste are described in the conditioning guidelines [9]. They specify requirements for the documentation of waste packages as well as for intermediate products and large components that are expected to be or have to be stored for a longer period of time. The regulations of the conditioning guidelines ensure that the data required to document the properties of the waste forms and waste packages are recorded during conditioning. It is expedient to prepare a documentation in a timely manner that already fulfils the requirements for documenting the properties of the waste forms and packages relevant for disposal and to have this documentation reviewed by the body designated pursuant to § 3(2) AtEV [8].

The availability and readability of the documentation as well as its correct assignment to the radioactive waste must be ensured throughout the entire storage period, e.g. until removal for disposal or clearance. Provisions to ensure the availability of the documentation after a longer storage period of the waste packages are known from Great Britain [22]. The IAEA document [23] also provides information on the maximum retention period for documents in the appendix. For documents made of regular paper, a lifetime of decades can be assumed without loss of readability. Magnetic and optical data carriers, however, are to be checked for readability after

storage periods of several years and secured by copying. The IAEA recommends, for example, that optical storage media (compact discs, DVDs) should be checked after five years [23].

Relevant data concerning waste forms or waste packages can be submitted to the operators and to the authorities for the storage or disposal facility in electronic form. After review of the data within the framework of product control, these data sets enable recording as well as accounting of waste and waste packages, which have already been delivered or are still to be delivered, e.g. in the form of a database for a repository or a storage facility. With this type of data transmission, verified electronic waste data are available in multiples at several locations and therefore protected against loss during storage. In addition to facilitating product control and simplification of recording and accounting for the existing and expected inventories, this approach provides further advantages for data integrity during storage. Here, electronic communication must meet the requirements of § 182 StrlSchG [2].

The waste package documentation is to be kept available for at least another year after delivery of the respective radioactive waste to a federal facility for safekeeping and disposal of radioactive waste in the manner set out in § 2(3) AtEV [8].

10 Operation of the storage facility

10.1 Operating principles

The storage facility shall be operated in such a manner that the necessary precautions against damage are taken according to the state of the art in science and technology. In particular, the following operating states are to be considered:

- for new storage facilities before start-up: all procedures for reaching the normal operating state for the first time (commissioning),
- normal operation and operational incidents,
- control of accidents and elimination of their consequences.

The entire operation is to be structured appropriately to ensure that operational processes can be carried out safely. For this purpose, the following requirements are to be met:

- all operational processes shall be clearly described and the qualifications of the operating personnel required for them shall be specified,
- all installations necessary for safe operation shall be specified, and
- the results of operation shall be systematically evaluated and used for the continuous improvement of the operational processes.

In particular, the necessary administrative prerequisites related to personnel, organisation and safety are to be established and proof of compliance is to be provided. Competencies and responsibilities are to be clearly

defined.

10.2 Organisation and management system of the storage facility operator

The organisational structure of the storage facility operator must provide for clearly defined responsibilities, competencies, powers and communication channels. In particular, the interfaces between the storage facility operator and the waste owners, if they are not identical, are to be defined in clear, unambiguous and comprehensive regulations.

The storage facility operator must ensure that the necessary personnel and the required skills, abilities and experience will be available throughout the entire operating period in order to be able to carry out all necessary activities properly. If the operators make use of external support for this, they must always be able to independently assess the resources and qualifications of the contractor for the proper execution of the activities as well as the quality of the result.

The storage facility operator has to establish a management system and to continuously monitor and develop it. The ultimate goal of the management system should be to achieve, continuously maintain and improve safety.

This requires that the management system

- brings together all requirements necessary for the safe operation of the storage facility in a coherent approach,

- describes all planned and systematic measures that are required for the implementation of these requirements, and

- ensures that requirements from the areas of occupational safety, environmental protection, plant security, quality assurance, ageing management (long-term availability of individual components) and economic efficiency are not considered separately from the safety requirements, thereby preventing potential negative impacts on safety (integrated management system).

The management system is to be maintained continuously for the entire time needed (design, construction, operation and termination of storage) and must cover normal operation as well as operational incidents, accidents and emergency situations.

The management system has to identify those processes that are necessary to achieve the organisational goals, including the provision of means necessary for compliance with all requirements and for task performance. The processes must be carried out and implemented following plans, the implementation is to be assessed and continuously improved. The work procedures of each process are to be carried out under controlled conditions and in compliance with the current provisions. Instructions, drawings and other aids are to be checked periodically to ensure their suitability and effectiveness.

A task of the management system is to compile the necessary qualifications and experience for all employees who perform safety-related tasks and to provide training programmes for development and maintenance of professional knowledge, skills and abilities.

The documentation of the management system includes at least the following:

- the company's safety philosophy,
- a description of the management system,
- a description of the competencies and responsibilities, their assignment, the decision-making structures and the interaction between the management, the performers and those who have to assess the performance,
- a description of the cooperation with important external organisations,
- a description of the processes, including information regarding preparation, review, performance and documentation of the work. In addition, the measures for assessment and, if possible, improvement of the processes and activities are to be described. In doing so, not only the operating experience of the own storage facility is to be taken into account, but also the operating experience from other, comparable storage facilities.

10.3 Commissioning of new storage facilities

Before the start of storage operation, all technical installations of the storage facility are to be subjected to commissioning tests. These tests are to be specified in a commissioning programme. They serve to verify that the installations of the storage facility have been installed so as to meet the requirements for the planned operation.

Prior to the first emplacement of radioactive waste, the entire handling process is to be tested, including the radiation protection measures. During this test, any deficiencies in the process that may still exist are identified, the handling of packaged radioactive waste and large components is optimised, and the planned procedures are adapted and finalised. Prior to the first emplacement of a new container type, inactive testing is to be conducted.

10.4 Operating manual, operating instructions

All operational processes and the measures to be taken in the event of incidents and accidents in operating instructions are to be described in specific documents, the collection of which is referred to as the "operating manual". The operating manual has to contain all operational and safety-related instructions, limits and conditions that are required for the operation of the storage facility and the management of incidents as well as accidents. The technical acceptance conditions and the operating regulations that may apply for the storage facility are also part of the operating manual. This includes, for example, regulations on personnel organisation, maintenance, radiation protection, guard and access, alarms, fire protection and first aid. In particular, the

operating manual has to address any safety-related aspects. This is to ensure that the personnel can initiate and perform the necessary measures during operational processes or in the event of incidents and accidents without any delay and in a reliable manner. In addition, the approach for modifying or supplementing components and procedures is to be specified.

For the structure of the operating manual and with respect to general requirements for the layout of the operating manual, nuclear safety standard KTA 1201 [24] may be used as a guide, in particular with regard to compliance with the state of the art and ergonomics as well as the completeness and clarity of descriptions. The operation of the storage facility should be structured according to the operating states of emplacement, storage and retrieval operation.

An appropriate procedure is to be developed and specified in the operating manual for the event that the radioactive waste delivered does not correspond to the declared data and might not fulfil the acceptance criteria of the storage facility.. Likewise, the notification and reporting procedures are to be defined for such cases.

10.5 Incoming inspections, emplacement

The delivery of radioactive waste to a storage facility requires prior declaration of readiness for acceptance by the storage facility operator. Prior to such a declaration, the operator must check and ensure that the radioactive waste to be delivered complies with the technical acceptance criteria. The information required for this purpose is to be provided by the deliverer of the radioactive waste, which may also be based on quality-assured information provided by the conditioner.

When radioactive waste is delivered, it is to be subjected to an incoming inspection. The incoming inspection has the purpose of verifying that the radioactive waste is identical with the declared radioactive waste for which readiness for acceptance has been determined and must include the following checks:

- condition and labelling of the waste unit,
- dose rate and non-fixed surface contamination of the waste unit, and
- agreement with other declared data (according to operational requirements).

As far as the emplacement of radioactive waste from a neighbouring nuclear installation or facility of the same operator takes place without using public transportation routes, certain parts of the controls already carried out in the neighbouring nuclear installation or facility do not have to be repeated for the incoming inspections of the storage facility if this is provided for in the operator's regulations.

Furthermore, the following is to be observed:

- radioactive waste to be stored is to be considered in the monitoring concept of the storage facility (Chapter 10.6), and

- the emplacement is to be recorded.

For the event that the radioactive waste delivered does not correspond to the declared data and may not fulfil the acceptance criteria of the storage facility, all precautions and actions to be taken must be specified in accordance with the procedure laid down in the operating manual (Chapter 10.4).

10.6 Monitoring concept for stored radioactive waste

Depending on the chemical and physical properties of the radioactive waste, the design of the containers and the ambient conditions in the storage facility, it is possible that the retention properties of the packaged radioactive waste are subject to a relevant change in the course of time during storage. For radioactive waste in storage, it is therefore to be checked whether adverse developments for its handleability or activity release or inadvertent dispersion are to be expected. If this cannot be excluded due to the chemical or physical properties of the radioactive waste, the design of the containers and the ambient conditions in the storage facility, measures for the timely detection of adverse developments are to be taken and stated in a monitoring concept.

A monitoring concept includes at least the following aspects:

- an assessment of the waste, container and storage properties regarding the adverse changes in the handleability of the packaged radioactive waste or activity release or inadvertent dispersal to be expected,

- a description of the test procedures (e.g. random sampling procedure, reference package procedure, rotation procedure or a combination of these procedures),

- information on how inspections are carried out (e.g. visual inspections directly with or without aiding devices (e.g. a mirror) or indirectly (using e.g. a camera),

- information on the specified test intervals and inspection lot sizes, and

- a description of the documentation of the test results with corresponding regulations in the event of changes being detected.

The aim of the monitoring concept is to draw conclusions about the condition of the radioactive waste in its entirety on the basis of the inspections carried out and thus to be able to detect adverse changes at an early stage. The monitoring concept is to be agreed with the competent authority. The same applies to the measures to be taken in the event of a need for action.

The nuclear safety standard KTA 3604 [25] exemplarily provides regulations for radioactive waste stored in thin-walled sheet steel containers in order to be able to derive an appropriate inspection concept with concrete test intervals and inspection lot sizes for monitoring in case of favourable ambient conditions during storage, depending on the waste and container properties. In case changes are detected during the inspection, KTA 3604 also provides assistance for categorisation and initiation of measures.

Depending on the actual duration and conditions of the storage, it cannot be ruled out that measures to restore conformity with the acceptance criteria of the storage facility will be necessary. A repair concept is to be drawn up for this purpose.

If damage is detected and if this has a relevant influence on radioactivity confinement or if limitations regarding handleability or compliance with fire protection requirements cannot be excluded, repair measures are to be taken. In order to enable realisation when required, installations and measures for this purpose are to be kept available in the short term. For example, overpacks are to be kept available for transport or it is to be ensured in some other way that they can be made available in due time to the extent required if no own treatment facilities are available.

10.7 Evaluation of operating experience and operational incidents

Safety-relevant events from commissioning, normal operation (in particular during maintenance and inspection) and recurrent tests are to be documented (Chapter 10.9). The type and scope of this documentation are to be specified. Safety-relevant events are to be reported in accordance with the provisions of the Nuclear Safety Officer and Reporting Ordinance (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV) [26]. Consequences derived from the evaluation of such events are to be assessed and, where appropriate, incorporated into the operating rules. For example, the above-mentioned measures shall be reviewed regularly (e.g. every five years) in the sense of an inspection programme and, if necessary, revised. The evaluations of safety-relevant events, the resulting modifications as well as the amendments to operating rules – also from other comparable storage facilities – are to be considered in the periodic safety review (Chapter 13) and evaluated comprehensively.

In addition, own operating experience as well as findings from comparable storage facilities are to be taken into account in the operational management of the storage facility. This ensures that experience is analysed and assessed for transferability in particular with regard to

- long-term material behaviour of the packaging,
- observed changes in waste forms, and
- ageing phenomena of technical installations of the storage facility and of the storage building.

In this way, also very slow processes and rare events or events only occurring in connection with a certain radioactive waste can be adequately considered in the operational management. For this purpose, procedures are to be provided which ensure the exchange of experience (e.g. on the basis of operating reports or in expert working groups) between the operators of storage facilities at appropriate intervals.

10.8 Removal from the facility

If radioactive waste is to be removed from storage at the facility, the necessary proofs of compliance with the provisions of the requirements under dangerous goods law [10 – 13] must be provided for any intended transport via public routes. When removing waste from the storage facility, exit inspections are to be performed. Radioactive waste leaving the facility is subject to unequivocal identification and declaration. The removal of

radioactive waste from storage is to be recorded.

The technical installations used for handling the packaged radioactive waste and large components and for their removal must be available until all stored radioactive waste has been removed. In this respect, it must be assumed that e.g. the removal of the waste packages, e.g. for the purpose of emplacement in a repository, can take place over a longer period of time. For this purpose,

- the necessary installations of the storage facility (e.g. lifting equipment) are to be kept either operable or in such a condition that operational readiness can be restored in the short term (e.g. by a recurrent test) and these can be used,

- the means necessary for the transport and its preparation are to be provided in due time, and

- the packaged radioactive waste is to be maintained in a condition that generally enables transportability.

10.9 Maintenance and recurrent tests

In the case of storage facilities yet to be constructed, all the installations of the storage facility requiring testing or maintenance must be readily accessible or made accessible by technical means. There must be sufficient space for testing and maintenance work while additional shielding, which might be necessary for radiation protection, has to be kept available.

Regulations for the preparation and performance of maintenance work are to be included in the operating manual.

For safety-relevant installations of the storage facility, as e.g.

- lifting equipment,
- alarm systems,
- fire protection equipment,
- equipment and systems for radiation protection, and
- ventilation and instrumentation and control systems, where applicable,

recurrent tests are to be performed. Recurrent tests are also to be performed regarding the safety-relevant properties of the storage building.

The frequency of the recurrent tests is to be defined according to the safety significance of the components to be tested under consideration of the subject-specific regulations. The recurrent tests are to be specified in a testing manual. The results of the tests must be documented and be available for long-term monitoring. The test results from maintenance and recurrent tests are to be taken into account in the periodic safety review (Chapter 13) and evaluated in a comprehensive manner.

11 Documentation

11.1 Documentation of the storage facility

The documentation of a storage facility has to take place within a systematically structured documentation system. Regarding the structure, nuclear safety standard KTA 1404 [21] can be used as a reference.

The documentation shall include at least the following documents:

- licences and modification licences,
- application documents insofar as they have been considered in the licensing procedure, individual proofs provided (e.g. on fire protection, internal and external hazards), safety reviews,
- proofs on design, manufacturing, construction, commissioning, operation and maintenance of safety-relevant components of the facility, e.g. plans, drawings, manufacturer and test certificates,
- modifications from supervisory procedures,
- operating manual, technical acceptance criteria, testing manual including test reports for safety-relevant components, radiation protection instruction,
- information on radiation protection, and
- operating reports (see Chapter 11.2).

From the time of commissioning of the storage facility, the entire documentation is to be stored in a way that it is protected against fire, flood, adverse magnetic effects, the effects of temperature, light and humidity as well as against vermin and unauthorised access by third parties.

Parts of the documentation of a storage facility are part of the safety documentation. This includes all the information and verifications that are relevant for the safe operation of the facilities and the level of protection.

An illustrative list with all parts of the safety documentation is given in Annex 1.

The safety documentation may consist of many individual documents, which should be clearly presented in a list with the corresponding revision status of the documents.

The safety documentation serves as a basis for safe operation throughout the entire lifetime of the storage facility from planning to construction, commissioning, operation and termination of storage. It also serves as a reference for the safety assessment of modifications to the storage facility and for changes in operating practice. It contains a description of all safety aspects of the storage facility and of all safety-relevant aspects of the site, the construction of the storage facility, the operation, the provisions for decommissioning and dismantling as well as of the management that contribute to the safe operation of the storage facility. It should comprise the storage facility itself as well as the radioactive waste and its safety-relevant characteristics.

The safety documentation must always be kept up to date so that

- modifications, new regulatory requirements and relevant standards,
- the results of the periodic safety review (Chapter 13), and
- the results of the evaluation of events

will be included in the documentation in a timely manner according to their safety significance.

11.2 Documentation of operation

The documentation of operation includes all documents that are prepared during operation. This includes:

- records of operating parameters,
- records of significant operational events and occurrences,
- protocols of measuring equipment,
- documentation of discharges,
- results of radiation protection monitoring, and
- results of recurrent tests and other checks.

Written reports on the operation of the storage facility are to be prepared at regular intervals, containing information on all major operational processes. These include, in particular,

- emplacement and removal, including accounting of the radioactive materials,
- the current storage facility occupancy,
- the results of the recurrent scheduled tests,
- other significant operational processes and occurrences,
- the results of measurements of the personal dose of individuals who were active in the storage facility,
- the results of the radiological measurement programmes for the facility and its surroundings, and
- conclusions and measures arising from internal and external occurrences.

The general purpose of the reports is to indicate whether the requirements for specified normal operation are being met.

11.3 Documentation of the radioactive waste

The requirements for the documentation of the radioactive waste and the responsibilities are described in Chapter 9.2.

12 Emergency preparedness

For the storage facility, an on-site emergency plan is to be drawn up. The emergency plan includes provisions for both radiological and non-radiological events. The emergency plan must include at least the information

listed in Annex 2 [27, 28]. The necessary internal organisational structures are to be established and continuously maintained. The internally responsible persons and the responsible persons for contact with the relevant external organisations for emergencies are to be defined. The persons responsible must be available for the entire duration of an emergency. Based on the on-site emergency plan it is to be ensured that for emergency response, qualified and experienced staff and installations are appropriately prepared, reliably available and ready for operations in emergencies. The on-site emergency plan shall be communicated to the competent authorities and external organisations that are relevant in case of emergencies. Emergency exercises are to be carried out at regular intervals [27]. The competent authority is to be informed about the exercises in advance so that it may participate in them. Some of the emergency exercises are to be carried out as integrated exercises together with the relevant external organisations. The emergency plan is to be reviewed regularly and the experience gained is to be taken into account when revising it.

Depending on the type of storage and the radioactive waste stored, different measures of off-site emergency preparedness may be required additionally (§§ 54, 106, 107, 152 StrlSchV [4]). In the case of storage facilities that exceed the activity limitations specified in § 106 StrlSchV, an emergency plan is required based on the possibilities for release of radioactive material from the storage facility, including the necessary off-site emergency preparedness measures. The information required for this purpose shall be made available to the competent authority as laid down in § 106 StrlSchV.

13 Periodic safety review

The operators must perform a safety review for their storage facilities regularly every ten years. The introduction of a safety review is based both on § 9h AtG [1] and Article 7(2) of the EU Directive on spent fuel and radioactive waste management [29] as well as on the so-called WENRA safety reference levels [27]. Germany, as a WENRA member state, has committed to implementing the latter in national regulations and to their practical implementation.

The ESK guidelines on the performance of periodic safety reviews and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste [30] can be used as a basis for the performance of the periodic safety review and applied mutatis mutandis, taking into account the deviating hazard potential.

Prior to the first periodic safety review, the methodology and scope of the review are to be defined specifically for each facility in agreement with the competent authority. In subsequent reviews, the methodology and scope are to be adapted based on the evaluation of experience gained from previous reviews.

The review begins with an update of the safety documentation, which is to be used as a reference. This is followed by an integrated safety assessment of any changes made to the storage facility, to the process sequences and to the operational organisation in the meantime.

A systematic evaluation of operating experience in the own storage facility as well as in similar storage facilities and the assessment of transferability to the own storage facility are to be included in this compilation.

A monitoring concept is to be presented for the management of long-term and ageing effects during the

envisaged operational lifetime. With regard to ageing, the results of regular walkdowns, inspections and checks of buildings, technical installations and, if applicable, of the waste stored are to be evaluated comprehensively with regard to long-term developments.

The safety review must conclude with an assessment on

- the current safety status of the storage facility,
- the expected development of the safety of the storage facility,
- the identification of relevant deviations (e.g. regarding technical developments and regulatory requirements) and how these deviations are to be assessed from the safety point of view, and
- which measures are foreseen to prevent any identified developments adverse to safety and to improve safety and in what time frame these measures shall be implemented (action plan).

The results of the safety review are to be documented in a report so that the results obtained and experience gained can be communicated (operators of similar installations and facilities, competent authority, transfer of knowledge to the own employees) and considered for future safety reviews. The report is to be submitted to the competent regulatory authority. Any improvement measures to be taken are determined by the operator in consultation with this authority.

14 Termination of storage

The removal of all stored radioactive waste is to be ensured in due time before the end of the storage period.

The storage facility is to be designed and constructed such that it can either be put to further use or demolished after the storage period in compliance with the radiation protection requirements.

Prior to any further use or demolition of the storage building it is to be demonstrated by measurements that the building is not contaminated or that it has been sufficiently decontaminated. For this purpose, it is to be shown that the requirements for clearance as defined in the Radiation Protection Ordinance [4] are met.

The relevant requirements of conventional building and waste legislation are to be observed.

15 Provisions, guidelines and standards

[1] Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz - AtG) vom 23. Dezember 1959,
Atomgesetz in der Fassung vom 15. Juli 1985 (BGBl. I. S.1565), das zuletzt durch Artikel 1 des Gesetzes vom 10. August 2021 (BGBl. I S. 3530) geändert worden ist

[2] Gesetz zum Schutz vor der schädlichen Wirkung ionisierender Strahlung
Strahlenschutzgesetz vom 27. Juni 2017 (BGBl. I S. 1966), das zuletzt durch Artikel 2 des Gesetzes vom 20. Mai 2021 (BGBl. I S. 1194) geändert worden ist

[3] BMU-Richtlinie zur Kontrolle radioaktiver Reststoffe und radioaktiver Abfälle vom 19. November 2008, BAnz. 2008, Nr. 197, S. 4777

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

[5] Bundesamt für Strahlenschutz
Anforderungen an endzulagernde radioaktive Abfälle (Endlagerungsbedingungen, Stand: Dezember 2014) - Endlager Konrad -, SE-IB-29/08-REV-2

[6] Bundesamt für Strahlenschutz
Produktkontrolle radioaktiver Abfälle, radiologische Aspekte - Endlager Konrad - Stand: Oktober 2010, SE-IB-30/08-REV-1

[7] Bundesamt für Strahlenschutz
Produktkontrolle radioaktiver Abfälle, stoffliche Aspekte - Endlager Konrad - Stand: Oktober 2010, SE-IB-31/08-REV-1

[8] Verordnung über Anforderungen und Verfahren zur Entsorgung radioaktiver Abfälle (Atomrechtliche Entsorgungsverordnung - AtEV) vom 29. November 2018
(BGBl. I S. 2034, 2172)

[9] Empfehlung der Entsorgungskommission vom 10.12.2020
Leitlinien für die Konditionierung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung, veröffentlicht im Bundesanzeiger (BAnz AT 29.09.2021 B4)

[10] GGVSEB
Verordnung über die innerstaatliche und grenzüberschreitende Beförderung gefährlicher Güter auf der Straße, mit Eisenbahnen und auf Binnengewässern (Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt - GGVSEB) vom 17. Juni 2009 in der Fassung der Bekanntmachung vom 26. März 2021 (BGBl. I S. 481), zuletzt geändert durch Artikel 3 Absatz 5 des Gesetzes vom 2. Juni 2021 (BGBl. I S. 1295)

[11] GGVSEB-Durchführungsrichtlinien – RSEB
Richtlinien zur Durchführung der Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt (GGVSEB) und weiterer gefahrgutrechtlicher Verordnungen (Durchführungsrichtlinien-Gefahrgut) - RSEB
vom 03. Mai 2019 (VkBl. 2017, Nr. 8, S. 306)

[12] ADR
Anlagen A und B des Europäischen Übereinkommens vom 30. September 1957 über die internationale Beförderung gefährlicher Güter auf der Straße (ADR)
in der seit dem 01. Januar 2019 geltenden Fassung (BGBl. 2018 II S. 443 mit Anlagenband)

[13] RID
Ordnung für die internationale Eisenbahnbeförderung gefährlicher Güter - RID (BGBl.II 1999, Nr. 33, S. 2256), Neufassung vom 16. Mai 2008 (BGBl.II 2008, Nr. 12, S. 475 mit Anlagenband), zuletzt geändert durch 21. RID-Änderungsverordnung vom 05. November 2018 (BGBl. 2018 II 2010, Nr. 21, S. 494)

[14] Allgemeine Verwaltungsvorschrift zur Ermittlung der Exposition von Einzelpersonen der Bevölkerung durch genehmigungs- oder anzeigebedürftige Tätigkeiten (AVV Tätigkeiten vom 08.Juni 2020 (BAnz AT 16.06.2020 B3)

[15] Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen (REI) vom 7. Dezember 2005 (GMBl. 2006, Nr. 14-17, S. 254)

[16] DIN 4102, Teile 1 bis 4
Brandverhalten von Baustoffen und Bauteilen
Teil 1: Fassung 05/1998; Teil 2: Fassung 09/1977; Teil 3 Fassung 09/1977;
Teil 4: Fassung 05/2016

[17] KTA 2201, Teil 1
Auslegung von Kernkraftwerken gegen seismische Einwirkungen
Teil 1: Grundsätze, Fassung 11/2011

[18] Verordnung zur Festlegung von Dosiswerten für frühe Notfallschutzmaßnahmen (Notfall-Dosiswerte-Verordnung – NDWV) vom 29. November 2018 (BGBl. I S. 2034, 2172)

[19] RSK-Leitlinien für Druckwasserreaktoren, 3. Ausgabe vom 14.10.1981 (BAnz. 1982, Nr. 69a)
mit den Änderungen:
in Abschn. 21.1 (BAnz. 1984, Nr. 104)
in Abschn. 21.2 (BAnz. 1983, Nr. 106)
in Abschn. 7 (BAnz. 1996, Nr. 158a) mit Berichtigung (BAnz. 1996, Nr. 214)
Stand 12/98

[20] BMI: Richtlinie für den Schutz von Kernkraftwerken gegen Druckwellen aus chemischen Reaktionen durch Auslegung der Kernkraftwerke hinsichtlich ihrer Festigkeit und induzierter Schwingungen sowie durch Sicherheitsabstände (Stand: August 1976), BAnz. Nr. 179 vom 22. September 1976

[21] KTA 1404
Dokumentation beim Bau und Betrieb von Kernkraftwerken; Fassung 11/2013

[22] Nuclear Decommissioning Authority (NDA)
WPS/870/03: Geological Disposal: Long-term Management of Information and Records: Explanatory Material and Guidance (September 2016)

[23] IAEA
Methods for Maintaining a Record of Waste Packages during Waste Processing and Storage
Technical Reports Series No. 434 (January 2005)

[24] KTA 1201
Anforderungen an das Betriebshandbuch; Fassung 11/2015

[25] KTA 3604
Lagerung, Handhabung und innerbetrieblicher Transport radioaktiver Stoffe (mit Ausnahme von Brennelementen) in Kernkraftwerken; Fassung 12/2020

[26] Verordnung über den kerntechnischen Sicherheitsbeauftragten und über die Meldung von Störfällen und sonstigen Ereignissen (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV) vom 14. Oktober 1992 (BGBl. I S. 1766), zuletzt geändert durch Artikel 18 der Verordnung vom 29. November 2018 (BGBl. I. S. 2034)

[27] Western European Nuclear Regulator's Agency (WENRA)
Waste and Spent Fuel Storage Safety Reference Levels v. 2.2
Report of the Working Group on Waste and Decommissioning (WGWD), April 2014

[28] IAEA Safety Standards
Preparedness and Response for a Nuclear or Radiological Emergency
General Safety Requirements No. GSR Part 7, November 2015

[29] Richtlinie 2011/70/EURATOM des Rates vom 19. Juli 2011 über einen Gemeinschaftsrahmen für die verantwortungsvolle und sichere Entsorgung abgebrannter Brennelemente und radioaktiver Abfälle. – EU-Abl. L199/48 v. 2.8.2011

[30] Empfehlung der Entsorgungskommission vom 13.03.2014
ESK-Leitlinien zur Durchführung von periodischen Sicherheitsüberprüfungen und zum technischen Alterungsmanagement für Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle

Annexes

Annex 1 to Chapter 11: Contents of the safety documentation [27]

The safety documentation of the storage facility should include the following:

- a description of the site characteristics, the storage facility and its installations, design features and safety functions, as well as a list of the safety-relevant structures, systems and components of the storage facility,
- a description of the handling and storage procedures as well as other operational processes in the storage facility,
- a description of the expected volume and characteristics of the radioactive waste to be stored,
- information on the expected operating time of the storage facility, including substantiations,
- the safety assessment for normal operation and for possible accidents following postulated initiating events as well as proofs of compliance with the safety criteria and radiological limits,
- a description of the management system,
- a description of the provisions to minimise operational radioactive waste,
- a description of commissioning, assessment of the deviations identified during commissioning including the reasons for deviations,
- definition of an adequate programme for the continuous verification that the radioactive waste complies with the specified storage conditions under the respective ambient conditions in the storage facility in the long term,
- the operating documentation on
  - operational limits and the conditions for the safe operation of the storage facility, its technical basis and the storage conditions for the radioactive waste,
  - process descriptions and operating procedures for safety-relevant operations,
  - provisions for operational inspections, maintenance and testing,
  - programme for the evaluation of operating experience,
  - ageing management programme,
  - training programme for employees, and
- a preliminary description of the concept for the termination of storage.

Annex 2 to Chapter 12: Contents of the on-site emergency plan [27]

Emergency preparedness

- List of conceivable events, including combinations of nuclear and non-nuclear hazard situations; where relevant: description of possible events and their consequences
- conditions and criteria for declaration of an emergency and description of appropriate means of alerting the responsible personnel and the authorities,
- an inventory list of emergency aids provided and their locations, and
- requirements for training of the personnel.

Personnel, organisational responsibilities and provisions

- Names of the persons in charge of internal activities and persons responsible for contacts with external organisations,
- a list of authorised persons entitled to declare an emergency, including their occupational title and description of functions,
- command and communication structure, including a description of related facilities and processes; means for instructing all persons who are to be informed about the on-site emergency measures should be provided,
- the measures to be performed by persons and organisations for execution of the emergency plan, and,
- the provisions for termination of the emergency.

Assessment of the impacts of the event

- Provisions for monitoring the radiological conditions on-site and off-site (water, vegetation, soil, air),
- assessment of the condition of the storage facility,
- provisions for minimisation of doses to individuals and medical care for injured people, and
- on-site measures to limit releases and prevent dispersion of radioactive material.

Annex 3: Definition of terms

The terms used in these guidelines are defined as follows:

- **Waste package**
  Unit of waste form and waste container intended for disposal.
  Source: Endlagerungsbedingungen Konrad SE-IB-29/08-REV2 (Konrad waste acceptance criteria)

- **Waste container, container**
  Packaging to hold radioactive waste.

- **Waste form**
  Processed radioactive waste without packaging.
  Source: Endlagerungsbedingungen Konrad SE-IB-29/08-REV2, DIN 25401-9 (Konrad waste acceptance criteria)

- **Decay storage**
  Storage of radioactive residues for decay of their activity to such a level that further treatment and disposal can be carried out under optimised radiation protection conditions or, where possible, clearance can take place.
  Source: ESK-Leitlinien zur Stilllegung kerntechnischer Anlagen (2020) (ESK guidelines for the decommissioning of nuclear installations)

- **Operating manual**
  Collective term for all documents that describe the operational processes and the measures to be taken in the event of incidents and accidents. These may be operating instructions, radiation protection instructions, operating rules and/or operating regulations or other operating documents.
  Source: ESK-Leitlinien für die Konditionierung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung (2020) (ESK guidelines for the conditioning of radioactive waste with negligible heat generation)

- **Thick-walled containers**
  Containers with inherent robustness against external and internal hazards due to their wall thickness.

- **Installations**
  For the purposes of these guidelines, this term refers to all structures, systems and components[1]. Where this term is used in a legal sense in these guidelines, this is explicitly stated in the text.
  [1]Source: ESK-Leitlinien zur Stilllegung kerntechnischer Anlagen (2020) (ESK guidelines for the decommissioning of nuclear installations)

- **Clearance of radioactive material**
  Release of materials, components, buildings, sites, etc. from supervision under nuclear and radiation protection law.
  Source: ESK-Informationspapier: Freigabe radioaktiver Stoffe und Herausgabe nicht radioaktiver Stoffe aus dem Abbau von Kernkraftwerken (2018) (ESK information paper: Clearance of radioactive material and removal of non-radioactive material from the dismantling of nuclear power plants)

- **Large components**
  Disassembled or dismantled plant components (e.g. steam generator, reactor pressure vessel) without additional enclosing container.

- **Conditioning**
  Treatment of radioactive waste, if necessary pre-treated, to qualified waste forms and their packaging in containers with the objective of storage and disposal. Conditioning may be carried out in more than one stage and during different time periods via intermediate products and in different conditioning facilities. Conditioning is carried out by procedures whose application has been approved in accordance with § 3(2) of the Nuclear Waste Management Ordinance (Atomrechtliche Entsorgungsverordnung – AtEV)
  Source: ESK-Leitlinien für die Konditionierung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung (2020) (ESK guidelines for the conditioning of radioactive waste with negligible heat generation)

- **Storage building**
  Storage hall including all rooms in which the residual radioactive material and waste associated with the storage are handled.

- **Radioactive waste with negligible heat generation**
  For the purpose of these guidelines, radioactive waste with negligible heat generation is defined as all types of radioactive waste with the exception of spent fuel and vitrified radioactive waste from reprocessing in canisters
  See Chapter 1.1 of these guidelines

- **Technical acceptance criteria of the storage facility**
  Quantitative or qualitative criteria to be fulfilled by the residual radioactive material or waste to be stored.

- **Packaged radioactive waste**
  Radioactive waste or waste forms in containers for disposal and/or storage.

- **Storage**
  Storage of residual radioactive material and waste for further treatment or until disposal.