Note:
This is a translation of the ESK recommendation entitled "ESK-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 (ESK)**

# ESK guidelines for the storage of radioactive waste with negligible heat generation

## *Revised version of 10.06.2013*

*Compared with the version of 23.08.2012, 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 8.2.2)*

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# 1 General

## 1.1 Scope of the guidelines

The guidelines apply to facilities for the storage of radioactive waste with negligible heat generation described below that are subject to licensing according to §§ 6, 7, 9 of the Atomic Energy Act (AtG) /1/ or § 7 of the Radiation Protection Ordinance (StrlSchV) /2/. The radioactive waste taken into consideration originate from the operation and dismantling of nuclear facilities as well as from other uses of radioactive substances such as in industry, medicine, research and and at the Federal Armed Forces. It is currently being stored either in central storage facilities, in decentralised storage facilities at the sites of nuclear facilities, in these facilities or in public or private collecting facilities. For the purpose of this recommendation, radioactive waste with negligible heat generation is defined as all types of radioactive waste which principally can fulfil the requirements according to the Konrad waste acceptance requirements, where required after decay storage.

The objective of these guidelines is to identify all safety-relevant influencing parameters that are relevant for the storage of radioactive waste with negligible heat generation. On this basis, requirements are derived both for the storage facilities and their operation as well as for the radioactive waste and its treatment, taking into account all boundary conditions to be met from today's perspective prior to the storage of the waste, regardless of whether emplacement in a repository or a later clearance of the waste is provided.

For facilities for the storage of relatively small amounts of radioactive waste with negligible heat generation, e.g. research laboratories, the requirements to be imposed according to the guidelines for storage facilities for radioactive waste with negligible heat generation are not appropriate in every case. The requirements of the guidelines with regard to the properties of the radioactive waste and its treatment are to be observed.

In 2002, plan approval was granted for the construction and operation of the Konrad repository, which has been confirmed by the supreme court in 2007. Since then, the repository has been under construction; its completion is expected for the end of this decade. The waste-specific ancillary provisions of the plan approval decision were – where applicable – implemented in the waste acceptance requirements for disposal. Furthermore, the procedure for meeting the first ancillary provision from the qualified legal water permission in Appendix IV to the Konrad plan approval decision was submitted to the competent water law regulatory authority and, after its supervisory approval in 2011, has been considered in the Konrad waste acceptance requirements, in the measures for material product control and in other documents. Currently, experiences are being gathered regarding the practical implementation.

The storage of radioactive waste with negligible heat generation thus extends to a period of about ten years for the major part of the waste, taking into account compliance with the requirements according to the waste acceptance requirements proof of which has to be furnished, until the commissioning of the Konrad repository and a further average period of ten years until emplacement in this facility. The resulting storage period of about 20 years forms the basis for the requirements formulated in these guidelines for safe storage with the objective of disposal,

- which are to be fulfilled by the waste forms and waste packages to be produced,

- whose fulfilment has to be demonstrated by the measures stated in Chapter 2.2, Chapter 4 and Chapter 10.4.3 for waste forms and waste packages conditioned to meet the waste acceptance requirements for Konrad and that have already been stored, and

- which are to be fulfilled by raw waste and by intermediates accordingly (i.e. partly conditioned radioactive waste).

For raw waste and intermediates, the corresponding fulfilment of the requirements mentioned in these guidelines might also have to be demonstrated for a storage period of more than 20 years, while the maximum duration depends on the intended operating time of the Konrad repository.

In addition to the storage of radioactive waste with the objective of emplacement in a repository, the storage of radioactive waste, such as large components, with the objective of activity decay also continues to gain in importance. The same safety requirements as required for the storage of radioactive waste with the objective of later disposal are to be applied – as far as transferable – to the longer-term decay or buffer storage with the objective of release from regulatory control or later conditioning for disposal under more favourable conditions. The period of decay storage is limited by the scheduled operating time of the Konrad repository.

The decay storage for clearance of radioactive substances for a non-hazardous reuse or conventional waste management (§ 29 StrlSchV) of less than five years is not dealt with here.

## 1.2 Protection goals

The radiological protection goals with which the storage of radioactive waste with negligible heat generation has to comply consist of the requirements that

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

2 any radiation 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 conditions of each individual case (§ 6, para. 2 StrlSchV).

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

Accordingly, there are the following fundamental protection goals for the waste packages, the storage facility with the technical installations and storage facility operation:

- Safe confinement of the radioactive substances,
- avoidance of any unnecessary radiation exposure, limitation and control of the radiation exposure of operating personnel and the general public, and, where applicable,

  for special waste also

- ensured maintenance of 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 performance of operation,
- safe handling and safe transport of radioactive substances,
- design against accidents, and
- as far as required due to the release potential, measures to mitigate the consequences of beyond design basis accidents.

Facilities for the storage of radioactive waste with negligible heat generation should be provided with passive safety features to the largest possible extent while dependence on active safety features, such as monitoring measures performed by the operating personnel for maintenance of safety, should be as low as possible. In case that a safety function can practically not be realised by passive safety features, fulfilment of the safety is to be maintained by active safety features.

There are additional requirements, not dealt with here, as regards liability, protection against disruptive actions or other third-party intervention and, in the individual case, the control of fissile material under international agreements.

## 2 Confinement of radioactive substances

The confinement of radioactive substances is to be ensured by a system of engineered barriers and complementary measures. For this purpose, several approaches can be used. So, for example, immobilisation in a waste matrix, confinement in waste containers or possibly the barrier function of building and ventilation with retention devices can contribute to it. Large components can confine their radioactive substances for example during their decay storage also without overpacks. In general, safe confinement can be achieved technically, depending on the concept chosen, by one barrier or the interaction of several barriers.

The facilities for the storage of the radioactive waste with negligible heat generation are designed, among other things, for the handling and storage of sealed radioactive substances, i.e. the waste containers or possibly also large components fulfil the task of activity confinement. For a safe storage, this activity confinement has to be ensured during the entire period of storage.

According to the requirement to give preference to passive safety features over active safety features, the freedom from maintenance of the waste packages (waste container and waste form) and also of the large components is largely to be ensured with respect to storage. This results in different requirements for waste forms, containers and large components, which are more restrictive in some cases than the requirements for disposal.

## 2.1 Waste forms and packages

The requirements for conditioned waste are particularly determined by their behaviour during specified normal operation of storage facilities and repositories and the design basis accidents to be postulated. By means of conditioning of the radioactive waste, intermediates or final products are to be produced which fulfil the requirements for safe handling, storage and transport also beyond the period of storage.

The waste acceptance requirements /3/, /4/, /5/ result in safety requirements for waste packages that relate to the activity inventory, to chemical, physical and biological properties of the waste forms and to the packaging of the waste. Properties relevant for disposal derived from it relate to the radioactive waste, the waste forms and the waste containers/packaging.

The following characteristics have been identified as relevant for disposal /4/:

- Total activity of the waste package,
- activity of relevant radionuclides,
- dose rate at the surface and at 1 m and 2 m distance,
- surface contamination of the waste package,
- composition of the raw waste,
- quality of the fixing agent,
- quality of the waste container,
- quantitative ratio: waste/fixing agent/water/aggregates,
- mixing,
- mass of the waste package, waste form or inner shieldings,
- setting and product condition,
- water content and residual moisture,
- thermal behaviour, and
- stackability and handling.

For waste containing fissile material, the fissile material content and the local distribution of the fissile material in the waste volume are to be specified. Related requirements are specified in the waste acceptance requirements for disposal /3/, /4/.

Basically, these characteristics are also relevant for storage. For this purpose, proof can be furnished that a substantial part of the requirements for the storage of radioactive waste conditioned to meet the requirements for disposal according to a process authorised by the BfS within the frame of the process qualification (§ 74, para. 2 StrlSchV /2/) have been fulfilled. Likewise, proofs already furnished that waste requirements for storage have been met can be used for disposal qualification.

For storage, waste forms and waste containers have to be chemically/physically sufficiently stable over the period of storage until their disposal. By conditioning of radioactive waste for storage or disposal it is to be ensured that waste package properties relevant for storage or disposal are maintained over the period of storage. In particular, changes in the waste form properties and the waste container properties have to be minimised (Chapter 2.2).

Indications to changes in the waste form are given by noticeable changes of the gas composition of the atmosphere inside the container that can be caused by digestion, fermentation or corrosion processes. Gas formation in waste packages is caused by chemical, physical and/or biological reactions. It is thus an indication of insufficient stability of the waste forms and should therefore be limited to a degree which is possible with the methods applied and which does not raise any safety concern. For this reason, appropriate treatment processes, such as drying of the waste and waste forms, are to be conducted prior to storage. The assessment of the gas formation rate during storage with a view to obtaining waste form properties relevant for storage and disposal is to be based on the state-of-the-art conditioning technology.[1]

Due to the generation of chemically/physically stable waste forms meeting the waste acceptance requirements for disposal and their traceable documentation, defined properties of the waste form can be assumed also after a storage of about 20 years. By appropriate measures (Chapter 4 and 10.4.3) it can be verified that defined properties of the waste forms can also be maintained beyond a storage period of about 20 years. Therefore, the waste forms, as e.g. compacted materials, can be handled with reasonable effort. Such a later handling after storage may take place, e.g., for the following reasons:

- Insertion of the packages for storage (filled inner containers according to the Konrad waste acceptance requirements) in overpacks meeting the requirements for disposal (waste containers according to the Konrad waste acceptance requirements),

- change in the container loading for disposal for optimised utilisation of the waste acceptance requirements for disposal,

1 see Annex 2

- optimisation of the required shielding due to the decay of radionuclides, and

- sorting and clearance measurements of waste with the objective of non-hazardous reuse or conventional waste management.

For packages with waste forms where major pressure build-up resulting from gas formation cannot be excluded also in case of proper conditioning, pressure relief measures are to be provided, as far as there are no requirements regarding the leak tightness of the waste containers. To prevent pressure build-up of more than 200 hPa /4/ in inner containers with pressure relief which were cemented into waste packages, cementing is carried out in such a way that sufficient discharge of the gases formed through the pores of the grouting compound from the inner container is verifiably ensured. For example, the results of tests to determine the gas permeability of the grouting compound and of studies on kinetic parameters of gas-forming reactions in waste forms can be used to assess the suitability of the cementing procedure for inner containers with pressure relief. On the basis of the results, additional conditioning activities, such as an increase in the cross-sectional area of pressure-relieving devices to a minimum, can be derived with the objective of preventing pressure build-up in cemented inner containers with pressure relief.

The compatibility between waste, fixing agent or waste matrix and container material are of special importance for storage.

For cement products, those compositions are to be avoided which lead to shrinking of the product with gap formation between product and container wall or with formation of cracks in the product, or which lead to a volume increase of the product due to phase transformations up to the destruction of the waste container.

Reactions between waste form and the waste container, as it was observed e.g. in case of containers made of austenitic material after filling with chloride-containing material, are to be prevented by means of adequate conditioning. The same applies to a potential reaction between residues of organic solvents and the coating material of the inner wall of the container.

Thus, for the assessment of waste form characteristics with regard to storage, potential changes of the waste package characteristics that may result from reactions between the 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 above-mentioned waste characteristics relevant for disposal for the period of storage.

In order to enable the documentation of the waste form characteristics in a traceable manner, the origin and characteristics of the raw waste is to be determined and documented in a first step. On the basis of the available knowledge from process qualification by the Federal Office for Radiation Protection (BfS), the waste forms to be produced are then to be assessed regarding their suitability for storage. If for storage only partial performance of treatment steps of the qualified conditioning process is provided, so the intermediates are to be assessed regarding their suitability for storage.

## 2.2 Waste containers and large components

As is the case for the waste forms, the requirements for waste containers and, where applicable, large components are primarily based on the safety analyses on specified normal operation and on the design basis accidents at a storage facility and a repository. The requirements are specified in the technical acceptance criteria of the storage facilities and in the waste acceptance requirements for disposal /3/, /4/. Moreover, the requirements under traffic law according to the applicable dangerous goods regulations /6/ to /9/ also have to be observed. In case that storage takes place in waste containers that are not qualified according to traffic law requirements, the traffic law requirements are to be fulfilled by the later package, e.g. by means of an additional outer packaging. The design of the waste containers has to be such that their handling is also ensured during and after storage. Analogous considerations apply for the storage of large components.

For storage of the waste containers and large components, long-term stability of the materials of containers and large components has to be taken into consideration to fulfil the requirements during the storage period. Integrity has to be ensured by means of an adequate design of the waste containers (material, dimensions, corrosion protection, and structural design, as e.g. avoidance of unprotected gaps). This design of the waste containers also has to take into consideration the physical, chemical and thermal properties of the waste form and the atmospheric conditions of the storage facility. Thus, the potential for any impairment of the integrity of containers and large components caused by impacts from the interior of containers and large components and from outside has to be considered.

Less stringent requirements may be applied to the design of the corrosion protection of the inner surface of the containers in case of waste forms with corrosion retardant properties, as e.g. dry combustion residues. The same applies to the design of the outer corrosion protection of waste containers and large components for storage in areas with dehumidified storage atmosphere.

As far as waste containers or large components are not suitable for storage without any doubt due to their design, e.g. as thick-walled concrete or cast iron containers, due to the properties of the content 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, as e.g. visual inspections, (Chapter 10.4.3).

In case of an unforeseen impairment of the integrity of the containers or large components, the integrity of the containers or large components is to be restored by means of a qualified procedure with appropriate measures, which e.g. have been specified in an officially approved repair concept, such that the requirements for containers as well as for large components will be fulfilled for the remaining period of storage (Chapter 9.5).

### 2.3 Storage building

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

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

A design of the building for the storage of waste which may lead to emissions of radioactive substances is also admissible if the requirements stated in Chapter 2.1 are fulfilled. However, with regard to the emissions of radioactive substances with exhaust air and waste water, such a design necessitates additional technical efforts for a controlled air flow and recording of the emissions by measurements.

## 3 Criticality safety

As in the storage facilities usually no waste with a criticality-relevant content of fissile material is stored, no special measures for criticality control are required. With regard to the future emplacement in the Konrad repository, the concentration and mass limits of the thermally fissile nuclides U-233, U-235, Pu-239 and Pu-241 in the waste packages have to comply with the waste acceptance requirements for disposal /3/, /4/.

If it is intended to store waste with a higher content of fissile material or with mixtures of fissile materials and substances influencing the neutron balance, as e.g. graphite, an examination by the competent authority shall be performed in the 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 (§ 46 StrlSchV) and occupationally exposed persons (§ 43 StrlSchV) 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.

For the operation of a storage facility, the dose rate limits for the packaged waste forms, waste packages and large components to be stored are specified such as to ensure that the provisions pursuant to §§ 55 and 56 StrlSchV will be observed with respect to the doses of individuals.

In order to furnish proof of the necessary shielding of the waste containers and waste packages, large components and storage facilities and 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 in the calculation of the radiation exposure in the environment and on the premises.

Regarding the placement and positioning of the packaged waste forms, waste packages and large components in the storage facility, the mutual self-shielding effect is to be taken into account. When defining the positioning, aspects of accessibility and controllability of the waste packages are also 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 the air vents, doors and expansion joints.

# 5 Radiation protection

## 5.1 Principles

According to § 6 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 kept as low as achievable, even if below the respective limit, by taking into consideration the state of the art in science and technology and by taking into account all circumstances of individual cases (ALARA principle). Consequently, the handling and monitoring measures performed by the staff in the storage area shall be minimised to the extent possible. The requirements for the storage of the 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 technical installations for the storage of 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 way of thinking and acting 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.

## 5.2 Radiation monitoring in the storage facility

According to § 36 StrlSchV, the entire storage facility is to be divided into radiation protection areas that are to be marked. In the radiation protection areas, the local dose or dose rate have to be measured and documented for each change in the storage occupancy and at regular intervals and documented. These measurements are to be performed at representative points. The gamma dose rate and, where required, the neutron dose rate 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 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 packages with significant activities of volatile radioactive substances (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 (§ 44 StrlSchV). For decontamination, organisational provisions are to be specified and adequate means be provided or be procurable in the short term.

For gamma and, where required, neutron radiation, the body dose of occupationally exposed persons in controlled areas is to be determined and documented by means of appropriate official dosimeters (§§ 40, 41, 42 StrlSchV). 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 are to be used in addition to the official dosimeters. Regarding the workplaces, protection of personnel against external and internal radiation exposure shall be ensured primarily by means of technical measures (§ 43 StrlSchV).

According to § 67 StrlSchV, 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.

### 5.3 Radiation monitoring in the environment

For storage facilities, the local dose is to be measured at representative points, e.g. at the fence of the facility, for compliance with the limits of § 46 StrlSchV. The Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI) /10/ is to be applied for facilities with licences according to the Atomic Energy Act and for facilities with licences according to the Radiation Protection Ordinance by analogy for the dose measurement.

More extensive monitoring measures shall be provided if discharge of radioactive substances during specified normal operation (§ 47 StrlSchV) has to be postulated. If the retention capability of the waste containers regarding the volatile radioactive substances (e.g. H-3 and C-14) cannot be ensured, the emissions resulting from it are to be determined and assessed for compliance with the limits of § 47 StrlSchV.

### 5.4 Clearance/removal of material

Material produced storage facility not being subject to the scope of § 44, para. 3 StrlSchV (“bringing out of controlled areas”) are to be assessed radiologically prior to the permanent release from being subject to the Atomic Energy Act. Material for which contamination can be excluded, may be removed. Radioactive substances for which this cannot be excluded is subject to a clearance procedure according to § 29 StrlSchV. 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, origin of the material and, where necessary, proof of homogeneity) as well as random control measurements.

The freedom from contamination of material 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 to 10 % of the permissible values for unrestricted clearance according to Appendix III, Table 1, Column 4 and Column 5 StrlSchV, taking into account the technical feasibility of measuring.

## 6 Structural requirements for new storage halls

The structural parts are to be built 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 until the the end of the scheduled operating life and on design basis accidents:

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

- The floor in the storage area shall have an adequate compressive strength and wear resistance.

- 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.

- The structural design also has to consider impact loads during transport processes, unless excluded by other measures. Further, crane loads and loads of other heavy plant components, e.g. shieldings, and special loads from internal impacts (Chapter 8.1) and external impacts (Chapter 8.2) are also to be taken into consideration.

- With the exception of decontaminable coating, the materials used for the building with reception and storage area must be “inflammable” (Class A according to DIN 4102, Part 1 /11/, KTA 2101 /12/) (Chapter 7.4).

- The building is to be equipped with earthing and lightning protection systems in accordance with the conventional rules and regulations. More stringent requirements are only to be considered where monitoring and protection functions may be affected; in this case, nuclear safety standard KTA 2206 /31/ is to be applied by analogy.

- The design of the storage building shall be such as to ensure stability for the load case fire according to DIN 4102, Part 2 to 4 /11/.

- The top edge of the floor has to be above the water level for the 100-year flood and other structural measures are to be provided against the intrusion of water. Temporarily measures are to be provided for the 10,000-year flood.

# 7 Technical installations

## 7.1 Lifting equipment and other transport equipment

The technical design of the lifting equipment used for the handling of containers and large components is based on the results of the analysis of the events during specified normal operation and during design basis accidents (Chapter 8). In general, requirements more stringent than that according KTA 3902, Section 3 /30/, are not to be imposed. The lifting equipment and devices shall be such that the waste and large components at the storage facility can be handled safely. For this purpose, maintenance work and inspections are to be carried out at regular intervals. If the lifting equipment and transport devices cannot be 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 and the required operational readiness.

Also after emplacement it is to be ensured that all necessary lifting equipment and transport devices are available on site or can be procured in the short term for use.

## 7.2 Room air conditioning

For the storage of sheet steel containers without corrosion protection measures and waste without hermetic isolation from the hall atmosphere, sufficient limitation of the relative humidity of the room air is to be ensured. For this purpose, room air conditioning of the storage hall may be necessary. In this respect, dehumidifiers or (underfloor) heating systems may be used. If required, measures are to be taken which enable sufficient ventilation of the waste package stacks at floor level. For this purpose, the waste packages can be placed e.g. on grids.

## 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 wastes stored there. The maintenance and test intervals are to be adjusted to the use and the required operational readiness.

## 7.4 Fire protection and fire protection systems, explosion protection

A fire protection concept is to be developed for the storage facility in which the individual measures of preventive fire protection by structural and engineered measures, the organisational (operational) fire protection

and of fire suppression are presented. Considering the use, the fire risk and the expected extent of damage, the individual components and their interconnection with regard to the protection goals are to be described. The degree of achievement of the defined protection goals is to be assessed within the framework of the fire protection concept.

For the entire storage period scheduled, measures are to be established for the prevention of fire loads and ignition sources, for early detection and for effective fire fighting. If formation of explosive gas mixtures has to be postulated resulting from releases from the waste stored, adequate preventive measures are to be implemented.

The safe confinement of the radioactive waste in the emplaced waste containers must also be ensured in the long term with regard to fire protection since a loss of safe confinement of the radioactive waste may also lead to an increase of the fire load in the storage facility.

## 8 Accident analyses

As regards the protection against safety-relevant events in storage facilities, the planning of structural or other technical protection measures against accidents has to include measures for the limitation of releases of radioactive substances into the environment and is to be based on the planning values of §§ 49 and 50 StrlSchV respectively, in conjunction with § 117, para. 16 StrlSchV.

In both cases (§ 49 and § 50 StrlSchV) it is to be determined in an accident analysis which operational disturbances and accidents may occur in connection with the storage of radioactive waste with negligible heat generation. For this purpose, the conditions of storage, including potential long-term effects and impacts from other facilities at the site, as well as operating procedures are to be analysed systematically and experiences from comparable facilities are to be taken into account.

On the basis of this analysis, the design basis accidents for storage are to be derived and differentiated from operational disturbance belonging to abnormal operation and the beyond design basis events. Human errors are to be considered in the analysis of the incident and accident possibilities or an activity release. For design basis accidents, compliance with the requirements of § 49 and 50 StrlSchV in conjunction with § 117, para. 16 StrlSchV are to be verified by calculation of the potential radiological consequences, as far as these possibilities cannot be excluded due to the precautions that have verifiably been taken.

### 8.1 Internal hazards

Regarding the storage of radioactive waste with negligible heat generation, the following three groups of internal events are generally to be considered as design basis accidents:

1. Mechanical impacts

- drop of a waste package or a large component from the maximum height to be considered in the most

unfavourable impact position, and

- drop down of the largest load to be considered onto the waste or large component.

2. Thermal impacts

The maximum stationary and temporary fire loads in the storage facility are to be considered. In addition to the demonstration of the retention capacity of the waste packages to be performed, potential fires in the facility with potential activity release are to be analysed. The release of radioactive substances from the waste packages depends on fire duration and temperature.

Even if the waste container itself is inflammable, a release of radionuclides may occur in case of fire impacts. The release mechanisms pyrolysis, evaporation and sublimation are also to be taken into consideration. The limitation of the maximum activity inventory of the radioactive waste stored is to be considered when analysing the release of radioactive substances into the environment.

Waste in thick-walled cast iron containers does not contribute to the fire load. This also applies to waste in concrete containers. Here, it is irrelevant whether it has been inserted in inner containers and grouted into concrete or not.

Radioactive waste in other containers is to be classified as inflammable for accident analyses if all other prerequisites are met:

- The radioactive waste is stored in sealed containers, such as sheet steel containers.
- There are no self-igniting or explosive substances in the radioactive waste packages.
- In the storage area, there are no materials which may lead to a release of heat to an extent which might impair the protective function of the waste containers stored.

3. Failures of safety-relevant installations

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:

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

- Man-made external hazards, such as impacts of harmful substances, blast waves caused by chemical reactions, external fire spreading to the interior, damages by mining, aircraft crash.

In addition, site-specific conditions are to be considered, where necessary.

Potential interactions with neighbouring nuclear power plants are dealt with in Chapter 8.2.1 and 8.2.2. External impacts due to deliberate interference by third parties are considered within the framework of measures taken against disruptive actions and other interference by third parties and not further addressed here.

### 8.2.1 Natural external hazards

The load assumptions for natural hazards are to be defined according to the site-specific conditions.

- The storage building is to be protected against lightning according to the relevant VDE guidelines and conditions (Chapter 6).

- The storage facility should be located at a flood-free site. If flooding cannot be excluded, the storage building must be protected against the intrusion of water by appropriate measures (Chapter 6).

- For the determination of the type of the seismic design of a storage facility it is to be examined site-specifically whether due to postulated damages caused by earthquake – e.g. collapse of the storage building, drop of heavy loads, drop down or topple over of waste packages or fire – the radiation exposure resulting from the release of radioactive substances into the environment might lead to an excess of the planning values of §§ 49 and 50 StrlSchV. If this is the case, the components of the storage facility are to be classified and designed against earthquake according to Nuclear Safety Standard 2201 /13/, applied by analogy.

### 8.2.2 Man-made external hazards

The load assumptions for man-made external events are determined according to the state of the art in science and technology under consideration of site-specific conditions. Within the framework of an accident analysis, it is to be demonstrated which consequences are to be expected from man-made external events. The decision which events shall be classified as design basis accidents as defined in the Radiation Protection Ordinance and for which events only protection measures are necessary under the aspect of minimisation of damage extent, shall be oriented towards the occurrence probability and the 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 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 RSK guidelines for pressurised water reactors for aircraft crash /14/ and the guideline of the Federal Ministry of the Interior (BMI) on the protection of nuclear power plants against blast waves /15/ and from site-specific specifications and the emplaced radionuclide inventories and their release behaviour. The aspect of damage extent reduction has been adequately taken into account if also in case of these events the radiological consequences determined under realistic boundary conditions do not necessitate major disaster control measures. The reduction of the consequences in case of aircraft crash and blast waves may either be achieved by the waste containers/packages alone or by a combination of waste containers/packages and storage building.

If the storage facility is to be built in the immediate vicinity of a 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 containers with high energy content.

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

## 9 Quality assurance

For quality assurance in the field of radioactive waste management, above all, requirements for waste forms and packages are to be met, proof of which is to be furnished, product controls are to be carried out, methods and waste containers are to be subjected to qualification or post-qualification, and a quality-assured documentation is to be established.

## 9.1 Radioactive waste management aspects relevant for storage and disposal

As part of radioactive waste management, the waste owner has to ensure that waste forms and packages meet the relevant requirements set out below:

- Requirements resulting, from the behaviour of the waste forms and packages as well as of large components during specified normal operation of storage facilities during anticipated operating conditions of abnormal operation of storage facilities and during design basis events postulated for the storage facility,

- requirements from handling and transport, including the requirements from keeping waste available for transport and transport to the repository after the storage period

- relevant requirements resulting from the disposal following storage, and

- requirements resulting from provisions of the waste owner regarding radioactive waste management, e.g. the need to conduct further conditioning steps after storage.

The product control of radioactive waste is an essential task of the waste owners' radioactive waste management. Before carrying out the actual work within the framework of radioactive waste management, the procedure is to be planned taking into account already existing waste management concepts, starting from the raw waste produced to the duration of conditioning and storage up to the time of retrieval of the waste packages for emplacement in the Konrad repository. Based on this plan, compliance with the waste acceptance requirements for disposal and its verification are to be ensured within the process qualification by the BfS. On the basis of the available knowledge from process qualification by the BfS, a description of the requirements relevant for storage including proof of their compliance is to be submitted to the BfS for qualification of the process for storage. This requires organisational and administrative regulations to define the responsibilities, tasks and activities of the parties involved.

On the other hand, fulfilment of the requirements mentioned is to be demonstrated within the framework of product control during the performance of work and the proper performance of the approved processes to be documented. Provisions for the performance of product control with regard to disposal and storage have been made on the basis of the Radiation Protection Ordinance /2/, the waste acceptance requirements for disposal /3/, /4/ /5/, the regulatory guideline on the control of residual radioactive substances and radioactive waste /16/ and the waste acceptance requirements of the storage facilities. Those involved in product control are the supervisory authority of the waste producer, the BfS being responsible for the repository, the supervisory authority of the storage facility, the experts consulted by these authorities, the waste producer and the service providers working on behalf of the waste producer.

The product control flow chart with related explanation according to the plan-approved product control measures also extended by material aspects /4/, /5/ is presented in Annex 1 to these guidelines. Product control

for radioactive waste is carried out according to this flow chart. Deviations require the approval of the competent authorities and the BfS.

Kind and scope of the measures related to product control are defined by the competent authorities, i.e. by the BfS and, where applicable, also by a campaign approval of the nuclear supervisory authority within the framework of process qualification and approval by the competent supervisory authority, taking into account the conditioning method, the waste characteristics and the waste acceptance requirements of the repository. This process qualification can be carried out in accordance with the application submitted as campaign-dependent or campaign-independent process qualification. Product control may also be performed based on random checks where kind and scope of checks is defined on the basis of the documentation submitted on production and properties of the waste packages. For this purpose, waste packages to be checked are selected and examined at the place of storage or outside storage in appropriate test facilities for compliance with the waste acceptance requirements for disposal.

For storage, the procedures mentioned for product control of radioactive waste are to be performed accordingly as part of the overall procedure for process qualification in storage facilities.

### 9.2 Process qualification

For process qualification of conditioning methods, the measures of the waste producers, the conditioners and the operators of storage and disposal facilities are to be considered in accordance with the requirements of the competent authorities, taking into account the assessments, accompanying controls and inspections by independent experts.

Verification of compliance with the Konrad waste acceptance requirements /3/ is mainly done within the framework of a campaign-dependent or campaign-independent process qualification. The product control through random checks, however, only plays a minor role, so that they will not be considered further in these guidelines. According to the requirements for product control for the Konrad repository /4/, /5/, the individual work and inspection steps for a campaign independent process qualification are to be described by the applicant in a manual. In general, however, the applicant applies for a campaign-dependent process qualification process, also submitting of a schedule on the proceeding. Since its introduction in 1988, this approach with listing of the work and inspection steps naming the persons responsible has generally proven successful also for storage. Experience has shown that compliance with the requirements from disposal, storage and supervisory procedures for waste campaigns can be ensured by such campaign-dependent process qualification.

Within the framework of process qualification, information and data on the entire conditioning process from registration of the raw waste, to the verification that the waste meets the requirements for disposal up to the retrieval of the waste packages for emplacement in the Konrad repository are to be submitted to the BfS or to the supervisory authority of the storage facility within the framework of the qualification for process

qualification in the storage facility. Partial conditioning steps are also allowed, provided they end with a useful intermediate. Their acceptability from a safety point of view is to be substantiated. The data relating to the partial conditioning steps are to be documented according to type and scope. It must be stated how these are kept permanently available.

### 9.3 Qualification of the waste containers

Compliance with the requirements for waste containers and packaging under consideration of Chapter 2.2 and Chapter 8 of these guidelines, the dangerous goods regulations /6/ to /9/, the waste acceptance requirements for disposal /3/, /4/ and the respective acceptance requirements for storage is verified for each container type within the framework of type tests and certified by the competent authorities. Proofs already furnished for transport or on the suitability for disposal can be used to verify suitability for storage.

Manufacturing has to take place based on an appropriate quality management system of the manufacturer and type-specific quality assurance programs (e.g. in the form of certified manufacturing and inspection plans) in compliance with the requirements specified as part of the type test for the required quality of the individual prototype container (e.g. in parts lists, material specifications, drawings).

Specifications on the performance of inspections during manufacturing by in-house specialists or by independent experts and on performance and review of quality-assuring measures and controls during manufacturing, filling and storage of the waste containers are laid down in the product control regulations on the waste acceptance requirements for disposal /4/ and are to be adopted in the acceptance requirements of the respective storage facility.

### 9.4 Documentation of the radioactive waste

The documentation on storage at a storage facility shall include the relevant data on the waste forms, waste packages and large components, on the origin of the waste, also for the purpose of disposal or later clearance. Specifications on the data to be documented are laid down in Annex X of the Radiation Protection Ordinance /2/. Specifications on the documentation of radioactive waste are included in the regulatory guideline on the control of residual radioactive substances and radioactive waste /16/. Data and information on the structure and contents of a waste package documentation are exemplary given in the technical acceptance requirements for the Gorleben storage facility /17/ and in the waste acceptance requirements for disposal and product control measures for the Konrad repository /3/, /4/, /5/.

The documentation of the waste forms, waste packages and large components for storage is to be performed in accordance with the existing requirements for future disposal and shall include all information required at this time in order to create the necessary documentation for later disposal. For the storage of waste that has not been conditioned until suitability for disposal, such as intermediates or disassembled large components,

documentation is to be performed accordingly, taking into account the requirements specified in the respective storage licence. Particularly in the case of an interruption of conditioning to a waste package according to the concept submitted for process qualification, all previously created documents on processing and characterisation are to be compiled. These documents are to be specified within the framework of process qualification. On the basis of information on the raw waste, on processing and packaging, information must be provided concerning the material composition of the waste packages to be emplaced.

The scope of declaration of radionuclides and material components has to be oriented towards the requirements of the waste acceptance requirements for the Konrad repository /3/, /4/, /5/.

In addition to the collection of data relevant for disposal and for the demonstration of product control measures, the documentation shall include proofs on the fulfilment of the requirements of storage. These may be, for example, further data on radionuclides with higher volatility or additional proofs on the permission to use the respective packaging.

The waste package documentation may be performed for each package or together for several packages of one conditioning campaign. In this respect, at least the issues stated below should be documented as follows

- Data sheet with data on waste form group, waste container classification, compliance with limit values, radionuclide inventories and material composition,
- records on process qualification performed and approval of conditioning campaign,
- records on the accompanying control performed by experts on site,
- records on the review of the documentation and statements of the competent authorities (to be completed after review and statement),
- description of raw waste origin and composition,
- description of the conditioning process, e.g. by means of operational data collection, including any deviations occurred and special occurrences as well as the accompanying controls performed,
- compilation of the analysis and measurement data (activity, gas and material analyses, dose rates, contaminations),
- description of activity calculation/activity determination and declaration of the activities of the repository-relevant radionuclides and the overall inventory and other radionuclides for storage,

- description of the material composition of the waste package with data from the material and the container list /3/, /5/,

- Description of the waste container with information on approval under traffic law (if required) and conducted type tests including test certificates granted by the BfS, proof of long-term durability/corrosion resistance for sheet steel (drums, containers), acceptance certificates and proof of compliance with handling instructions, and

- documents on the origin (e.g. drum lists, transport documents, reception reports of the conditioning facility, etc.).

For the creation of a waste package documentation, general documentation quality requirements regarding clearness and completeness are to be observed. The access to the documents and their readability must be ensured for the entire period of storage up to emplacement in a repository or clearance according to § 29 StrlSchV. Here, Annex B of nuclear safety standard KTA 1404 /18/ can be referred to as a guideline, for electronic documents also /28/, /29/. Any retention periods otherwise specified shall be at least adjusted to the storage period envisaged.

To ensure availability of the documentation it must be ensured that during the long-term storage of the data,

- these will be available at any time, and
- consistency with the stored waste can be determined.

Provisions to ensure availability after a longer period of storage of the waste packages are known from the UK /19/, /20/. In the annex to IAEA document /21/, guidance is provided on the maximum retention period of documents. For documents made of standard paper, a storage period of decades can be assumed without impairment of readability. Magnetic and optical media, however, are to be checked for readability after storage periods of several years and secured by copying. The IAEA recommends, e.g. for optical storage media (compact disc, DVD), a control after five years /21/.

The main data on 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 of waste and waste packages delivered or to be delivered, e.g. in the form of a database for a repository or a storage facility. With such a data transmission, verified electronic waste data are available in multiple 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.

According to § 73, para. 3 StrlSchV /2/, the waste package documentation is to be kept available for at least another year a plant after delivery of the respective radioactive waste to a federal facility for safekeeping and disposal of radioactive waste.

### 9.5 Post-qualification and post-conditioning of waste

Many different requirements are to be met for waste forms and waste packages under storage according to the licences of the storage facilities issued by the authorities, taking into account all safety aspects.

Accordingly, waste forms and waste packages are stored in Germany's storage facilities according to the condition of the waste stored that can be divided into the following groups:

- Waste forms or waste packages produced in a process qualified by the BfS method and for which there is a statement of the BfS regarding their suitability for disposal,

- waste forms or waste packages produced according to an inspection plan approved within a supervisory procedure of the respective storage facility, and

- products and packages neither produced in a qualified process nor according to an inspection plan approved within a supervisory procedure.

Depending on the condition of the waste stored, measures are to be taken to enable later full compliance with the requirements of the Konrad repository. Furthermore, compliance with the protection goals of storage is to be ensured for the entire storage period envisaged.

A post-qualification of waste forms and waste packages is to be carried out firstly by a document research and, where necessary, additional investigations. For this purpose, the available documentation on the waste is to be reviewed and existing knowledge to be compiled and evaluated. Any subsequent investigations of the waste packages aim at filling gaps in the documentation identified. These post-qualification campaigns are to be notified to competent authority for product control, as is the case for conditioning campaigns for newly produced waste. As part of assessing a post-qualification campaign, the available waste package documentation is to be submitted to the competent *Länder* and federal authorities together with a schedule.

A delayed start of measures for post-qualification of radioactive waste should be avoided as far as reasonably possible as regards an increasing loss of information associated with the time delay. Here, for example, the stability of the waste packages and the safe operation of the storage facility, logistical processes of the storage facility and the information gain to be achieved are to be considered.

If the research in the context of post-qualification only reveals gaps in the documentation, so post-qualification may be performed in dependence on the conditions of the storage facility by examinations with the aim to fill the gaps in the package documentation for later disposal.

If suitability of the existing waste forms and waste packages for storage cannot be verified through research and checks, within the framework of post-qualification, a post-conditioning campaign is to be planned and performed without any delay. Deficiencies of waste packages identified during the post-qualification are to be eliminated by qualified treatment processes.

## 10 Storage facility operation

The guidelines aim at the operation of the currently existing storage facilities for which it was not foreseeable at the time when licence was granted that the storage period of the wastes can extend over several decades. This storage period may, among other things, also have an effect on the organisation of the storage facility operation. However, in it safety principles, the guidelines are also to be applied to storage facilities to be built. It therefore will be pointed out in the following if individual provisions exclusively refer to facilities to be built.

Further, distinction is to be made according to the storage concept, i.e. according to the respective contribution of the waste form, waste container, waste package and storage building to the fulfilment of the safety requirements. Further distinctions may result with regard to the spectrum of the waste emplaced.

### 10.1 Operating principles

Construction and operation of the storage facility shall be performed 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:

- In case of storage facilities yet to be constructed: all processes for reaching normal operating conditions of the facility for the first time (commissioning),
- specified normal operation,
- detection and control of operational disturbances and accidents and elimination of their consequences.

For safe performance of the operational processes, the entire operation shall be structured appropriately. For this purpose, the following requirements are to be met:

- All operational processes shall be clearly described.
- All installations necessary for safe performance of operation shall be specified.
- Persons with performance authorisation shall be assigned to the operational processes.

In particular, the necessary administrative prerequisites relating to personnel, organisation and safety shall be established and proof thereof to be furnished. 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.

### 10.2 Organisation and management system of the storage facility operator

The organisational structure of the storage facility operator must show clearly defined powers, responsibilities and communication channels. In particular, also the interfaces between storage facility operators and waste owners are to be defined in clear, precise and complete regulations, provided that operator and owner are not identical.

The organisational structure must ensure that throughout the entire period of time necessary for safety the necessary personnel and the required skills, abilities and experience will be available to perform all necessary activities appropriately. If the organisation makes us of external assistance for it, it must always be able to ensure the proper execution of the activities of the external organisation independently.

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 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 facility, and the quality and economic efficiency are not considered separately from safety requirements, thereby preventing potential negative impacts on safety.

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 disturbances, design basis accidents 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 must be carried and implemented as planned, implementation is to be assessed and continuously to be improved. 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 are to 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 professional knowledge, skills and abilities.

The management system is to be described. The documentation of the management system includes 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,
- 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.

### 10.3 Commissioning of new storage facilities

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.

Prior to first waste emplacement, the entire handling process, including radiation protection measures, is to be tested. During this trial run, any potential deficiencies in the process are identified, handling of waste packages is optimised and the planned proceeding adapted and finally defined. Prior to first emplacement of a new container type, inactive testing is to be conducted.

## 10.4 Operation

### 10.4.1 Operating manual, operating instructions

Documents are to be created that describe all the operational processes and measures to be taken in case of incidents in clear operating instructions. For these documents, the term operating manual is used in the following. The operating manual shall include all operational and safety-related instructions, limits and requirements necessary for specified normal operation of the facility and for accident management and at least the operational regulations applicable for the storage facility. These include, for example, the personnel organisation, the maintenance regulations, the radiation protection regulations, the guard and access regulations, the alarm regulations, and the first aid regulations. For the structure of the operating manual and with respect to general requirements for the layout of the operating manual, in particular with regard to compliance with the state of the art and ergonomics as well as to the completeness and clarity of descriptions, nuclear safety standard KTA 1201 /22/ may be used as a guide. The operating regulations of the storage facility are part of the operating manual. The operation of the overall facility should be structured according to emplacement, storage and retrieval operation.

In particular, the operating manual has to address all safety-related aspects affecting safety. This is to ensure that the personnel can initiate and perform the necessary measures during operational processes or in case of incidents without any delay and in a reliable manner. In addition, the proceeding for modification or supplementations of components and procedures is to be specified.

### 10.4.2 Incoming inspections, emplacement

Prior to each emplacement of waste, these are subjected to an incoming inspection (§ 75, para 3 StrlSchV). The incoming inspection serves the purpose of verification and shall enable the following:

- Identification control: determination whether the waste agrees with the waste declared for reception.
- Compliance with the acceptance requirements: verification that the acceptance requirements defined in the licence of the storage facility have been met. For this purpose, quality-assured data of the conditioner may also be referred to.
- Verification of the data of the deliverer: determination of specific characteristics, such as container type and mass.

As far as emplacement of the waste from a neighbouring facility of the same operator is performed without using public transportation routes, certain parts of the controls, which were already performed at the neighbouring facility, may be dispensed with for the incoming inspections of the storage facility.

For the emplacement operation, to be regulated in an instruction or provision, the following is to be controlled (also applicable to retrieval operation):

- Dose rate and surface contamination of the waste unit,
- condition and declaration of the waste unit, and
- agreement with the declared data.

Further, the following is to be observed:

- In case of non-compliance, extended controls shall be performed.
- The incoming inspections shall only be performed by trained personnel.
- Operational disturbances and deviations at packages detected during an incoming inspection shall be reported to the supervisory authority immediately. For this purpose, a reporting scheme shall be established.
- Emplacement shall be recorded.

In case of non-compliance with acceptance requirements, a conceptual approach is to be developed and defined. The concept must specify all precautions and actions required for this case (additional checks to be performed, e.g. by additional measurements or check for transportability, separate storage, if necessary with additional protection measures such as shields or measures against spread of contamination, measures to preserve evidence, to investigate causes and to inform the deliverer and the authorities).

### 10.4.3 Monitoring, recurrent tests

If it has to be assumed for storage that the retention properties of the waste packages are subject to a relevant change in the course of time, measures are to be taken for an early detection of adverse developments. For this purpose, a concept is to be developed, for example the following, depending on the type of storage facility and waste package:

- Emplacement of the waste packages in the storage facility can be performed such that these are made accessible, when required, and may be subjected to visual examinations and inspections.

- The visual examinations and inspections are performed on reference packages. On the basis of the condition of these reference packages, conclusions are drawn on the condition of the other waste packages. This proceeding requires that the reference packages are stored under representative conditions with regard to potential degradations of their retention properties.

Reference packages are to be preferred in particular if visual examinations and inspections directly on the waste packages stored in groups would lead to relevant radiation exposure due to a high local dose rate.

The assumptions and boundary conditions for the waste package properties and relevant waste characteristics used in the safety analyses, especially the limitations of the dose rates and the radionuclide inventory, are to be included in acceptance requirements for the storage facility. For verification that the acceptance requirements

are complied with, implementation provisions are to be defined. This also includes work instructions and examination procedures to be considered for the handling of the packages.

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

- lifting equipment,
- alarm systems,
- radiation protection systems, and,
- where necessary, ventilation and instrumentation and control systems,

recurrent tests are to be performed. Their frequency is to be defined according to the safety significance of the components to be tested under consideration of the specific regulations. Typical test cycles are annually or bi-annually. The recurrent tests are to be defined in a testing manual in analogous application of nuclear safety standard KTA 1202 /23/. The results of the recurrent tests are to be documented and must be available for long-term monitoring.

The operation of the facilities is to be monitored to identify safety-relevant operational disturbances and accidents in a reliable manner and the countermeasures laid down in the operating manual can be taken. Operational disturbances are to be recorded centrally and, if required, to be forwarded to the competent supervisory authorities and documented.

Safety-relevant events during commissioning, specified normal operation (in particular during maintenance and inspection) and recurrent tests are to be documented (Chapter 10.7). Kind and scope of this documentation are to be defined. Safety-relevant events are to be reported in accordance with the provisions of the Nuclear Safety Officer and Reporting Ordinance (AtSMV) /32/ or the Radiation Protection Ordinance. The consequences derived from the evaluation of such events is to be assessed and, where appropriate, included in the operating rules. So, for example, the above measures shall be reviewed regularly (e.g. every five years) and, if necessary, revised in terms of an inspection programme. The results from maintenance and recurrent tests, the evaluation of safety-relevant events, the resulting changes and amendments to the operating rules (Chapter 12) are to be considered in the periodic safety review and evaluated comprehensively.

### 10.4.4 Evaluation of operating experience

Experiences from operation of comparable facilities are to be taken into consideration for the operation of the storage facility. This ensures that experiences are analysed and assessed for their transferability particularly with regard to

- the long-term material behaviour of the packaging,
- observations on slow changes of the waste form, and
- ageing phenomena of installations of the storage facility.

In this way, very slow processes and rare events or only occurring in connection with certain wastes can be adequately considered in the operational management. To this end, procedures are to be provided which ensure the exchange of experiences (e.g. on the basis of operating reports or in specialised working groups) between the operators of storage facilities at appropriate intervals.

### 10.4.5 Removal from the facility

If wastes shall be removed from storage at the facility, the necessary proofs on compliance with traffic law provisions /6/ to /9/ are to be furnished if transport on public roads is intended. When removing waste from the storage facility, exit inspections are to be performed. Waste packages leaving the facility are subject to unequivocal identification and declaration. In addition, the removal of waste is to be logged.

The technical equipment used for the handling of the waste forms, waste packages and large components and their transport must be available until removal from the storage facility will be completed. In this respect, it must be assumed that e.g. a transport of the waste packages, e.g. for emplacement in a repository, may take place over a longer period of time. To this end,

- the necessary installations of the storage facility (e.g. lifting equipment) are to be kept either operable or in such a conditions 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 waste packages are to be maintained in a condition which generally enables the fulfilment of requirements under traffic law.

## 10.5 Maintenance

For maintenance, a distinction is to be drawn between the types of storage facility installations and the waste stored.

For 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. The spatial conditions are to be designed such that there is sufficient space for maintenance work while keeping available additional shieldings which might be necessary for reasons of radiation protection. Regulations governing the preparation and performance of maintenance work are to be included in the operating manual.

Due to the long storage periods of packages it cannot be excluded that for some waste packages repair or post-

treatment will be required. If damages to waste packages are detected, and if these have a relevant impact on the activity confinement, or if limitations regarding handleability or compliance with requirements of fire protection cannot be excluded, the waste packages are to be subjected to a treatment. In order to enable realisation when required, installations and measures are to be kept available in the short term. So, for example, overpacks for the transport of the waste packages are to be kept available or it is to be ensured in another way that these can be made available for the different package types stored to the necessary extent if required. For these repairs, a repair concept is to be developed where it is described in which way defective waste containers or waste packages are repaired.

### 10.6 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 accounting of the radioactive substances,
- the current storage facility occupancy,
- the results of the scheduled recurrent tests,
- other significant operational processes and occurrences,
- the results of measurements of the personal dose of individuals who were active in the storage facility, and
- the results of dose rate measurements at the specified measuring points.

The purpose of the report is to indicate whether the radiological and static boundary conditions are met with the emplaced containers.

### 10.7 Documentation of the storage facility

The documentation of a storage has to take place within in a systematically structured documentation system. Regarding the structure, nuclear safety standard KTA 1404 /18/ may be used as a reference. In Section 3.1, the KTA standard also defines the general documentation requirements that apply as regards their contents also to this case.

The documentation includes at least the following documents:

- Licences and modification licences,
- modifications from supervisory procedures,
- documents on design, manufacture, construction, commissioning, operation and maintenance of safety-relevant components of the facility,
- documents on the waste packages stored,
- information on safety-relevant events, and

- information on radiation protection.

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 also for fire protection reasons, so that in case of demand accessibility is given.

Parts of the documentation of the storage facility are part of the safety documentation. This includes all the information and proofs that are relevant to the safe operation of the facilities and the level of protection. These are, e.g.,

- 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, internal and external hazards),
- plans, drawings, manufacturer and test certificates, safety reviews, and
- operating reports.

An illustrative list with all items belonging to the safety documentation is given in Annex 3.

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 operating life of the facility from planning to construction, commissioning, operation and termination of storage. It also serves as a reference for the safety assessment of modifications in the facility and for modifications in operating practice. It contains a description of all safety aspects of the facility and of all safety-relevant aspects of the site, the construction of the facility, operation, the provisions for decommissioning and dismantling as well as of the management that contribute to the safe operation of the facility. It should comprise the facility itself as well as the waste and its 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 review (Chapter 12), 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.

### 10.8 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 only used in case of demand or temporarily. The following cases are to be distinguished:

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

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

- Storage facilities not requiring permanent staffing: Here, the functions are limited 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 and evaluations (Chapter 10.3). 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.

## 11 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 has to include at least the information listed in the Annex 3 /24/, /25/. 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 must be 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 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 external 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 reviewed regularly and the experience gained are to be taken into account in the revision.

Depending on the type of storage facility and the stored waste, different measures of off-site emergency preparedness may be required additionally (§§ 50-53 StrlSchV). For storage facilities that exceed the specified activity limitations in § 53 StrlSchV an on-site emergency preparedness plan is to be drawn up based on the possibilities for release of radioactive substances from the storage facility and, where appropriate, is to be co-ordinated with the emergency preparedness plans of neighbouring nuclear facilities and agreed upon with the competent 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 facilities, the competent authorities and safety bodies.

## 12 Periodic safety review

The operator of the facility must perform a safety review for the facility at regular intervals of ten years. The introduction of a safety review is based both on Art. 7 para. 2 of the EU directive on nuclear waste management /27/ and the so-called WENRA safety reference levels /24/, to whose implementation in the national regulations and in practice Germany has committed itself as a WENRA member state.

By means of the safety reviews, safety and regulatory deviations of relevant standards, rules and the state of the art are to be identified and assessed. Identified changes

- in technical procedures,
- of the facility and its components,
- in the operational organisation,
- of the technical development,
- from operating experience, and
- by ageing of the facility, its technical components and the waste stored

are to be reviewed for their impact on safety and to be assessed from the safety point of view. In this respect, particular attention is to be paid to adverse reactions, interactions and cumulative effects. Furthermore, the ambient conditions in the storage facility (e.g. temperature, humidity) for waste packages and all deviations from any specified storage conditions are to be taken into account.

Prior to the first periodic safety review, methodology and scope of the review are to be defined specifically for each facility. In subsequent reviews, methodology and scope are to be adapted based on the lessons learned from previous reviews.

The review begins with an update of the safety documentation (see Chapter 10.7), which is to be used as a reference. In particular, the list of safety-relevant structures, systems and components is to be checked and updated where necessary. In the next step, all relevant changes of them in the past 10-year period (see above) are to be compiled. Replaceable systems, structures and components are to be reviewed in particular with regard

to their technical ageing (compared with the current state of the art, long-term maintainability, long-term availability of replacement of equivalent quality).

Changes and foreseeable changes in regulatory requirements, technical standards and regulations and in the state of the art are also to be identified.

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

For the management of long-term and ageing effects during the period of use of the storage facility applied for, a monitoring concept is to be presented. With regard to ageing, the results of regular walkdowns, inspections and checks of buildings, technical installations and the waste stored are to be evaluated comprehensively with regard to long-term developments. Here, a distinction can be drawn between replaceable (e.g. measuring, monitoring and alarm systems) and non-replaceable components (e.g. buildings) since ageing management has to pursue different objectives (replaceable: preventive replacement, non-replaceable: measures for protection and maintenance). If for individual safety-relevant components there is no sufficient experience from the own facility or other comparable facilities with regard to its ageing characteristics, component-specific examinations are considered to be appropriate. Here, the scope of checks (complete, examples, periodic or one time) is to be defined based on the ageing influences, the known and assumed mechanisms of ageing (e.g. corrosion, fatigue, wear) and the expected failure rate (e.g. frequently, occasionally, rarely, unknown/not assessable). The check for ageing aspects concludes with a forecast of the developments in the facility and with regard to the waste stored therein in the next decade.

The availability of the necessary personnel, the knowledge and experience necessary for operation and the foreseeable future tasks as well as foreseeable personnel and organisational changes are to be compiled and assessed with regard to the long-term continued operation of the facility.

The safety review has to be concluded with an assessment on

- the current safety status of the facility and the waste stored,
- the expected development of the safety of the facility and the waste stored,
- the identification of relevant deviations and how these deviations are to be assessed from the safety point of view,
- the measures to prevent adverse developments regarding safety that have been identified and to improve safety that are provided and in what periods of time these measures shall be implemented (action plan).

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

## 13 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 containers stored there.

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.

## 14 Provisions, guidelines and standards

/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 des Gesetzes vom 24.02.2012 (BGBL. I, Nr. 10, S. 212)

/2/ Verordnung über den Schutz vor Schäden durch ionisierende Strahlen (Strahlenschutzverordnung - StrlSchV) 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/ Bundesamt für Strahlenschutz
Anforderungen an endzulagernde radioaktive Abfälle (Endlagerungsbedingungen, Stand: Oktober 2010) - Endlager Konrad -, SE-IB-29/08-REV-1

/4/ Bundesamt für Strahlenschutz
Produktkontrolle radioaktiver Abfälle, radiologische Aspekte - Endlager Konrad - Stand: Oktober 2010, SE-IB-30/08-Rev-1

/5/ Bundesamt für Strahlenschutz
Produktkontrolle radioaktiver Abfälle, stoffliche Aspekte - Endlager Konrad - Stand: Oktober 2010, SE-IB-31/08-REV-1

/6/ 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 (BGBl. I 2009, Nr. 33, S. 1389); neugefasst durch Bekanntmachung vom 16. Dezember 2011 (BGBl. I 2011, Nr. 67, S. 2733)

/7/ GGVSEB-Durchführungsrichtlinien – RSEB
Richtlinien zur Durchführung der Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt (GGVSEB)
vom 29. April 2011 (VkBl. 2011, Nr. 9, S. 354)

/8/ ADR
Anlagen A und B des Europäischen Übereinkommens vom 30. September 1957 über die internationale Beförderung gefährlicher Güter auf der Straße (ADR)
in der Fassung vom 25. November 2010 (BGBl.II 2010, Nr. 34, S. 1412; Anlagenband)

/9/ 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 16. RID-Änderungs-verordnung vom 11. November 2010 (BGBl.II 2010, Nr. 32, S. 1273)

/10/ Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen (REI) vom 07.12.2005 (GMBl. 2006, Nr. 14-17, S. 254)

/11/ DIN 4102, Teile 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 vom 11/2004

/12/ 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)

/13/ KTA 2201.1
Auslegung von Kernkraftwerken gegen seismische Einwirkungen
Teil 1: Grundsätze, Fassung 11/11

/14/ 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

/15/ 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

/16/ BMU
Richtlinie zur Kontrolle radioaktiver Reststoffe und radioaktiver Abfälle
vom 19. November 2008
BAnz. 2008, Nr. 197, S. 4777

/17/ BLG
Technische Annahmebedingungen (TA) für das Abfalllager Gorleben
Rev. 2.0, Stand 12/95

/18/ KTA 1404
Dokumentation beim Bau und Betrieb von Kernkraftwerken; Fassung 6/01

/19/ Michelle Wise, David Gray and Ian Upshall
INFORMATION TECHNOLOGY For the record
Nuclear Engineering International, 13 October 2005

/20/ Nuclear Decommissioning Authority (NDA)
WPS/870/02: Long-term Management of Information and Records: Explanatory Material and Guidance
WASTE PACKAGE SPECIFICATION AND GUIDANCE DOCUMENTATION
March 2008, Number: 9698928

/21/ IAEA
Methods for Maintaining a Record of Waste Packages during Waste Processing and Storage
Technical Reports Series No. 434 (January 2005)

/22/ KTA 1201
Anforderungen an das Betriebshandbuch; Fassung 2009/11

/23/ KTA 1202
Anforderungen an das Prüfhandbuch; Fassung 2009/11

/24/ Western European Nuclear Regulator's Agency (WENRA): Waste and Spent Fuel Storage Safety Reference Levels Report. – Version 2.1, February 2011

/25/ International Atomic Energy Agency (IAEA)
Preparedness and Response for a Nuclear or Radiological Emergency - Requirements.
IAEA Safety Standards Series No. GS-R-2, Vienna, (November 2002)

/26/ Gutachtergemeinschaft RADWASTE
TÜV NORD EnSys Hannover GmbH & Co. KG, Produktkontrollstelle des BfS in der Forschungszentrum Jülich GmbH, WEITERE STANDORTE,
Langzeitverhalten von vernachlässigbar Wärme entwickelnden, radioaktiven Abfallprodukten / -gebinden
August / September 2009

/27/ 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

/28/ Bundesamt für die Sicherheit in der Informationstechnik (BSI): BSI Technische Richtlinie 03 125 – Beweiswerterhaltung kryptographisch signierter Dokumente. – BSI TR – 03-125, Version 1.1, 18.02.2011

/29/ DIN 31645: Information und Dokumentation – Leitfaden zur Informationsübernahme in digitale Langzeitarchive; Ausgabe 11/2011

/30/ KTA 3902
Auslegung von Hebezeugen in Kernkraftwerken (Fassung 6/1999); Änderungsentwurf 2010/11

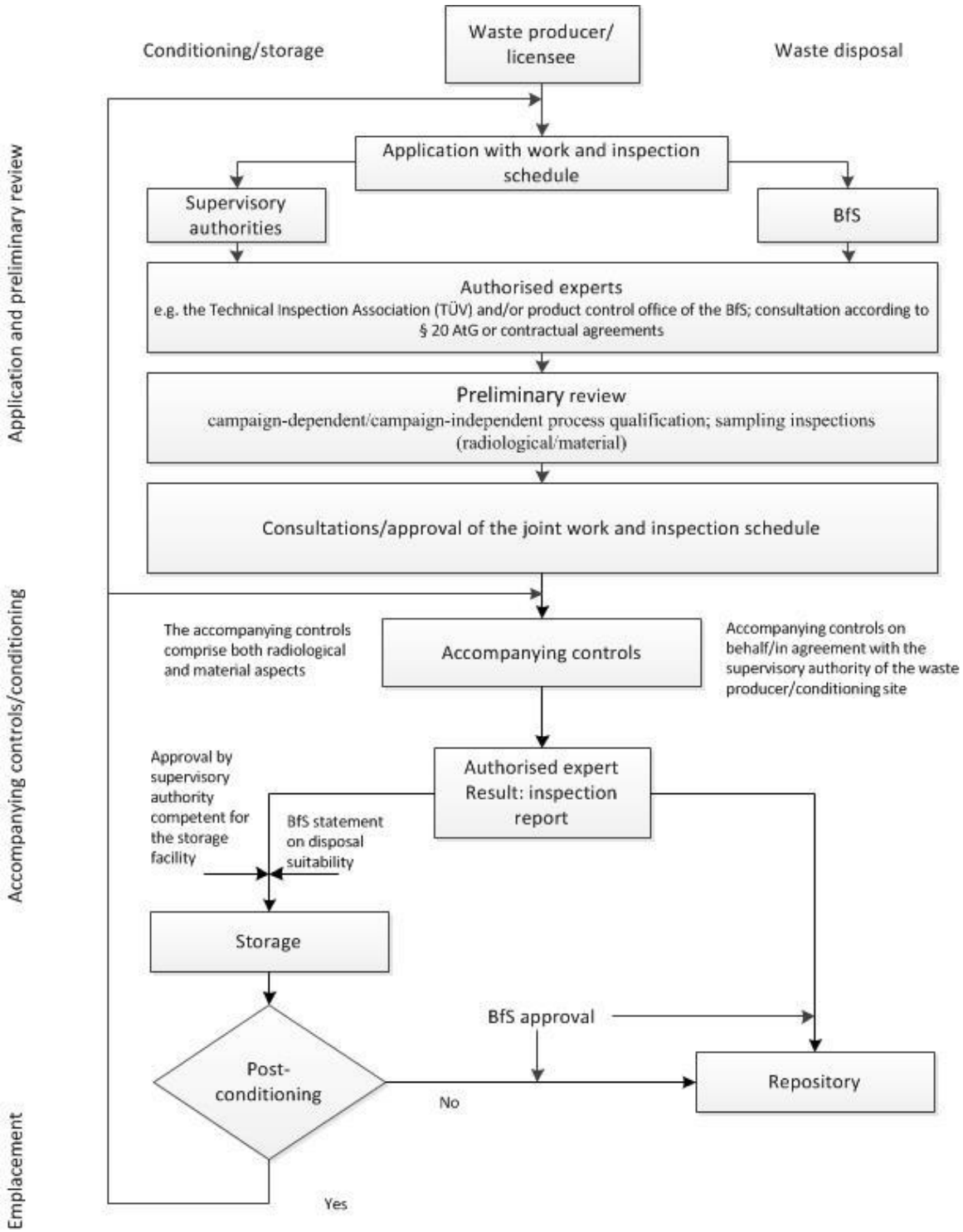
/31/ KTA 2206
Auslegung von Kernkraftwerken gegen Blitzeinwirkungen; Fassung 2009/11

/32/ Verordnung über den kerntechnischen Sicherheitsbeauftragen und über die Meldung von Störfällen und sonstigen Ereignissen (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV) vom 14. Oktober 1992 (BGBl. I. Nr. 48, S. 1766), zuletzt geändert durch Verordnung vom 8. Juni 2010 (BGBl. I. Nr. 31, S. 755)

# Annexes

## Annex 1 to Chapter 9.1

**Product control flow chart for radioactive waste from nuclear facilities /4/**



**Flow chart legend /4/**

**Waste producer/licensee:**

Submits an application to the BfS and the supervisory authority on conditioning and inspection plans together with a work and inspection schedule. The *Land* collecting facilities assume, among other things, the tasks of the waste producers within the frame of product control.

**Application with work and inspection schedule:**

An application may be submitted for the qualification of a procedure or a specific conditioning campaign (including sampling inspection) or a sampling inspection. The respective schedule comprises all relevant work and inspection steps of the project with regard to the waste packages. The application with the part relevant for the verification that the waste acceptance requirements for disposal have been meet and the parts of the schedule being specific for the facility and/or relevant for storage is submitted to the BfS and the competent supervisory authorities by the waste producer/licensee.

**Supervisory authority:**

Competent for facilities and measures of the waste producer/licensee and for a potential storage facility. In accordance with § 20 AtG, it commissions, where required, experts to review the documents submitted regarding compliance with the requirements of a specific nuclear facility or for storage, respectively, in agreement with the experts consulted by the BfS. It grants the approval of performance of planned conditioning or storage. It informs the BfS of its decision.

**Federal Office for Radiation Protection (BfS):**

Commissions, if required, experts to review the documents submitted on the requirements for disposal in agreement with the experts consulted by the supervisory authorities. The BfS informs the competent supervisory authorities of the result of its review.

**Preliminary review:**

The preliminary review is the review of the work and inspection schedule submitted and, where required, further documents. It takes place campaign-dependent or campaign-independent on a conditioning procedure or a sampling inspection procedure. On the basis of the preliminary review, the experts involved specify in the schedule which inspections are regarded as necessary. Experts are commissioned in specific cases, as defined in the schedule, in consultation with the BfS. The review results of the experts shall in each case be outlined in one statement under consideration of the results of the consultation of the other experts involved, which forms the basis for the decision on the project applied for.

**Approval of the joint work and inspection schedule:**

It is given by the BfS regarding the verification that the waste acceptance requirements for disposal have been fulfilled. The approval of implementation of the schedule is granted by the competent supervisory authority.

**Accompanying controls:**

The inspections performed by the experts specified in the work and inspection schedule are performed and documented on behalf of the supervisory authority of the waste producer (see also preliminary review). In case of external conditioning, the accompanying control is also performed on behalf of this authority with the possibility of consulting local experts.

**Authorised expert:**

The expert for accompanying controls summarises the results of the accompanying controls regarding the requirements of the storage facility and the repository in an inspection protocol for the supervisory authorities and the BfS. On the basis of this inspection protocol and review of the documentation, the BfS expert prepares an inspection report for the BfS.

**Storage:**

According to the requirements for the storage facility (storage in terms of § 78 StrlSchV /2/ or § 6, para. 1 AtG /1/ or as part of an activity subject to licensing pursuant to § 7 or § 9 AtG /1/ or other type of storage), the competent supervisory authority gives its approval to the emplacement. The BfS issues a statement on the compliance with waste acceptance requirements for disposal as far as at this time it has the results of the examinations required from the point of view of disposal.

**Post-conditioning:**

In case of work and inspection plans already subjected to preliminary reviews that consider post-conditioning measures that might be required, still necessary post- conditioning of waste packages requires accompanying controls. For waste packages to be subjected to post-conditioning without approved work and inspection schedule, the complete product control procedure is to be performed.

**Repository:**

The transport of the waste packages to the repository is subject to the approval by the BfS.

**Annex 2 to Chapter 2.1 (from /26/)**

## Assessment of gas formation rates of conditioned waste regarding maintenance of waste form properties during storage that are relevant for disposal

Changes of properties of the waste forms are indicated by changes in the gas compositions of the atmosphere inside the waste packages. Gases such as hydrogen, methane, carbon dioxide or carbon monoxide are formed by digestion, fermentation or corrosion processes. Here, the extent of the changes of waste form properties corresponds to the amount of gas developed. The assessment of the analysis results of the gas samples has so far been based on a gas formation rate of 2 ml/($m^3$·h), which in accordance with the present state of the conditioning technique is generally reached for compacted mixed waste.

The evaluation of the gas analysis results showed that compliance with this recommendation in principle presents no major problems. Exemplary considerations show that in some cases even larger gas formation rates can be tolerated regarding compliance with the waste acceptance requirements for disposal. Even with conservative approaches regarding the effect of the chemical reactions that lead to gas formation and regarding the assumed kinetics of these reactions, studies showed that with gas formation rates below 10 ml/($m^3$ h), with the exception of waste forms of the waste form group APG03, no adverse effects for the suitability of the products for disposal are to be feared also for a storage period of 20 years.

Since the estimated maximum permissible gas formation rates relate to the classification of the waste forms according to waste form groups to determine the cumulative values for accidents, these are to be adhered to with high reliability for each waste package of a test batch. To limit the efforts and radiation exposure of the staff, usually, only a limited number of gas samples are taken. For assessing the suitability of the units of this test batch for disposal, a mean value of the gas formation rates determined can then be referred to. To cover the possible distributions of gas formation rates within this test batch, the permissible mean value of a sample is lower than the maximum permissible gas formation rate for a single waste package.

Table 1 summarises for the various requirements for waste form groups, the maximum permissible gas formation rates for each package of a test batch, and the permissible mean values for a sample. If a complete control of all waste packages of a test or conditioning batch is performed, the maximum gas formation rate can of course be used to assess the suitability for disposal.

Regarding compliance with the basic requirement “free liquid”, maximum permissible gas formation rates of 10 and 20 ml/($m^3$·h) were determined for a single package with waste of waste form groups APG01 and APG02, and APG04 and APG05, respectively. The gas samples of a sampling must show a mean value of the gas formation rate of less than 5 or 10 ml/($m^3$·h), respectively.

For waste forms of APG06, the table does not include information on permissible gas formation rates. For such waste forms, no mechanisms for the formation of gases due to relocation of the waste after a cooling phase were found.

Table 1: Maximum permissible gas formation rates and maximum permissible mean values of analyses of a sampling

| Waste form-group | Requirements | Maximum gas formation rate [ml/(m³·h)] | Permissible mean value for a conditioning batch [ml/(m³·h)] |
|---|---|---|---|
| APG01 | Free liquid | 10 | 5 |
| APG02 | Flammable, meltable substances | 10 | 5 |
| APG03 | Non-metallic components | 3 | 2 |
| APG04 | Strength of the compacts | 20 | 10 |
| APG05 | Compressive strength | 20 | 10 |

By increasing the extent of sampling, the waste deliverer may demonstrate that the requirements are met. If this should not be feasible or successful, post-conditioning measures are to be carried out for the test batch. packages with waste forms of waste form group APG01, 02, 04 or 05, which have a gas formation rate of more than 10 and 20 ml/(m³ • h), respectively, post-conditioning may take place, for example, by drying. If due to knowledge of the waste composition it can be excluded that liquids or flammable substances with a melting point below 300°C can be formed by decomposition of organic material, so the maximum permissible gas formation rate of 20 ml/(m³ h) can be referred to for assessments of waste forms of the waste form groups APG01, 02, 04 and 05.

## Annex 3 to Chapter 10.7 and Chapter 11: Contents of the safety documentation, contents of the accident management plan

### 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 installations, 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 facility,
- a description of the expected amount and characteristics of the waste to be stored,
- information on the expected operating time of the 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 operational waste,
- a description of commissioning, assessment of deviations identified here, including the reasons for deviations,
- definition of an appropriate programme for continuous proof that the waste packages 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 waste packages,
    - process descriptions and operating procedures for safety-relevant operations,
    - provisions for operational inspections, maintenance and testing,
    - programme for the evaluation of operating experience,
    - programme for ageing management, and
    - training programme for employees,
- a preliminary description of the concept for the termination of storage.

**Contents of the accident management plan**

**Emergency preparedness**

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

**Personnel, organisational responsibilities and provisions**

- Names of the persons in charge of internal activities and being responsible for contacts with external organisations,
- a list of authorised persons with occupational title and description of functions allowed to declare an emergency,
- 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,
- 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 inside and outside of the site (water, vegetation, soil, air),

- assessment of the storage facility condition,

- Provisions for minimisation of doses to individuals and for medical care for injured people, and

- internal measures to limit releases and to prevent dispersion of radioactive substances.