Note:
This is a translation of the ESK recommendation "Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnder radioaktiver Abfälle in Behältern".
In case of discrepancies between the English translation and the German original, the original shall prevail.

E S K

RECOMMENDATION of the Nuclear Waste Management Commission (ESK)

Guidelines for dry cask storage of spent fuel and heat-generating waste

Revised version of 10.06.2013

Compared with the original version of 21.06.2012, in Chapter 12.4.3 of the version of 29.11.2012, an incorrect reference "(Appendix III, Table 1, Column 4)" has been replaced with the correct wording "for the supervised area". In the revised version of 10.06.2013, a specification was made with regard to the criterion to be taken into account in the considerations related to the reduction of the harmful effects of man-made hazards (Chapter 9.2.2).

Contents

1 General

1.1 Scope of application

The Guidelines apply to the dry storage of spent fuel and heat-generating radioactive waste in tightly sealed metal containers. The safety requirements compiled here are independent of whether storage is performed on the basis of a licence pursuant to the Atomic Energy Act (AtG) /1/ or the Radiation Protection Ordinance (StrlSchV) /2/.

In particular, the Guidelines apply to the following inventories:

- Spent fuel assemblies from light water reactors using uranium oxide (with and without burnable neutron absorbers) or uranium-plutonium oxide as nuclear fuel,
- spent fuel assemblies from the high temperature reactors AVR and THTR [3] using uranium oxide, thorium oxide or carbide materials as nuclear fuel and graphite as moderator,
- spent fuel assemblies from prototype and research reactors (e.g. KNK, RFR, MTR, FRM-II and TRIGA) using uranium or plutonium in the form of oxide, silicide or as uranium-aluminium alloy as nuclear fuel,
- canisters with vitrified fission product solutions from the reprocessing of spent fuel (CSD-V and VEK glass canisters) [4, 5],
- canisters with compacted hulls and structural parts from reprocessing (CSD-C) [6], and
- canisters with vitrified radioactive waste from reprocessing (CSD-B) [7].

The Guidelines also apply to the storage of fuel rods in canisters (i.e. after separation of the fuel assemblies into individual fuel rods). Fuel assemblies which have undergone repairs or from which individual rods have been removed, as well as fuel assemblies or fuel rods with defective cladding are also considered in the Guidelines.

The Guidelines refer to a temporary storage of the above inventories, with the aim of a subsequent disposal. Since a decision on the related disposal concept and its realisation has not been made yet, the actual time needed for storage cannot be stated. In the Guidelines, the safety requirements are therefore formulated such that the specific safety analyses are performed for each of the periods applied for in the licensing procedures. However, the period of 40 years, on which previous storage licences are based, may be referred to as an appropriate time scale. Here, the knowledge gained so far on this storage period can be taken into account. Should it appear that this period will not be sufficient, appropriate additional analyses (e.g. on the long-term behaviour of materials and components of the casks and inventories under the specific load conditions of the storage facility) are to be performed.

1.2 Protection goals

The radiological protection goals, which the technical design and the operation of the storage facility have to comply with, include the requirements that

1 any unnecessary radiation exposure or contamination of man and environment shall be avoided (§ 6 (1) StrlSchV /2/),

2 any unnecessary radiation exposure or contamination of man and environment shall be minimised, even if below the respective limit, by taking into consideration the state of the art and by taking into account all circumstances of individual cases (§ 6 (2) StrlSchV /2/).

The planning of structural or other engineered protection measures against design basis accidents is to be based on the requirements of §§ 49 and 50 in conjunction with § 117 (16) StrlSchV /2/.

The fundamental protection goals derived from it are:

- confinement of radioactive material,
- stable decay heat removal,
- maintenance of subcriticality, and
- avoidance of unnecessary radiation exposure, limitation and control of radiation exposure of the operating personnel and the general public.

The requirements derived from it are:

- shielding of ionising radiation,
- design and implementation of the installations in compliance with the requirements for operation and maintenance,
- safety-oriented organisation and performance of operation,
- safe handling and safe transport of radioactive material,
- design against accidents, and
- measures to mitigate the consequences of beyond design basis accidents.

There are additional requirements, which are not dealt with here, concerning liability /8/, protection against disruptive actions or other third-party intervention /9/, /10/ and the control of fissile material as required by international agreements.

2 Confinement of radioactive material

Confinement of radioactive material is to be ensured by the casks and, where required, additional barriers. Additional barriers may be

- the fuel matrix and the cladding tubes in the case of intact fuel assemblies from light water reactors,
- the fuel matrix and an encapsulation in the case of defective fuel assemblies from light water reactors,
- the fuel particles, the graphite matrix and the fuel assembly cans in the case of fuel assemblies from the high temperature reactors AVR and THTR,
- the fuel matrix and the storage canisters in the case of fuel assemblies from prototype and research reactors (e.g. KNK, RFR, MTR, FRM-II and TRIGA),
- the glass matrix and the canisters in the case of vitrified fission product solutions from reprocessing (CSD-V and VEK glass canisters),
- the material and the canisters in the case of compacted hulls and structural parts from reprocessing (CSD-C), and
- the glass matrix and the canisters in the case of vitrified radioactive waste from reprocessing (CSD-B).

For demonstrating the confinement of the radioactive material, the nuclide characteristics of the radioactive material must also be considered in addition to the interaction of the individual barriers.

2.1 Inventories

During storage, handling, transport and unloading of inventories (cf. Chapter 1.1), the structure of the components that surround the radioactive material contained in the inventory and specify its geometry must be maintained. For this purpose, corrosive damage is to be ruled out with sufficient certainty. To this end, appropriate measures are the limitation of residual moisture and corrosive material and an inert cask atmosphere.

For irradiated fuel rods from light water reactors, the occurrence of systematic cladding tube failure is to be excluded for the entire storage period by the limitation of cladding tube corrosion and compliance with the material-specific maximum tangential stress/strain. The corresponding proof must take into account the operating history of the fuel assemblies specifically or in covering manner.

For the storage of defective fuel rods, special measures are necessary, e.g. gas-tight claddings and/or moisture absorbers, which ensure compliance with the requirements.
For spent fuel assemblies from prototype and research reactors, the above requirements apply accordingly, taking into account the change in materials and element geometries. This applies especially to the surrounding canisters and their welds.

For spent fuel elements from the high temperature reactors AVR and THTR, particular attention is to be paid to the defective particle fraction (barrier function of the coated particles). For the storage of cans with undefined or increased residual moisture, special measures are required, such as gas-tight welding of the cans and/or moisture absorbers, which ensure compliance with the requirements.

2.2 Casks

The casks fulfil significant passive safety functions with regard to the protection goals of confinement of radioactive material, stable removal of the decay heat, maintenance of subcriticality and avoidance of unnecessary radiation exposure. For this purpose, massive metallic containers either made of monolithic ductile cast iron or forged steel are to be used. The casks are either to be sealed tightly by means of long-term stable bolted lid systems or a volumetrically welded lid. The confinement of radioactive material is to be ensured also in case of design basis and beyond design basis events that may have led to an increased leakage rate of the cask.

For spent fuel assemblies (cf. Chapter 1.1), the casks are to be closed with a monitored double-lid closure system or a volumetrically welded lid to ensure confinement. The double-lid closure system consists of two independent lid closure systems (primary and secondary lid closure system) or barriers, each of them bolted on the cask. For bolted cask closure systems, long-term stable spring-energised metal seals with metal jacket are to be used. When installing seals, a standard helium leakage rate of $<10^{-8}$ Pa·m^3/s is to be proven for each seal and of $\leq 10^{-8}$ Pa·m^3/s for the overall lid barrier. This is a system-specific quality criterion with regard to long-term functional reliability and not a leaktightness requirement for radiological reasons.

Barriers with double-lid closure system have to be constantly monitored for their sealing function. For this purpose, a monitoring system is to be used which will send a signal to a central monitoring point as soon as there is a malfunction in one of the two cask closure systems. The monitoring system must allow the identification of the cask affected. The design of the system is to be based on the ambient conditions prevailing within the storage facility. A self-reporting function of the alarm groups reacting to system-internal anomalies has to be provided as well as a self-reporting system for the failure of individual components.

In case an impairment of the sealing function of a barrier of the double-lid closure system is found, a repair concept has to be followed that is specified in the operating documents. This must ensure that the requirements of the two-barrier concept are fulfilled again with the specified leaktightness. The repair concept also has to show which repairs can be carried out at the storage facility and which repairs may have to take place in another facility. In case of repair of the secondary lid, the component affected is to be replaced. In case of repair of the primary lid, the cask can be transferred into the hot cell of a nuclear

facility which may be adjacent to the storage facility, or it may be transported to it on public roads on the basis of a transport permit. The latter requires qualification of the secondary lid barrier under traffic law within the framework of the cask type approval. Alternatively, an additional lid is to be provided, sealed by means of welding instead of the metal seal, which is placed on the intact secondary lid barrier, thus restoring the two-barrier concept in the storage facility. Its components as well as the welding method and the required welding staff are to be qualified and constantly kept available internally or externally. The repaired sealing system also needs to be constantly monitored for its sealing function.

At the time of emplacement, the casks must have a valid approval under traffic law. For transport of the casks, the requirements under traffic law must be met in accordance with the applicable regulations governing the transport of dangerous goods at the time of transport. The measures to be provided during operation of the storage facility within the framework of periodic safety reviews and ageing management also require creating the conditions necessary for being able to demonstrate and verify the technically sound condition of the casks on a continuous basis and within the framework of in-service inspections required under traffic law before transportation. The scope of these in-service inspections allows for taking into account the specific conditions of storage. When applying the repair concept with additional welded lid, care must be taken that either this or the secondary lid is qualified as a barrier in terms of the type approval under traffic law.

For inventories with significantly less release potential in the cask interior compared to LWR fuel assemblies, other technical concepts for the closure of the casks are permissible, provided that confinement and compliance with the protection goals as a whole continue to be ensured.

3 Criticality safety

For the storage of nuclear fuels it must be ensured that during specified normal storage, cask handling and all design basis accidents to be postulated as well as in the event of aircraft crash and pressure blast wave from outside, the nuclear fuels emplaced as well as their configuration will remain subcritical. Here, the requirements of DIN 25403, Part 1, have to be fulfilled, especially the technical safety measures referred to therein and the safety principles which relate to the protection against disruptive events and the demonstration of criticality safety /11/.

Criticality safety during the storage of nuclear fuels has to be demonstrated for the most unfavourable conditions expected during normal specified operation. In this demonstration, the calculated neutron multiplication factor k_{eff} must not exceed the limit of 0.95, with calculation uncertainties and fabrication tolerances according to DIN 25403, Part 1, /11/, DIN 25478 /12/ and DIN 25712 /13/ which are to be taken into account in the result.

In connection with the dry cask storage of spent fuel it is usually necessary to ensure criticality safety by one or several of the following measures:

- limitation of the enrichment of the fuel assemblies, without or with consideration of the burn-up of the fuel assemblies and the associated reduction of the fissile material content as well as the neutron-absorbing effect of the fission products and actinides,

- limitation of the dimensions and the number of fuel assemblies and specification of their geometric configuration in the fuel basket,

- preclusion or limitation of neutron moderation, especially preclusion of inadmissible water volumes in the casks and maintenance of dry conditions in the storage room,

- use of neutron absorbers installed either in the fuel basket or in the emplaced fuel assemblies themselves.

It also is to be demonstrated that subcriticality is maintained in case of deviations from specified normal operation, and during design basis accidents and beyond design basis events, e.g. assuming a closest possible cask configuration and, especially for the flooding of the casks (during loading with fuel assemblies) with water, for incorrect loading of the casks, provided this is not ruled out by appropriate control measures, and for possible changes in the structure of the fuel assemblies and the fuel basket.

For the demonstration of criticality safety, any neutron moderators that may be contained in the nuclear fuel or in the cask must be considered. The same applies to the reflection effect of the fuel assembly cask and its surroundings.

As for the demonstration of criticality safety when flooding with water, the respective most unfavourable moderation ratio possible is to be assumed. In this context, it is to be considered that there may be repaired fuel assemblies or such fuel assemblies where individual fuel rods have been removed or replaced by other rods.

For storage of fuel rods in canisters, the most unfavourable moderation ratio possible is to be assumed for the event of flooding of the canisters with water.

If the burn-up of the fuel assemblies is taken into account in the demonstration of criticality safety, the underlying minimum burn-up is to be verified by measurements on the fuel assembly prior to its emplacement. The requirements of DIN 25712 /13/ are to be fulfilled.

Criticality safety of the fuel assembly casks and the inventories is already examined as part of the approval procedure under traffic law. In addition to this approval, it is to be demonstrated that criticality safety is also given under the conditions prevailing during storage, especially with respect to the reflection

effect of the storage facility and the neutron interaction within the cask configuration, which may deviate from the boundary conditions of the approval under traffic law.

4 Heat removal

Removal of the decay heat must be ensured in such a way that temperatures on the casks and inventories as well as for the storage building will remain below admissible limits at which compliance with the protection goals is reliably ensured for the entire duration of storage. It must be possible to dissipate heat to the environment passively by natural convection.

4.1 Heat removal from the casks

Heat removal must take place in such a way that no cask temperatures will arise that may lead to an inadmissible impairment of the gamma and neutron radiation shielding or the leaktightness of the cask and that no inadmissible inventory temperatures can occur. Especially for LWR fuel assemblies, the fuel rod temperatures must remain low enough to preclude a systematic failure of the fuel rod cladding (see Chapter 2.1).

4.2 Heat removal from the storage facility

For removal of the decay heat of the emplaced fuel assemblies and heat-generating radioactive waste, the storage building must be equipped with inlet and exhaust air openings. The air flow design must be such that the air heated up by the casks is dissipated to the environment and the corresponding amount of outside air is supplied to the casks. It is important to ensure that temperatures arising in the building structures will not be higher than the design temperatures.

If special boundary conditions of cask configuration have to be taken into consideration, these are to be specified in an occupancy plan (see Chapter 12.4.5). Any possible deviations from this occupancy plan are to be assessed with regard to their safety relevance.

Inlet and exhaust air openings may be kept closed in storage areas in which no casks or only casks with negligible heat generation are stored if this will not lead to an inadmissible impairment of heat removal from the casks emplaced. For an optimisation of the necessary air exchange rates and for safe heat removal, detailed regulations are to be included in the operating manual.

5 Shielding of ionising radiation

During storage of spent fuel and heat-generating radioactive waste, adequate shielding of the ionising radiation is to be ensured by the cask design and, additionally, by the design of the storage building in order to protect the general public and the operating personnel.

For an individual member of the general public, the effective dose limit per calendar year is 1 millisievert. This limit also applies to individuals on site who are not occupationally exposed to radiation. This limit has to be adhered to when demonstrating the requisite shielding as the sum of the radiation exposure obtained from direct and scattered radiation of the storage facility and with consideration of the contributions to radiation exposure from any discharges, from the direct and scattered radiation emitted by all contributing nuclear facilities at the site and from former activities. The stay times of members of the general public, which are decisive for the determination of the radiation exposure resulting from direct and scattered radiation, are governed by the conditions prevailing at the site; if no well-founded reasons are given for a limited stay time, permanent stay has to be assumed.

The requirement of transportability of the casks and the limitation of radiation exposure of the general public and operating personnel lead, depending on the shielding effect of the building and the storage concept, to dose rate targets for the gamma and neutron radiation on the cask surface whose compliance must be ensured by the cask design. With a high shielding effect of the building, the dose rate on the cask surface is either limited by the requirement of transportability or for reasons of occupational radiation protection (prevention of exclusion area conditions in the storage area).

For the demonstration of the required shielding by calculating the radiation exposure in the environment and at the facility site, gamma and neutron radiation, including any occurring scattered radiation and secondary radiation, is to be taken into account. For these calculations, qualified calculation methods are to be used and their suitability is to be demonstrated. In the calculation, the highest possible gamma and neutron source intensity in the casks and in the entire storage facility as well as the most unfavourable spatial distribution of the radiation sources, also including transport and handling processes, are to be assumed. If necessary, other radioactive substances that may arise (e.g. radioactive waste, contaminated or activated empty casks) are to be considered in the registration of radiation sources.

For the intended operation of the facility, it is to be checked whether the operator's cabs of lifting and transport equipment used in the storage area are to be shielded to minimise radiation exposure.

For the configuration of the casks in the storage facility, making use of the mutual shielding is of advantage. However, the aspects of accessibility and controllability of the casks as well as their thermal influence on each other are to be considered when defining the configuration (see Chapter 12.4.5).

For movable additional shields or gates with shielding functions, precautions are to be taken that an inadvertent removal of these shields is prevented and that gates are not left open.

In the design of the storage facility building, the aspect of shielding is to be taken into account, in particular with regard to the design of the inlet and exhaust air openings, gates and expansion joints.

6 Radiation protection

6.1 Principles

According to § 6 of the Radiation Protection Ordinance (StrlSchV) /2/, any unnecessary radiation exposure or contamination of man and the environment shall be avoided. Here, any unnecessary radiation exposure or contamination of man and the environment shall be minimised, even if below the respective limit, by taking into consideration the state of the art and by taking into account all circumstances of individual cases. Consequently, the handling and monitoring measures performed by the staff in the storage area shall be minimised to the extent possible. The requirements on the storage of the spent fuel and heat-generating radioactive waste are derived from this protection goal.

According to § 34 StrlSchV /2/, a radiation protection instruction is to be issued for the operation of the facilities and technical installations for the storage of fuel assemblies and heat-generating radioactive waste. This radiation protection instruction has to include the protection goals mentioned and the requirements and radiation protection measures derived from them. Further, the radiation protection instruction has to include the measures for the employees for ensuring the technical qualification in the field of radiation protection and for the promotion of a safety-oriented attitude and behaviour in accordance with the provisions of the Radiation Protection Ordinance.

Planning and execution of maintenance, controls and repairs are to be regulated in a procedure for work clearance under consideration of radiation protection aspects. The required equipment and installations must be available or procurable within an appropriate period of time.

The storage facility is to be divided into radiation protection areas in accordance with the radiation protection requirements and marked accordingly. Here, a differentiation is to be made between supervised, controlled and exclusion areas according to § 3 StrlSchV /2. It should be avoided to have areas with local dose rates that would require the establishment of an exclusion area.

6.2 Radiation monitoring in the storage facility

In the radiation protection areas, the local dose and the local dose rate have to be measured and documented for each change in the inventory, however at least once a year. This measurement is to be performed at representative points. Here, gamma and neutron dose rates are to be recorded. Mobile measuring equipment

is to be provided to the extent necessary and used, in particular, in connection with maintenance measures.

The room air in working areas in which contamination may occur is to be monitored for control purposes, e.g. by means of mobile air sample collectors. Transport areas within the storage area, persons, work places, transport paths and mobile objects are to be checked for contamination in an adequate manner and the results to be documented. For decontamination, organisational specifications are to be made and adequate means be provided or be procurable in the short term.

For gamma and neutron radiation, the body dose of occupationally exposed persons in controlled areas is to be determined and documented by means of adequate official dosimeters, e.g. Albedo dosimeters. Regarding work performed at the storage facilities, dosimeters whose results can be read at any time and that comply with the state of the art shall be used in addition to the official dosimeters. For work in the storage facilities, dosimeters whose results can be read at any time and that comply with the state of the art are to be used in addition to the official dosimeters. Regarding the work places, protection of personnel against external and internal radiation exposure shall be ensured primarily by means of technical measures (§ 43 StrlSchV /2/).

According to § 67 StrlSchV /2/, the radiation measuring devices used and kept available shall meet the requirements of the measurement purpose and be tested for their functional performance and serviced at regular intervals. The measuring devices shall be available in sufficient numbers.

6.3 Radiation monitoring in the environment

For storage facilities, the local dose rate resulting from gamma and neutron radiation is to be monitored at representative places, e.g. at the facility's perimeter fence, regarding compliance with the limits of § 46 StrlSchV. Details are regulated by /14/.

Storage facilities in the neighbourhood of a nuclear facility that disposes of a system to monitor the environment are also to be included in this monitoring system, if required by contractual agreements.

6.4 Clearance/removal of substances

Substances in the storage facility that do not fall within the scope of § 44 (3) StrlSchV /2/ ("bringing outside") are to be assessed radiologically prior to the permanent release from being subject to the Atomic Energy Act. Substances for which contamination and activation can be excluded, may be removed. Radioactive substances for which this cannot be excluded are subject to a clearance procedure according to § 29 StrlSchV /2/. The procedures for removal and clearance are to be laid down in the operating rules and regulations.

The clearance procedure must allow the review of essential data (nuclide vector, suitability and calibration of measuring equipment, and origin of the substance and, if necessary, proof of homogeneity) as well as random control measurements.

The freedom from contamination and activation of substances intended for removal is to be demonstrated via plausibility considerations, taking into account the history of the facility, as well as random evidence preservation measurements. Here, the detection limits of the evidence preservation measurements should be oriented, taking into account the technical feasibility of measuring, to 10% of the allowable values for unrestricted clearance according to Appendix III, Table 1, Column 4 and Column 5 StrlSchV /2/.

7 Structural provisions

The structural provisions are implemented according to the building regulations of the *Länder* and the generally accepted engineering standards. In addition, further design requirements result from the safety analyses on specified normal operation of the storage facility and on design basis accidents:

- For the design of the building, the intended duration of use is to be considered with regard to usability and durability of the building materials and components.

- Inlet and exhaust air openings of the storage building are to be arranged and dimensioned such that safe removal of the decay heat of the inventory is ensured (cf. 4.1).

- The temperature load and ageing resistance of the building structures resulting from the heat dissipated from the casks are to be considered in the structural design (cf. 4.1 and 15).

- Shipment areas and cask maintenance stations (also referred to as cask reception and maintenance areas) are to be designed to have surface coatings that are easy to decontaminate.

- The structural parts of the storage building must have sufficient temperature, pressure and wear resistance. The floor in the storage area must have a compacted and smoothed top layer.

- The base plate of the storage facility must be designed such that it can be driven on by transport vehicles and bear the cask loads in accordance with the intended occupancy plan. Here, partial occupancy conditions also have to be considered (also see Chapter 12.4.5 Storage facility occupancy).

- The structural design also has to consider impact loads during transport processes, unless excluded by measures. Further, crane loads and loads of other heavy plant components, e.g. shieldings, and special loads from internal and external impacts are also to be taken into consideration.

- If cask crash is to be assumed, the building structures in the storage and shipment area are to be designed to limit damage such that the safety function of the building (stability, shielding and heat dissipation) is maintained and that there is the possibility of repair. To limit the stress on cask and building structures, special measures may be necessary, such as the use of shock absorbing structures in potential crash areas.

- Storage and shipment areas form a fire compartment, unless significant fire loads are stored in the shipment area. Adjacent buildings, such as office and staff facilities, laboratories and workshops, are to be designed as separate fire compartments.

- With the exception of decontaminable coatings and structural water proofing, the materials used for the building with shipment and storage area must be "inflammable" (Class A according to DIN 4102-1 /15/) (cf. Section 8.4).

- The design of the storage building must ensure stability for the load case of fire according to DIN 4102, Part 2 to 4 /15/.

- The building is to be provided with earthing and lightning protection systems in accordance with KTA 2206 /16/.

- The storage facilities are to be protected against flooding in accordance with KTA 2207 /17/.

- The design of the storage building must ensure stability for the earthquake load case in accordance with KTA 2201 /18/ (cf. Chapter 9.2.1).

8 Technical installations

8.1 Lifting equipment and other transport equipment

The technical design of lifting equipment used for the handling of the casks is to be based on KTA 3902 /19a/. A design according to more stringent requirements is not necessary if it is demonstrated that in the event of handling incidents, e.g. cask crash, the accident planning values of §§ 49 and 50 in conjunction with § 117 (16) StrlSchV are complied with and the building is designed against resulting loads. Controlled drives are to be provided for lifts and motors to ensure safe handling of the casks.

A system is to be provided for the storage hall crane to limit the lifting height and for approaching pre-selected setdown areas for casks in the storage facility. For the case of operational disturbances, measures are to be provided for setting down the load.

For the earthquake load case, stability of the storage hall crane is to be demonstrated without load according to KTA 3902 /19a/.

In principle, it is also possible to use ground-operated transport vehicles for transporting the casks in the storage facility. In this case, the building is to be designed for the loads accordingly. Impact loads also have to be considered in the design of the building and the casks.

8.2 Ventilation

It must be possible to remove the decay heat at all cask positions by passive installations (natural convection).

If active ventilation systems are provided for the storage area, it must be ensured that the removal of the decay heat by natural convection is not inadmissibly impaired in case of disturbances or design basis accidents.

The air exchange rates in the storage area are to be chosen such that the formation of condensed water in considerable amounts is prevented. For this purpose, it is permissible to adapt the air exchange rates to the heat output of the casks emplaced.

In the cask maintenance station, an active ventilation system is to be provided if passive cooling is not sufficient to support heat removal. Since the work in the cask maintenance station can be interrupted at any time, it is sufficient if it is possible in the event of anomalies to switch to passive cask cooling by simple standard manual measures.

For maintenance work on the cask where a release of radioactive or other harmful gases cannot be excluded, an extraction system is to be kept available.

8.3 Electrical installations

For electrical power supply of the storage facility, normal power supply, backup power, and uninterruptible power supply must be provided.

The normal power supply system is used for the operation of the storage area and the supply for the infrastructure. The design has to comply with conventional regulations (VDE rules).

The backup power supply system, i.e. the second normal power supply system, and the uninterruptible power supply system serve the supply for important installations. Parts of the lighting and surveillance systems are to be connected to the backup power supply system. Depending on its safety significance, it is sufficient to design the backup power supply as single-train system because no active safety systems are necessary to

comply with the protection goals and all ongoing activities can be interrupted at any time without risk.

The uninterruptible power supply system has to supply the security systems, the emergency lighting and illuminated sings and, where required, important IT systems and radiation measuring systems.

8.4 Fire protection and fire protection systems

For the storage building, a fire protection concept is to be established in accordance with KTA 2101.1 /20/.

The confinement of radioactive material and adequate shielding must be maintained during and after fires.

The fire protection measures must be suitable for limiting any potential fire loads acting on the casks in the handling and storage configuration such that at least one sealing barrier remains functional so far that the dose limits specified in § 49 and 50 in conjunction with § 117 (16) StrlSchV /2/ are complied with.

The fire loads in the building are to be minimised. In the storage area, the storage of flammable substances is only permitted if these substances are stored in a condition in which their ignition can be ruled out. The design of the fire protection measures has to comply with DIN 4102 /15/ and KTA 2101 /20/. Here, the respective more stringent requirement is to be applied.

Except for the storage area, the length of the escape routes in the building must not exceed a walking distance of 50 m each. In the storage area, the maximum permissible walking distance is 120 m.

To fight incipient fires, mobile fire fighting systems are to be kept available that are distributed throughout the building, also considering temporarily present fire loads. In the selection of extinguishing agents, possible consequential damages (e.g. due to corrosion) are to be considered. The operating personnel must be trained in the fighting of incipient fires.

8.5 Treatment of waste and contaminated water

The casks to be brought into the storage facility must undergo controls prior to their delivery, which also include contamination controls. During these and other activities in the storage facility, small amounts of contaminated waste or residues and contaminated waters are produced. The resulting operational waste, such as material from wipe tests, used cleaning agents or waters possibly produced in the controlled area, are to be collected in suitable containers. Prior to any removal of water it is to be checked for its

activity. Depending on the measuring result, this water may be cleared or given to owners of other licences /2/.

Regarding the removal of radioactive waste, the BMU guideline on the control of radioactive waste with negligible heat generation not delivered to a *Land* collecting facility is to be observed for the collection, labelling, processing and documentation /21/. For non-radioactive waste and waste water, the requirements of the waste and water laws are to be observed.

Details on the treatment of waste and residues are to be regulated in the operating manual.

8.6 Shipment area and cask maintenance station

A shipment area and a cask maintenance station - also referred to as cask reception and maintenance areas – are to be provided in the storage facility, separate from the storage area, where work for storage of the casks and removal from the facility as well as maintenance and repair are performed.

In the cask maintenance station, a crane must be available for transporting components of the lid system. With respect to any required work involving a release of contaminants, such as welding or painting, appropriate ventilation or exhaust systems are to be provided for the cask maintenance station. For welding, suitable protection measures are to be provided additionally. If a release of radioactive substances cannot be ruled out in connection with work on the casks, appropriate exhaust and sampling systems are to be provided for the protection of the personnel.

9 Accident analyses

Through an accident analysis it is to be investigated which operational disturbances and design basis accidents may arise in connection with the storage of the spent fuel assemblies and heat-generating radioactive waste. For this purpose, the specific conditions of storage including potential long-term effects and the operational processes are to be analysed systematically and experiences from similar facilities to be considered.

From this analysis, the design basis accidents for storage are to be derived and delimited from operational disturbances belonging to abnormal operation and from beyond design basis events. Human error is to be taken into account in the analysis of the potential accidents. For beyond design basis accidents, compliance with the requirements of §§ 49 and 50 in conjunction with § 117 (16) StrlSchV /2/ is to be verified by calculation of the potential radiological impacts, unless the possibility of an accident can be ruled out due to the precautions that have verifiably been taken.

9.1 Internal hazards

For the dry storage of spent fuel and heat-generating radioactive waste, the following internal events are usually to be considered as design basis accidents:

1 Mechanical impacts:

- Crash of a cask, taking into account all scenarios that result from the actions defined in the operating manual.

  If lifting equipment of the storage facility (crane and load-bearing equipment) are designed to meet the increased requirements of KTA 3902 /19a/ and the load attaching points of the casks the more stringent requirements of KTA 3905 /19b/ and continued compliance with these requirements is ensured for the duration of storage (e.g. for lifting equipment by means of in-service inspections according to KTA 3903 /19c/), cask crash is not to be assumed and crash scenarios are not to be considered.

- Collision of a cask during handling, taking into account the possible impact or collision partner.

- Crash of the largest load onto the casks to be considered.

  From the analysis of all operationally permissible operations in an storage facility, those scenarios are to be derived which represent the highest (global) mechanical stresses on the cask structure. To determine these scenarios, appropriate engineering analysis methods, taking into consideration main influencing parameters such as drop height, impact kinematics and impact partners (e.g. vehicle, building, shock absorber), are to be referred to. As a next step, stability is clearly to be demonstrated for the scenarios determined this way according to state of the art under consideration of local (usually numerical) stress analyses and the material parameters depending on the stress boundary conditions (e.g. temperature, strain rate, ageing), allowing to assess compliance with the protection goals.

2 Thermal impacts caused be fire

The maximum stationary and temporary fire loads in the storage facility are to be considered. In addition to the demonstrations to be provided for the integrity of the casks and the sealing function as described in 8.4, possible fires in the storage facility involving potential activity releases are to be analysed. Flammable operational waste and temporarily present potential fire sources are to be considered in the accident analyses.

9.2 External hazards

For the dry storage of spent fuel and heat-generating waste, the following external hazards are usually to be considered:

- External natural hazards, such as storm, rain, snow, frost, lightning, flooding, landslides and earthquakes,

- external man-made hazards, such as impacts of harmful substances, pressure waves caused by chemical reactions, external fire spreading inside (forest fire), damage from mining, aircraft crash (accidental crash of a fast-flying military aircraft).

Where necessary, site-specific characteristics are to be considered additionally.

Possible interactions with neighbouring nuclear facilities are dealt with in Chapter 9.2.3. External hazards due to wilful actions by third parties are considered in connection with the protection against disruptive actions and other cases of third-party intervention /9/ and /10/.

9.2.1 External natural hazards

External natural hazards are to be considered as operational loads or as design basis accidents. The load assumptions for these impacts caused by nature are to be specified in accordance with the site conditions:

1 The design against storms, rain, snowfall and frost is to be based on the most adverse weather conditions to be expected at the site.

2 The storage building is to be protected against lightning in accordance with KTA 2206 /16/ and according to the relevant VDE guidelines and regulations.

3 The storage facility should be located at a flood-free site. If inundation caused by flooding cannot be ruled out, the storage facility is to be protected against flooding in accordance with the requirements of KTA 2207 /17/.

4 Compliance with the protection goals is to be ensured for the design basis earthquake. Earthquake impacts on technical installations - such as lifting equipment, shielding doors - or on the storage building must not lead to any inadmissible radiological consequences for the general public according to § 49 and 50 in conjunction with § 117 (16) StrlSchV /2/. For the consideration of the earthquake load case, the design earthquake according to nuclear safety standard KTA 2201.1 /18/ is to be used as a design basis.

9.2.2 External man-made hazards

The load assumptions for external man-made hazards follow the state of the art in science and technology under consideration of site-specific conditions. Within the frame of an accident analysis, it is to be shown which impacts are to be expected from external man-induced hazards. The decision which events are to be classified as design basis accidents and which events only require protection measures under the aspect of minimisation of damage extent is to be oriented towards occurrence frequency and impacts of the events.

Aircraft crash, blast wave and ingress of toxic substances are, in general, beyond design basis accidents. In this respect, damage reduction measures for aircraft crash and blast wave with impact from outside are to be considered on the basis of the load assumptions from RSK guidelines for pressurised water reactors for aircraft crash /22/ and the guideline of the Federal Ministry of the Interior (BMI) on the protection of nuclear power plants against blast waves /23/ and of the site-specific specifications and the emplaced nuclide-specific activity inventories and their release behaviour. The aspect of damage reduction is considered to be fulfilled if the radiological consequences of these events determined under realistic boundary conditions do not require any drastic disaster control measures /24/. The reduction of damage caused by aircraft crash and blast wave may either be achieved by the casks or by a combination of cask and storage facility/building.

In addition to the destruction of the aircraft structure, the impact of the aircraft on the storage building according to the load-time function as specified in /22/ will also lead, depending on the building structure, to its damage or destruction. The safety-relevant load scenarios resulting therefrom for the casks are to be assessed. This may include the impact of compact aircraft structures, such as aircraft engines and landing gear as well as heavier parts of the building (e.g. roof truss crash), on the casks.

If the casks get damaged or buried due to the impact of components, wreckage or technical installations crashing down, subsequent fires or debris loads must not impair the protection goals in an inadmissible manner.

9.2.3 Interaction with an existing nuclear power plant

For storage in the immediate vicinity of an existing nuclear power plant, the following events at the power plant site are to be considered and the impacts on the storage facility to be examined:

- Collapse of the stack or other structural parts,
- turbine failure, and
- failure of casks with high energy content.

Moreover, in each case, the accessibility of the storage facility and the neighbouring nuclear power plant is to be ensured.

10 Self-sufficient operation of the storage facility

For storage facilities located in the immediate vicinity of another nuclear facility in operation, sharing of infrastructure facilities is permissible. These include, among others,

- instrumentation and control systems and equipment,
- environmental monitoring systems,
- physical protection systems,
- supply and disposal of media, including electrical supply,
- general services, and
- personnel.

When shared, is to be ensured that the operation of the storage facility will not be in a manner that would be inadmissible from a safety-related point of view. It also has to be ensured that the displays of the cask surveillance system will also be shown in the storage facility.

If operation of the storage facility is planned for a period that exceeds the operating time of the neighbouring nuclear plant whose installations are shared, a concept is to be presented, showing the measures to establish self-sufficient operation of the storage facility following the decommissioning of the neighbouring nuclear facility. In this context, the repair concept for the casks also is to be adapted.

11 Quality assurance

A quality assurance concept for the construction and operation of the storage facility that is graded according to safety requirements is already to be developed during planning and design of the storage facility. For this purpose it is expedient to assign all systems, parts and components to specified quality classes according to their safety-related or radiological significance.

The accompanying quality control for quality assurance comprises the design review, accompanying controls during manufacturing, and acceptance and functional tests. The scope of the accompanying controls is to be specified according to the safety requirements of the respective quality class. The basic procedure has to take place in line with DIN ISO 9000 and following standards and in accordance with KTA 1401 /25/. For the documentation, the principles of KTA 1404 /26/ shall apply.

The manufacture of the casks and all of their components is based on a quality management system certified according to DIN ISO 9000 and following standards. In particular, the conditions of the note /27/ as last

amended apply. Prior to loading, compliance of the cask quality with the requirements for storage is confirmed in the form of a certificate of conformity on the basis of the final acceptance certificate under traffic law and the manufacturer's documentation on components not covered by it, including the storage-specific assessment of all documented deviations. For separately manufactured safety-relevant components, such as metal seals, welded lids and pressure switches, separate conformity certificates may be presented.

12 Operation of the storage facility

12.1 Operating principles

Construction and operation of the storage facility have to be such that the necessary precautions are taken according to the state of the art in science and technology. In particular, the following operating conditions are to be considered:

- For newly constructed storage facilities: all processes for reaching normal operating conditions of the facility for the first time (commissioning),
- specified normal operation, and
- identification and management of anomalies and design basis accidents, as well as elimination of their consequences.

For the safe performance of these operational processes, the entire operation is to be structured in an adequate manner. For this purpose, the following requirements are to be complied with:

- All operational processes are clearly to be described.
- All systems and equipment necessary for safe performance of operation are to be specified.
- Persons with performance authorisation are to be assigned to the operational processes.

In particular, the necessary personnel, organisational and safety-related administrative prerequisites are to be established and demonstrated. For the operational processes as well as the management of design basis accidents and elimination of their consequences, clear instructions are to be laid down in an operating manual. Competencies and responsibilities are clearly to be specified.

12.2 Organisation and management system

The organisational structure of the storage facility operator must show clearly defined powers, responsibilities and communication channels. The organisational structure must ensure that throughout the period of time necessary for safety the required personnel with the necessary skills, abilities and experience will be available to perform all necessary activities appropriately.

If the storage facility organisation makes use of external aid, it must ensure the proper execution of the activities of the external organisation.

The storage organisation has to establish a management system and to continuously monitor and develop it. The management system shall be congruent with the organisational goals and contribute to the implementation of these goals. The ultimate goal of the management system should be to achieve and 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 actions that are required for the implementation of these requirements, and

- ensures that requirements concerning occupational safety, the environment, the protection and maintenance of the storage facility, and the quality and economic efficiency are not considered separately from safety requirements, thereby avoiding potential negative impacts on safety.

The management system is to be maintained continuously for the entire time needed (design, construction, operation, decommissioning and dismantling of the storage facility) and must cover normal operation as well as anomalies and accident and emergency situations.

In the management system, those processes are to be identified 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 should be carried and implemented as planned, implementation should be assessed and improved continuously. The work steps of each process are to be carried out under controlled conditions and in compliance with the applicable provisions. Instructions, drawings and other aids should be checked periodically to ensure their suitability and effectiveness.

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

The management system is to be described. The documentation of the management system should include at least the following:

- the company’s safety policy,
- a description of the management system,
- a description of the roles and responsibilities, their assignment, the decision-making structures and the interaction with the management, the performers and those who have to assess the performance,
- a description of the co-operation with relevant external organisations, and

- a description of the processes, including information regarding preparation, independent 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.

12.3 Commissioning

Prior to the start of storage operation, all installations of the storage facility are to undergo commissioning tests. These tests are to be specified in a commissioning programme. They serve to verify that the installations of the storage facility were installed so as to meet the requirements of planned operation.

At each storage facility, all cask types Iicensed for storage are to undergo cold testing with one cask each for the entire handling procedure, including radiation protection measures, prior to first emplacement. These tests serve to identify procedure deficiencies that might still exist, to optimise handling of the casks, and to adapt and finally define the planned procedures.

12.4 Operation

12.4.1 Normal operation

An operating manual is to be prepared in accordance with KTA 1201 /28/, describing all operational processes as well as the measures to be taken in case of design basis accidents in the form of clear operating instructions. In particular, all aspects related to safety are to be addressed. Moreover, the procedure in connection with modifications or the supplementation of parts of the facility and of procedures is to be defined.

The assumptions and boundary conditions applied in the safety analyses for cask characteristics and inventories are to be summarised in technical acceptance criteria for the storage facility. For the verification of compliance with the technical acceptance criteria, implementation instructions are to be prepared which include, in particular, operating and test procedures to be applied for cask loading and handling.

Safety-related installations of the storage facility are to be subjected to in-service inspections whose frequency is to be stipulated in accordance with the safety significance of the components to be tested under consideration of the specific regulations. The in-service inspections are to be defined in a testing manual in accordance with KTA 1202 /29/. The concept and design of the facilities is to be such that the area to be inspected is fully accessible and the inspections can be carried out with low radiation exposure of the personnel. Type and scope as well as the involvement of experts in the inspections are to be specified for initial tests and in-service inspections. The results of the in-service inspections are to be documented and are available for long-term monitoring.

The operation of the storage facility is to be monitored such that safety-significant operational anomalies and design basis accidents can be reliably detected and countermeasures laid down in the operating manual can be taken. Fault alarms are to be centrally recorded and documented.

Records are to be kept for safety-significant events. Safety-relevant findings from commissioning and normal specified operation (especially for maintenance and inspections) are to be documented. Type and scope of this documentation are to be specified. Safety-significant events are to be reported in accordance with the provisions of the Nuclear Safety Officer and Reporting Ordinance (AtSMV) /30/. The consequences derived from the evaluation of such events are to be assessed and, where appropriate, considered in the plant operating procedures accordingly.

Experiences from operation of comparable facilities are to be taken into consideration for the operation of the storage facility. This will ensure that experiences are particularly analysed and assessed with regard to ageing phenomena of installations of the storage facility. In this way, even very slow processes and rare events or only occurring in connection with certain cask types can be adequately considered in the operational management. For this purpose, procedures are to be provided to ensure the exchange of experiences (e.g. on the basis of operating reports) between the operators of storage facilities at appropriate intervals.

The technical equipment used for the handling of the casks and their transport must be available until all casks have been removed. It must be assumed that a removal of the casks, e.g. in preparation for emplacement in a disposal facility, may take place over a longer period of time. For this purpose,

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

- the auxiliary means necessary for transport and its preparation are to be available when required, and

- the casks are to be maintained in a condition which enables the fulfilment of requirements under traffic law.

12.4.2 Abnormal operation

Abnormal operating conditions include failures of safety-relevant components and systems, such as

- loss of power supply,
- failure of components of lifting and transport equipment,
- failure of a seal of the double-lid closure system,
- malfunction of the cask monitoring system including pressure switch (cf. Chapter 2.2),
- failure of monitoring installations (e.g. fire alarm system, radiation monitoring and other I&C installations),
- damage to structures which may lead to the impairment of safety-relevant systems, and
- failure of ventilation systems or active components to support heat removal (e.g. in the cask maintenance station).

For abnormal operating conditions, proof of compliance with the limits of § 46 and § 47 StrlSchV /2/ is to be provided.

In case of failures or malfunctions of the above components and systems, repair measures are to be initiated immediately in agreement with the competent authority.

Due to the passive safety concept for the dry storage of fuel assemblies and heat-generating radioactive waste in accordance with this guideline, an explicit derivation of maximum allowable repair times is not necessary, since the above abnormal operating conditions have no direct impact on the compliance with the protection goals.

On the basis of a safety assessment of the storage concept and under consideration of the experience available to date in the field of dry storage of fuel assemblies and heat-generating radioactive waste, the following repair time regulation for the cask monitoring system is appropriate.

After actuation of the cask monitoring system, the cause is to be clarified within a diagnosis time of five working days and a decision to be made on the assignment to one of the following three cases:

1 ***Pressure switch defective:*** Preparation of replacement of the pressure switch is to be started immediately. The cause of the pressure switch failure will be clarified separately.

2 ***I&C defective:*** Preparation of the repair is to be started immediately. Until completion of the repair, the affected pressure switch signals are to be read out discontinuously at monthly intervals.

3 ***Seal defective:*** Preparation of the repair is to be started immediately according to the repair concept (replacement of the seal, installation of additional lid or removal).

12.4.3 Incoming casks control

Only those casks may be accepted whose loading was carried out in accordance with the technical acceptance criteria (see Chapter 12.4.1) of the respective storage facility. Incoming casks are to be examined for their surface contamination. Only those containers may be emplaced whose surface contamination does not exceed the admissible limits according to the Radiation Protection Ordinance (StrlSchV) /2/ for the supervised area. If emplacement takes place from a neighbouring nuclear power plant without transport on public roads, it may be provided that certain parts of the controls that must be performed during the loading process at the nuclear power plant may be dispensed when to be emplaced in the storage facility.

During transport of the casks to the storage facility on public roads, the transport documentation is to be presented. The documentation must show whether the routine transport conditions have been met.

If several casks are delivered at the same time, an area has to be provided for temporary storage until the casks are ready for emplacement in the storage area. The short-term storage area is to be designed under the aspects of operational radiation protection.

Should incoming controls reveal any deviations from the acceptance criteria of the storage facility, the competent authority is to be informed, and appropriate measures are to be defined.

Should during transport deviations from the routine conditions of transport have occurred, the casks must be subjected to special examinations for damage or impairment. All measures that are used to restore the required conditions are to be performed according to a step-by-step schedule approved by the competent authority.

12.4.4 Outgoing casks control

If outgoing casks are to be transported on public roads, they are to be checked by measurements for compliance with requirements resulting from traffic law and with regard to the fulfilment of the requirements of the accepting facility. People, objects and work equipment are to be subjected to an appropriate exit control according to the Radiation Protection Ordinance.

12.4.5 Storage facility occupancy

For the arrangement of the casks in the storage area, an occupancy plan is to be prepared.

The arrangement of the casks defined by the occupancy plan must ensure that the maximum radiological, thermal and mechanical loads considered in the building design are reliably observed in each storage segment. Moreover, the cask configuration must ensure aspects of handling and accessibility for controls.

Each storage, removal and relocation of casks is to be documented. Here, continuous compliance with the maximum radiological, thermal and mechanical loads considered in the building design is also to be documented.

Joint storage of inventories mentioned in this guideline with related equipment for handling and transport of the casks and with radioactive waste and components from the operation and decommissioning of a nuclear installation or facility is possible if they are in solid form and do not impair the safety of the storage of spent fuel and heat-generating waste.
Here, the possible influences of these materials which might affect the safety of storage are to be analysed. In particular, any associated additional fire loads, the moderating effect of certain substances with regard to maintaining criticality safety and additional handling processes are to be considered.

The storage of the inventories referred to is to be separated appropriately from the storage of non-heat-generating radioactive waste for the purposes of proper storage by spacing or partitioning. The emplacement and removal processes of the waste packages with non-heat-generating radioactive waste or components from the operation and decommissioning of a nuclear installation or facility are to be designed to prevent damage to the stored casks for spent fuel and heat-generating waste.

12.4.6 Maintenance

All installations of the storage facility requiring testing or maintenance are to be positioned for easy access or made available by technical means. The spatial conditions must be such that there is sufficient space for maintenance work, keeping available additional shieldings which might be necessary for reasons of radiation protection. For the preparation and performance of maintenance work, procedures are to be included in the operating manual.

12.4.7 Operating reports

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

- emplacement and removal, including balancing of the nuclear fuel inventory and the total activity of the stored nuclear fuel,
- the current storage facility occupancy,
- the results of the scheduled in-service inspections,

- the other significant operational processes and occurrences, and
- the results of measurements of the personal dose of individuals who were active in the storage facility.

The purpose of the report is to indicate whether the radiological, thermal and static boundary conditions are met with the storage casks.

12.5 Documentation of the storage facility

The documentation of an storage facility is to be performed in accordance with the documentation system specified in nuclear safety standard KTA 1404 /26/. Readability and retention period have to take into account the anticipated time of disposal.

The documentation is divided into licensing/supervision documentation, quality documentation and operating documentation. It comprises the following documents:

- Licences and modification licences,
- modifications from supervisory procedures,
- design, manufacture, construction, commissioning, operation and maintenance,
- safety-relevant components of the facility,
- documents relating to the transport and storage casks as well as to the inventories,
- information on safety-relevant events, and
- information on radiation protection.

Parts of the documentation of the storage are part of the safety documentation (see below).

From the time of commissioning of the storage facility, all the documentation is to be stored such that it is protected against fire, flood, adverse magnetic effects, detrimental influences of temperature, light and humidity as well as against pests and unauthorised access by third parties. A duplicate documentation is to be kept spatially separate and with regard to fire protection be kept, so that in case of demand accessibility is given.

The safety documentation of the storage facility includes all the information and proofs that are relevant for the safe operation of the facility and the level of protection. These are, for example,

- operating manual, testing manual including test reports for safety-relevant components, radiation protection instruction,

- licence(s), application documents as far as considered in the approval procedure, individual proofs provided (e.g. fire protection, external hazards), and

- plans, drawings, manufacturer and test certificates, safety reviews.

An illustrative list with all items belonging to the safety documentation is given in Annex 1.

The safety documentation may consist of many individual documents. In this case, these should be clearly presented in a list with the corresponding revision status of the documents.
The safety documentation serves as a basis for reliable operation throughout the entire lifetime of the storage facility from planning to construction, commissioning, decommissioning and dismantling. It also serves as a reference for the safety assessment of modifications in the storage facility and for modifications 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, 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 casks and their safety-relevant properties.

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 reviews (see Chapter 15), and
- the results of the evaluation of events

will be included in the documentation as soon as possible and in accordance with their safety significance.

12.6 Personnel

Regardless of the situation on site, the storage facility must be staffed with qualified personnel in sufficient numbers who meet the requirements of safety and is trained regularly. This also applies especially if personnel are used from neighbouring nuclear installations or only used in case of demand or temporarily. The following cases are to be distinguished:

- Storage facilities belonging to a nuclear installation in operation or being dismantled: Here, personnel of the nuclear installation are used for the majority of the tasks.

- Storage facilities permanently staffed with own personnel: These facilities are to be considered self-sufficient with regard to operation.

- Storage facilities not requiring permanent staffing: Here, the functions are limited, e.g., to the use of personnel in case of demand for emplacement or removal campaigns or regular inspections. The demand is temporarily and is mostly covered by personnel mainly fulfilling other tasks.

For the operation of the storage facility, teams are to be established, who work together as regularly as possible, practising an intensive exchange of experience and also conduct tests (cf. Chapter 12.3) and evaluations. These staff members are to be entrusted with this task on a continuous basis.

The technical qualification required in dependence on the position is to be verified according to the requirements of the Radiation Protection Ordinance or special provisions, respectively. The requirements regarding responsibilities in issues related to nuclear safety are regulated by the Atomic Energy Act and the Radiation Protection Ordinance. The competencies and deputy regulations are clearly to be laid down in the operating manual of the storage facility.

13 Emergency preparedness

For the storage facility, an internal emergency plan is to be drawn up. The emergency plan includes provisions for both radiological and non-radiological events. The emergency plan must at least include the information listed in Annex 1 to this chapter /32/. The necessary internal organisational structures are to be established and continuously maintained. The internal responsibilities and the persons responsible for contact with the relevant external organisations for emergencies are to be defined. The persons responsible are to be kept available for the entire duration of an emergency. Based on the internal emergency plan it is to be ensured that for emergency response qualified and experienced staff, facilities and installations are appropriately prepared, reliably available and ready for operations in emergencies. The internal emergency plan is to be brought to the attention of the competent supervisory authorities and relevant organisations in case of emergencies. Emergency exercises are to be carried out at regular intervals. The competent supervisory authority is to be informed of the exercises in advance and may participate. Some of the emergency exercises are to be carried out as an integrated exercise together with the relevant external organisations. The emergency plan is to be regularly reviewed and the experience gained to be taken into account in the revision.

Depending on the type of storage and the stored casks, different measures of off-site emergency preparedness may be required additionally (see §§ 50-53 StrlSchV /2/). Based on the possibilities for the release of radioactive substances from the storage facility, an on-site emergency preparedness plan is to be drawn up for the storage facility and, where required, co-ordinated with the emergency preparedness plans of neighbouring nuclear facilities and agreed upon with the competent local and regional authorities. Hard copies of the on-site emergency preparedness plan are always to be kept available at a permanently staffed location. Further copies are to be submitted, where applicable, to the neighbouring nuclear facilities, the competent authorities and safety bodies.

14 Periodic safety review

The operator of the storage facility must regularly perform a safety review for his storage facility every ten years /31/. The monitoring concept must ensure the monitoring of the overall condition of the storage

facility. Details are regulated in the guidelines for the periodic safety review (PSR) of storage facilities for spent fuel and heat-generating radioactive waste /33/.

For the management of the long-term and ageing effects during the applied-for duration of use of the storage facility, an ageing management concept is to be submitted and measures to be carried out in accordance with the recommendations on ageing management /34/.

15 Termination of storage

In due time before expiry of the storage licence granted for the storage facility, first steps are to be taken for the removal of all casks stored there. For this purpose, all documents necessary for the transport permit (e.g. type approval, documentation of in-service inspections) are to be provided and measures, such as cask testing and inspections before removal, to be prepared.

The storage facility is to be designed and constructed such that it can be decommissioned in compliance with the radiation protection requirements and can either be made available for alternative use or removed. 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 has been sufficiently decontaminated and is free of any inadmissible activation. The requirements under building and waste law are to be observed.

16 Relevant provisions, guidelines, standards

The following provisions, guidelines and technical standards are - irrespective of whether or not they have been referred to in the above Guidelines - relevant for the dry storage of spent fuel and heat-generating radioactive waste:

/1/ Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz - AtG) vom 23. Dezember 1959, Neufassung vom 15. Juli 1985 (BGBl. I., Nr. 41, S.1565), zuletzt geändert durch Art. 5 Abs. 6 G vom 24.02.2012 (BGBL. I, S 212)

/2/ StrlSchV
Verordnung über den Schutz vor Schäden durch ionisierende Strahlen (Strahlenschutzverordnung - StrSchV) vom 20. Juli 2001, BGBl. I Nr. 38 vom 26. Juli 2001, S.1714 ff., zuletzt geändert durch Artikel 5 Absatz 7 des Gesetzes zur Neuordnung des Kreislaufwirtschafts- und Abfallrechts vom 24.02.2012, BGBl. I Nr. 10 vom 29.02.2012, S. 212

/3/ Kugeler, K. und Schulten, R.: Hochtemperaturtechnik. Springer-Verlag, Heidelberg, 1989. ISBN: 3-54051535-6

/4/ CSD-V : RSK-Stellungnahme vom 16.03.1988 (230. Sitzung) betr. COGEMA-Spezifikationen für verglaste Abfälle aus der Wiederaufarbeitung von abgebrannten LWR-Brennelementen aus deutschen Kernkraftwerken

/5/ VEK: ESK-Stellungnahme vom 17.09.2008 (3. Sitzung) zur Verglasungseinrichtung Karlsruhe (VEK), 2. Teilbetriebsgenehmigung

/6/ CSD-C: RSK-Stellungnahme vom 08.09.2005 (386. Sitzung) betr. Spezifikation der Fa. Areva/Cogema zu hochdruckkompaktierten radioaktiven Abfällen (CSD-C) aus der Wiederaufarbeitung von deutschen LWR-Brennelementen

/7/ CSD-B: ESK-Stellungnahme vom 09.12.2009 (15. Sitzung) betr. Spezifikation der Fa. Areva NC zu mittelradioaktiven Abfällen (CSD-B) aus der Wiederaufarbeitung von deutschen LWR-Brennelementen

/8/ Verordnung über die Deckungsvorsorge nach dem Atomgesetz (Atomrechtliche Deckungsvorsorge-Verordnung – AtDeckV) vom 25. Januar 1977 (BGBl. I. Nr. 8, S. 220), zuletzt geändert durch Art. 9 Abs. 12 des Gesetzes vom 23.11.2007 (BGBl. I. Nr. 59, S. 2631)

/9/ Richtlinie über Maßnahmen für den Schutz von Anlagen des Kernbrennstoffkreislaufes und sonstigen kerntechnischen Einrichtungen gegen Störmaßnahmen oder sonstige Einwirkungen zugangsberechtigter Personen vom 28. Januar 1991 (GMBl. 1991, Nr. 9, S. 228)

/10/ Sicherung von Zwischenlagern für bestrahlte Brennelemente aus Leichtwasserreaktoren an Kernkraftwerksstandorten in Transport- und Lagerbehältern gegen Störmaßnahmen oder sonstige Einwirkungen Dritter (Stand: 7. August 2000); BMU-Erlass vom 1. Dezember 2000 – RS I 3 – 14640 – 1/7 VS-NfD

11/ DIN 25403: Kritikalitätssicherheit bei der Verarbeitung und Handhabung von Kernbrennstoffen, Teil 1, Grundsätze. Ausgabe: 06/2007

/12/ DIN 25478: Einsatz von Berechnungssystemen beim Nachweis der Kritikalitätssicherheit; Beiblatt 1: Erläuterungen (erscheint 09/2012)

/13/ DIN 25712: Kritikalitätssicherheit unter Anrechnung des Brennstoffabbrands bei Transport und Lagerung bestrahlter Leichtwasserreaktor-Brennelemente in Behältern; 01.07.2007

/14/ Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen (REI) vom 07.12.2005 (GMBl. 23.03.2006, Nr. 14-17, S. 253/4)

/15/ DIN 4102 mit den Teilen 1 bis 4
Brandverhalten von Baustoffen und Bauteilen
(Teil 1: Fassung 05/98; Teil 2: Fassung 09/77; Teil 3: Fassung 09/77; Teil 4: Fassung 03/94, Änderung A 1 11/2004)

/16/ KTA 2206
Auslegung von Kernkraftwerken gegen Blitzeinwirkungen
Fassung 2009 - 11

/17/ KTA-Regel 2207:
Schutz von Kernkraftwerken gegen Hochwasser, Fassung 11/2004 (Stand: 11/2009)

/18/ KTA 2201 Auslegung von Kernkraftwerken gegen seismische Einwirkungen;
Teil 1 Grundsätze, Fassung 11/2011
Teil 2 Baugrund, Fassung 06/90; Regeländerungsentwurf (Gründruck) von 11/2011
Teil 3 Auslegung der baulichen Anlagen (Entwurf), Fassung 06/90
(Regelentwurfsvorschlag von 11/2011)
Teil 4 Anforderungen an Verfahren zum Nachweis der Erdbebensicherheit für maschinen- und elektrotechnische Anlagenteile, Fassung 06/2000
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/19a/ KTA-Regel 3902: Auslegung von Hebezeugen in Kernkraftwerken, Fassung 6/99 (Stand: 11/2004), Regeländerungsentwurf Fassung 11/2010

/19b/ KTA-Regel 3905: Lastanschlagpunkte an Lasten in Kernkraftwerken. Fassung 6/1999, Regeländerungsentwurf Fassung 11/2011

/19c/ KTA-Regel 3903: Prüfung und Betrieb von Hebezeugen in Kernkraftwerken
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/20/ KTA 2101.2
Brandschutz in Kernkraftwerken, Teil 2: Brandschutz an baulichen Anlagen,
Fassung 12/00 (Stand: 11/2005)
KTA 2101.1
Brandschutz in Kernkraftwerken, Teil 1: Grundsätze des Brandschutzes,
Fassung 12/00 (Stand: 11/2005)

/21/ BMU
Richtlinie zur Kontrolle radioaktiver Abfälle mit vernachlässigbarer Wärmeentwicklung, die nicht an eine Landessammelstelle abgeliefert werden (Abfall-Richtlinie) vom 16. Januar 1989 (Bundesanzeiger 1989, Nr. 63a), letzte Ergänzung vom 14. Januar 1994 (Bundesanzeiger 1994, Nr. 19).
Inhaltlich ersetzt durch die Richtlinie zur Kontrolle radioaktiver Reststoffe und radioaktiver Abfälle vom 18.11.2008 (BAnz. 2008, Nr. 197)

/22/ 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) und
in Abschn. 7 (BAnz. 1996, Nr. 158a) mit Berichtigung (BAnz 1996, Nr. 214)
Stand: 12/98

/23/ 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

/24/ Rahmenempfehlung für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen
Stand: 21.09.2008 (GMBl. Nr. 62/63 v. 19.12.2008)

/25/ KTA-Regel 1401:
Allgemeine Anforderung an die Qualitätssicherung, Fassung 11/86; Stand 06/2001

/26/ KTA 1404
Dokumentation beim Bau und Betrieb von Kernkraftwerken
Fassung 06/2001

/27/ Vermerk BAM III 3, BfS ET-S2, TÜV H-S/A vom 03. September 1997 i. d. F. vom 14. Januar 1998: "Maßnahmen zur Qualitätssicherung und -überwachung bei der Fertigung und Inbetriebnahme der verkehrsrechtlich zugelassenen Behälter zur Zwischenlagerung radioaktiver Stoffe"

/28/ KTA 1201
Anforderungen an das Betriebshandbuch; Fassung 11/2009

/29/ KTA 1202
Anforderungen an das Prüfhandbuch; Fassung 11/2009

/30/ Verordnung über den kerntechnischen Sicherheitsbeauftragten und über die Meldung von Störfällen und sonstigen Ereignissen (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV) vom 14.10.1992 (BGBl. I 1992, Nr. 48, S. 1766), zuletzt geändert durch Art. 1 der Verordnung vom 08.06.2010 (BGBl. I 2010, Nr. 31, S. 755)

/31/ Western European Nuclear Regulator Agency (WENRA): Waste and Spent Fuel Storage Safety Reference Levels Report. – Version 2.1, February 2011

/32/ International Atomic Energy Agency (IAEA): Preparedness and Response for a Nuclear or Radiological Emergency; Requirements. - Series No. GS-R-2, Vienna November 2002

/33/ Empfehlungen für Leitlinien zur Durchführung von periodischen Sicherheitsüberprüfungen von Zwischenlagern für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle (PSÜ-ZL); ESK, 14. Sitzung am 04.11.2010

/34/ ENTWURF/ Alterungsmanagement bei der trockenen Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnder Abfälle in Behältern (abgestimmt im ESK-Ausschuss AZ am 18.01.2012)

Annex to Chapters 13 and 14:

Contents of an internal emergency plan, contents of the safety documentation

Contents of the internal emergency plan

Emergency preparedness

1 Requirement on the training of personnel,
2 list of possible accidents, including combinations of nuclear and non-nuclear hazardous situations; where relevant: description of possible severe accidents and their consequences,
3 conditions and criteria under which an emergency is declared and a description of appropriate means of alerting the responsible personnel and the authorities,
4 an inventory list of emergency aids provided and locations.

Personnel, organisational responsibilities and provisions

1 Names of the persons in charge of internal activities and being responsible for contacts with external organisations,
2 a list of authorised persons with occupational title and description of functions allowed to declare an emergency,
3 command and communication structure, including a description of related facilities and processes; possibilities should be provided for instructing all persons who are to be informed on the measures on site in case of an emergency,
4 the measures to be performed by persons and organisations for execution of the emergency plan, and
5 provisions for termination of the emergency.

Assessment of the impacts of the event

6 Provisions for monitoring the radiological conditions inside and outside of the site (water, vegetation, soil, air), and
7 assessment of the storage facility condition.

Assessment of the impacts of the event

8 Provisions to minimise doses to individuals and for medical care for injured people, and
9 internal measures to limit releases and to prevent dispersion of radioactive material.

Contents of the safety documentation

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

- a description of the site characteristics, the storage facility and its equipment, the design features and safety functions, as well as a list of safety-relevant structures, systems and components of the storage facility,
- a description of the handling and storage activities and other operational processes in the storage facility,
- a description of the expected amount and characteristics of the casks 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 during postulated initiating events, as well as proof of compliance with the safety criteria and radiological limits,
- a description of the management systems,
- a description of the provisions to minimise waste produced during operation,
- a description of commissioning, assessment of deviations identified here, including the reasons for deviations,
- definition of an appropriate programme for continuous proof that the casks comply 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 conditions for the safe operation of the storage facility, its technical basis, and the storage conditions for the casks,
    - process descriptions and operating procedures for safety-relevant operations,

- provisions for operational inspections, maintenance and testing,
- programme for evaluation of operating experience,
- programme for ageing management, and
- training programme for employees,

- a preliminary description of the concept for decommissioning and dismantling of the storage facility.