Note:
This is a translation of the ESK recommendation "Leitlinien zur Stilllegung kerntechnischer Anlagen".
In case of discrepancies between the English translation and the German original, the original shall prevail.

ESK

RECOMMENDATION of the Nuclear Waste Management Commission (ESK)

Guidelines for the decommissioning of nuclear facilities

Contents

1 Scope of application

These guidelines present the technical requirements and processes to be applied for the decommissioning of facilities and parts thereof licensed under § 7 of the Atomic Energy Act (AtG).

They also apply to facilities for the storage or the handling of nuclear fuel according to §§ 6 and 9 AtG as well as to facilities for the handling of radioactive material or facilities for the generation of ionising radiation according to §§ 7 and 11 of the Radiation Protection Ordinance (StrlSchV), as far as the individual requirements are applicable and the required measures are justified due to the hazard potential during decommissioning of these facilities.

These guidelines take into account the recommendations of the international standards and regulations [1 to 3] and complement the requirements and specifications of the Decommissioning Guideline [4] from a technical point of view.

2 Definition of terms

For a better understanding of some of the following definitions, reference is made to the chart in the annex.

- **Dismantling concept**
  Description of the main technical and organisational measures for dismantling of a facility, including their interdependencies and the anticipated schedule. The dismantling concept is part of the decommissioning planning.

- **Dismantling planning**
  The dismantling planning provides details on the measures described in the dismantling concept.

- **Decay storage**
  Storage of radioactive residues for decay of their activity to such a level that further treatment and disposal can be carried out under optimised radiation protection conditions or, where possible, clearance can be given.

- **Work permit procedures**
  Procedures for planning, approval, performance, monitoring, review and documentation of activities in the supervisory procedure that are specified in the operating documentation of the respective facility.

- **Permanent shutdown**
  All technical and administrative measures to permanently cease use as designed and specified.

- **Installations**
  The term installations refers to all components, systems and structures of a facility.

- **Waste management concept**
  Presentation of the expected material flows during dismantling of a facility, including their quantities, the main processing steps and paths for non-hazardous removal or reuse, or disposal as radioactive waste. The waste management concept is part of the decommissioning planning.

- **Waste management planning**
  The waste management planning provides details on the measures described in the waste management concept.

- **Absence of nuclear fuel**
  The absence of nuclear fuel in a facility or a part thereof is defined as the condition during which nuclear fuel only exists in such small quantities that criticality can be excluded (fuel and defective rods are removed).

- **Buffer storage**
  Temporary storage of removed facility components and of radioactive material in suitable areas or in suitable rooms for processing (e.g. decontamination, disassembly) and treatment (e.g. conditioning) or keeping them ready for transport. Maximum periods for temporary storage are to be defined, where appropriate waste- and room-specifically.

- **Radioactive residues**
  Radioactive residues are radioactive substances for which the way of waste management has not been decided yet and which are either utilised without detrimental effects or disposed of as radioactive waste in a procedure regulated by law. This also includes disassembled or dismantled facility components, parts of buildings, debris from demolition as well as movable objects being contaminated or activated.

- **Radiological characterisation**
  Radiological characterisation is understood as the determination of the state of a facility as a whole or parts thereof as regards contamination, activation and dose rate.

- **Safe enclosure**
  Safe enclosure is defined as the intermediate state of a facility achieved by technical and structural measures after final cessation of power operation or production and after having reached absence of nuclear fuel in which it will remain for a longer period of time and the remaining radioactive inventory will remain safely enclosed even with reduced monitoring effort.

- **Decommissioning**
  The decommissioning of a facility in the technical sense includes all measures after final cessation of power operation or production to achieve the decommissioning objective.

- **Decommissioning manual**
  The decommissioning manual contains regulations on the decommissioning of a nuclear facility and the safety-related and operational installations required for operation during decommissioning. The

decommissioning manual is usually based on the regulations in the operating manual for power operation or production.

- **Decommissioning concept**
  The decommissioning concept is the presentation of the main measures for decommissioning of a facility as well as for waste management and serves to demonstrate the general feasibility of the measures until achieving the decommissioning objective.

- **Decommissioning phases**
  Decommissioning can be divided into several phases where the individual phases may overlap in time. The number of phases is to be determined by the operator within the overall view of the decommissioning (see Chapter 6).

- **Decommissioning planning**
  The decommissioning planning specifies the measures described in the decommissioning concept to the degree required for the implementation of decommissioning, dismantling and waste management.

3 Decommissioning concept

The decommissioning of a facility in the technical sense comprises all measures after final cessation of power operation or production to achieve the decommissioning objective. This objective is

- the removal of the facility (demolition of the building structures and release of land areas from the scope of application of the AtG – "green field"),
- the conventional use of the facility after release from the scope of application of the AtG, or
- the further use as a facility or installation within the scope of application of the AtG.

The decommissioning objective can either be achieved directly (immediate dismantling) or via the intermediate stage of safe enclosure.

Already during construction and operation of a facility, its future decommissioning is to be considered such that by design, layout and arrangement of the installations future decommissioning will not be impeded. For this purpose, a decommissioning concept is already to be drawn up during construction.

The decommissioning concept contains

- a general description of how decommissioning and dismantling can be carried out safely and reliably and how the resulting radioactive residues/waste can be managed in accordance with the requirements to be met,

  and

- a list of the main documents and information from construction and operation of the facility required for the realisation of the decommissioning as well as specifications on their archiving.

Accompanying to the operation of the facility, the decommissioning concept is to be reviewed regularly (about every ten years) and event-based, in particular in case of modifications to the facility relevant for decommissioning, and to be updated where required. This concerns:

- relevant facility data,
- waste management routes provided, and
- the basic procedure for decommissioning, taking into account the experience feedback from current decommissioning projects and taking into account the further development of the state of the art as well as changes to the rules and regulations and the administrative framework conditions.

Furthermore, it is to be ensured that

- provisions are in place to support a later decommissioning, as far as these are appropriate and permissible under the aspects of safety during operation of the facility, and

- the data relevant for decommissioning are documented, such as

  - events and processes relevant for decommissioning (constructional measures, activity releases, operational occurrences, decontamination work performed, reportable events, etc.), and

  - operational and facility-related data (e.g. masses, materials, radiology) and their continuous updating (e.g. with regard to activation of facility components; where required, samples of the materials used are to be taken and stored for reference).

4 Measures to prepare the dismantling of the facility

The precautions against damage necessary according to the state of the art in science and technology are to be maintained also after termination of power operation or production. For this purpose, the installations required during power operation or production have to ensure compliance with the main safety functions with the necessary effectiveness and reliability also after termination of power operation or production.

From the point of view of safety, the following measures should be performed, among others, after termination of power operation or production as early as possible:

- complete removal of nuclear fuel,

- reduction of the radioactive inventory, e.g. by system decontamination and removal of operational waste,

- radiological characterisation of the entire facility based on system assessments and taking into account nuclide-specific analyses, contamination and dose rate measurements as well as the operating history with relevant occurrences, and

- inventory taking of hazardous (e.g. flammable, toxic, water-endangering) substances.

From the point of view of safety, among others, the following measures can also be started and performed after termination of power operation or production:

- amendment of the operating rules, depending on the facility state, such as changes regarding the minimum availabilities of installations, the modes of operation of systems, the frequency of in-service inspections, the provisions in the emergency manual or the relevant processes and responsibilities,

- removal of materials that only served the purpose of fulfilling specific occupational safety requirements during power operation or production and that are no longer needed,

- taking installations out of operation that had safety relevance during power operation or production but are no longer needed for the current facility state and for decommissioning,

- establishment of areas for logistics (e.g. areas for buffer storage, transport routes),

- removal of components no longer used in power operation or production but having remained in the facility.

Before carrying out such measures it is to be demonstrated that they are unobjectionable from the point of view of safety. For this purpose, the existing operating regulations have to be amended where required or to be supplemented by specific regulations.

5 Radiological characterisation

The required level of detail and accuracy of the radiological characterisation depends on its objective during decommissioning. The first step of the radiological characterisation serves to establish the basis for the waste management concept and for the dismantling concept (e.g. activity inventory, accidents, dismantling strategy, possible clearance of buildings and site). A system decontamination should be carried out before the start of dismantling to achieve the maximum benefit from a radiological point of view on the one hand, and to take into account the subsequent state in the radiological characterisation for the dismantling concept on the other hand. In addition, it is to be examined – as far as necessary for the dismantling concept – whether and how far contamination has penetrated into building structures. Here, it would be appropriate to examine at an early stage whether deeply penetrated contamination or activation could lead to deviating approaches for the dismantling of the facility (statically relevant concrete structures in the area of the containment, floor and bearing walls in very highly contaminated areas). Further investigations on the penetration behaviour that will not have an influence on the implementation of the overall project can be carried out at a later stage.

Later steps of the radiological characterisation during dismantling serve to plan concrete measures for the protection against external and internal radiation exposure, the selection of optimised techniques for dismantling, disassembly and decontamination, the validation of calculated activities of radioactive waste, and the determination of definite nuclide vectors and enveloping measuring geometries for clearance.

Overall, the level of detail of the radiological characterisation as part of the decommissioning planning is lower than during the dismantling of the facility.

6 Decommissioning planning

The decommissioning planning has to contain a detailed description of the measures for decommissioning. In multi-phase projects, the level of detail may refer to the respective current phase. The decommissioning planning has to comprise, in particular,

- a dismantling concept,
- a waste management concept,
- a safety analysis,
- a description of the operating rules and the documentation provided, and
- a description of all measures others than dismantling measures

The necessary measures which do not represent dismantling measures include, e.g., the construction of handling and storage facilities, the conversion of facilities or the construction of new components, the provision of (mobile) equipment for the treatment or conditioning of waste, and changes of use of rooms. When implementing these measures, the retroactive effects on the facility are to be analysed.

The dismantling concept has to include, in particular, the following:

- dismantling steps and dismantling measures for installations and buildings, including their interdependencies and the anticipated time schedule, and
- dismantling, disassembly and decontamination techniques and the auxiliary equipment needed.

The waste management concept has to include, in particular, the following:

- description and classification of radioactive residues produced,
- waste management for radioactive waste,
- clearance procedures for radioactive material,
- concept for clearance/removal of land areas and buildings, and
- presentation of the material streams including required specific transport and storage logistics as well as their interdependencies.

Both the dismantling concept and the waste management concept should be drawn up taking into account the conventional pollutants and form the basis of dismantling planning and waste management planning.

The safety analyses mainly have to take into account the following (see also Chapter 8):

- analysis of operating processes and the impact on the environment by direct radiation and by discharges with exhaust air and waste water,
- safety concept for preventing and limiting the consequences of accidents,
- safety-relevant installations and required operating systems, and
- systematic hazard and accident analysis (adjusted to the potential risk during dismantling taking into account the techniques used and hazardous materials during dismantling).

The operating rules have to take into account, among other things, the following (see also Chapter 9):

- operating organisation and safety management including description of safety-relevant processes,
- the procedure for the classification and re-classification of installations,
- the procedure for modifications, including the change of use of facility rooms,
- the procedure for radioactive waste management as well as for clearance/removal of materials, of soil areas and of buildings or parts thereof,
- the work permit procedures, and
- the measures provided for radiation protection, occupational health and safety and fire protection.

As part of the decommissioning planning, all measures provided to achieve the objective of decommissioning and the masses and activities of the expected total of radioactive waste and radioactive material to be cleared are to be specified. If in the course of decommissioning no major modifications to the measures provided for future decommissioning phases will become necessary, for multi-phase projects it is sufficient to present such an overall view for the first decommissioning phase. The overall view must show for all phases that the measures applied for for a specific phase will not impair or prevent further measures and that an appropriate order of the dismantling measures is provided. The overall view thus corresponds to the specifications required according to § 19b, para. 1 of the Nuclear Licensing Procedure Ordinance (AtVfV) on all measures planned for decommissioning, safe enclosure or the dismantling of the facility or parts thereof.

7 Measures during dismantling of the facility

7.1 Infrastructure and logistics

When dismantling the facility, access to further parts of the facility to be dismantled and space for the handling of these parts and the tools used for this purpose (e.g. remote handling equipment) is to be provided by removal of facility parts no longer required on a step-by-step basis. Where necessary, the operational transport routes are to be extended or new transport routes to be created (e.g. installation of new doors and locks).

The installations for handling and transport of the dismantled residues within the facility and on the facility site are to be determined and classified in accordance with their safety relevance (see Chapter 8).

To sort the radioactive residues from dismantling according to material type and degree of contamination, sufficient space is to be provided for the necessary measuring devices and the necessary buffer storage. For decontamination of dismantled facility components and conditioning of the waste produced, the necessary installations are to be provided.

For treatment of the radioactive residues produced, appropriate installations are to be provided with sufficient capacity. As far as possible, sorting should already take place when radioactive residues are produced. Alternatively, sorting and treatment of the radioactive residues (disassembly, decontamination, radiological measurements, conditioning) can also be carried out in external installations. In this case, availability, sufficient capacity and suitability of such installations are to be demonstrated and information must be provided on the transport (means of transport, packaging and transport routes) to these installations. As part of dismantling planning and waste management planning, availability, sufficient capacity and suitability have to be checked and adjusted where necessary.

For buffer storage and decay storage of the radioactive residues and intermediate storage of the conditioned radioactive waste, sufficient capacity is to be provided on site or in external installations.

For intermediate storage, the requirements according to [5] are to be considered.

Infrastructure and logistics are to be aligned with a view to minimising the radiation exposure of personnel and the environment to a level reasonably achievable.

7.2 Dismantling

For the dismantling measures provided, a dismantling plan is to be prepared. Objectives for this planning are the safe work performance, the enclosure of radioactive material in the facility, and minimisation of radiation exposure of personnel and the environment to a level reasonably achievable. The dismantling has to be performed in appropriate partial steps with appropriate dismantling techniques in accordance with the transport and storage logistics and the availability of necessary equipment and of supply and auxiliary systems. The dismantling is to be planned and performed such that the safety-relevant measures required to comply with the main safety functions will not be affected in their function and availability.

For dismantling, tried and tested dismantling, disassembly and decontamination techniques are to be used that are optimised, among other things, with a view to minimising secondary waste and the radiation exposure of personnel. New techniques are to be tested and qualified (e.g. in “cold tests”).

The respective dismantling measures are to be presented for review in accordance with the work permit procedures for the performance of work approved by the licensing and supervisory authority (see Chapter 9).

The radiation protection measures are to be adapted to the requirements and changed framework conditions of dismantling. For this purpose, the changed nuclide composition and the longer times of stay of personnel in areas with open contamination compared to power operation or production are to be considered. The direct radiation is to be determined for each dismantling area. Where appropriate, the use of shielding devices and installations for remote-controlled dismantling and handling are to be provided in order to reduce the radiation exposure of personnel by direct radiation.

7.3 Treatment of residues and waste

As part of the dismantling planning, the masses are to be determined for all materials produced during decommissioning, quantitative allocations of materials to waste management routes to be made, and the waste management routes to be described, all based on the operating history, system analyses and specific measurements. Here, decay storage (see also Chapter 7.4) may also be considered. The secondary waste expected is also to be taken into account, depending on the dismantling and decontamination techniques provided. The internal procedure for the collection, measurement, decontamination, conditioning and packaging is to be defined and laid down in the operating rules and procedures. All radioactive materials produced during dismantling are to be registered in a record system, so that their conditioning state and their whereabouts up to and including the final transfer to third parties (§ 70 StrlSchV) can be determined at any time. In addition to the radiological characterisation, the material composition of the radioactive waste is to be documented in detail [6].

Clearance of radioactive material

The clearance procedures are to be defined according to the type of material and the respective waste management route provided (see § 29 StrlSchV).

- The clearance procedure must allow the review of basic data (nuclide vector, suitability and calibration of measuring equipment, origin of the material and, where appropriate, activity distribution) as well as random control measurements.

- The clearance measurements of buildings and parts of buildings shall principally be carried out on the standing structure so as to prevent mixing of materials with different levels of activity when broken up to building rubble, thus achieving compliance with clearance levels. If, however, a clearance measurement on the standing structure is not feasible with reasonable effort, e.g. for reasons related to building statics or due to unavoidable transverse radiation into areas in which clearance measurements are to be performed, there may be deviations from the principle of performing clearance measurement in justified individual cases. In these cases, it must be prevented, at least prior to the production of building rubble, within the framework of an indicative pre-measurement and removal of local accumulations of activity that “hot spots” are mixed with clearable material. Alternatively, individual parts of the building can be removed in one piece and be measured for clearance in areas with low

ambient radiation. It is appropriate to introduce differentiation criteria for the decision as to when building structures are to be classified as part of the building or building rubble.

- Soil areas and excavated soil are clearable without restrictions if they comply with clearance levels for the clearance of soil areas (Appendix III, Table 1, Column 7 StrlSchV). Application of clearance levels to building rubble and excavated soil (Appendix III, Table 1, Column 4 or 6 StrlSchV) is only permissible in cases where a large-scale reuse of the excavated soil as a topsoil can be excluded. Here, low contents of excavated soil in the rubble from demolition or clearance of small masses are acceptable.

- For the clearance of the facility site and of buildings for further use, criteria are to be laid down taking into account the nuclide composition of the remaining contamination and the procedures for demonstrating compliance with these criteria. This also applies to the foundations and other building structures remaining on the facility site.

- In order to carry out measurements for a clearance decision on the produced amounts of radioactive material to be cleared, appropriate measurement stations must be available in sufficient capacity. If external installations are used for this purpose, is to be ensured that all data relevant for the clearance measurement will be forwarded and documented.

Removal of material

For non-radioactive material that originate from activities subject to licensing and from areas where contamination or activation is not to be postulated due to the operating history, it is to be demonstrated by control measurements for preservation of evidence that the material to be removed do not fall under the provisions of § 29 StrlSchV.

The non-existence of contamination and activation of material intended for removal is to be demonstrated via plausibility considerations, taking into account the history of the facility, as well as by random evidence preservation measurements. Here, the detection limits of the evidence preservation measurements should be oriented to 10 % of the values referred to for unrestricted clearance, taking into account the technical feasibility of measuring.

The experience gained from previous dismantling projects shows that also in the supervised areas on the facility site that are free from contamination according to the provisions, local contamination may be detected at locations for which there is no contamination suspected from operating history and therefore could remain undetected in random checks. It is therefore to be demonstrated by the operator in a verifiable manner that also unexpected contamination will reliably be detected with the scope of measurements provided.

From the point of view of safety, findings from measurements above the detection limit but below 10 % of the clearance levels do not require the performance of a clearance procedure. However, it is to be examined in case of such findings whether the previous scope of measurements, based on the assumption of freedom from contamination and activation, is adequate and whether the classification of the material/site area as "contamination or activation free" might have to be corrected retrospectively, taking into account further measurement results where appropriate.

7.4 Safe enclosure

Although the aspects related to safety and waste management generally support a prioritisation of immediate dismantling, the intermediate stage of safe enclosure may also be appropriate for a facility. In this case, implementation and duration of safe enclosure have to be justified, especially with regard to radiation protection and waste management, and the safety advantages for the option chosen have to be demonstrated. This also applies to any longer-term safekeeping of buildings provided, as well as to facility parts and components that are intended for decay storage.

As part of the decommissioning planning, any measures for the preparation and transfer of the facility into safe enclosure and the measures during this state are to be described. Within the overall view of the decommissioning it is also to be demonstrated that the dismantling of the facility can be carried out safely after the end of safe enclosure. Here, the aspects having an influence on the later dismantling are to be identified and the planned duration of safe enclosure to be described. The measures during safe enclosure must not impede the subsequent dismantling. The safety analyses must take into account the overall decommissioning project (see Chapter 8).

To this end, the following requirements related to safe enclosure are to be considered in particular:

- The radiological characterisation must be completed with sufficient detail so that the overall decommissioning planning (including waste management) can be carried out and assessed. This also applies to the decay storage of facility parts and components. Here, relevant data are to be determined and documented for later decommissioning and waste management. Furthermore, the waste management objective intended by the deferred decommissioning is to be defined.
  For safekeeping of buildings in the longer term, sampling has to be carried out analogously to that for clearance so that nuclide composition, the level of contamination and the nuclide distribution including the activity penetrated are sufficiently well known. At the time of radiological characterisation, the cut-off criterion cannot be considered for the clearance according to § 29 StrlSchV (10 % criterion) since over the period of safekeeping, there will be substantial changes in the nuclide composition.

- When planning the safe enclosure, the change in the composition of the facility contamination towards radionuclides which cannot be readily measured is to be considered with the aim of being able to detect any contamination of personnel and material after safe enclosure with sufficient reliability.

- The implementation of a safe enclosure requires the performance of technical/structural measures which safely enclose the radioactive inventory of the facility for the intended period of enclosure also with reduced monitoring effort (especially passive installations, e.g. sealing of systems, provision of additional material barriers).

- For buildings and safety-relevant installations as well as for installations and systems that are required for later dismantling, an ageing management is to be implemented in accordance with the requirements of nuclear safety standard 1403 [7] of the Nuclear Safety Standards Commission (KTA), a conservation, monitoring and maintenance programme is to be defined, and the necessary personnel is to be qualified.

- A periodic safety review of the facility is to be carried out every ten years.

- The information relevant for the later dismantling of the facility from operation and safe enclosure must be documented. Here, the physical and technical condition of the facility and the operating experience during safe enclosure are particularly to be taken into account. Knowledge transfer to the future dismantling personnel is to be ensured.

8 Safety

8.1 Main safety functions

During the decommissioning of a facility, precautions against damage are to be taken as necessary according to the state of the art in science and technology. To this end, the fulfilment of the main safety functions

- confinement of radioactive material, and
- avoidance of unnecessary radiation exposure, limit and control of radiation exposure of personnel and the general public

is to be ensured.

As long as the facility is not yet free from nuclear fuel, compliance with the following safety functions is to be ensured additionally:

- maintenance of subcriticality, and
- residual heat removal.

As far as required from a safety point of view, the relevant requirements of the "Safety Requirements for Nuclear Power Plants" [8] are also to be observed.

The installations required to fulfil the safety functions must be available with the necessary effectiveness and reliability. To what extent installations are required in detail results from the safety analyses which must include considerations for the decommissioning operation as well as for abnormal occurrences and accidents.

The measures for dismantling of the installation are to be designed such that there will be no impermissible retroactive effects on the respective installations still necessary for maintaining decommissioning operation.

8.2 Requirements for safety analyses

The safety analyses are to be based on a range of events for the processes during decommissioning that covers all potentially occurring events. For each decommissioning phase, the impacts on systems, safety-relevant installations, buildings, etc., as well as the source term for radiologically relevant events are to be examined for all events listed in Chapter 8.3, unless it can be demonstrated that the respective event type is excluded. Furthermore, it is to be examined whether there are other potential events that are not covered by the events listed in Chapter 8.3. If this is the case, such events identified must also be considered.

In the safety analyses, the specific technical conditions and processes of the facility are to be analysed systematically and account is to be taken of experience from comparable facilities and projects. When analysing potential causes of abnormal occurrences and accidents, human error is to be taken into account. For the analyses, it is to be postulated that in addition, there is an independent single failure. This single failure can also occur in energy supply or monitoring systems.

As far as credit is taken from protective measures, i.e. the function of safety-relevant installations or administrative measures, it is to be ensured that the functions assumed will be available with the postulated effectiveness and reliability. Furthermore, the safety analyses have to take into account and evaluate interdependencies and interactions between different partial steps of the processes under consideration during dismantling.

If administrative measures or temporary installations should be required for the control of events, it is to be examined whether their effectiveness may be impaired by the event. As far as administrative measures or temporary installations play a role in controlling the event, it is to be analysed how their failure affects the control of the abnormal occurrence or accident.

As long as there are still fuel assemblies and defective rods in the facility, these are to be considered in the safety analyses.

If a particular event is to be classified as design basis accident, compliance with the planning values of §§ 50 StrlSchV in conjunction with § 117, para. 16 StrlSchV is to be demonstrated as part of a radiological accident analysis.

Safety analyses are also to be performed with regard to the effects on the personnel by the operation of the facility, the implementation of the decommissioning, as well as in case of abnormal occurrences and accidents.

Furthermore, the effects of decommissioning operation on the environment by direct radiation and by discharges with exhaust air and waste water during normal operation are to be examined.

During the transition from power operation or production to decommissioning and as dismantling progresses, it is to be examined whether any of the existing safety demonstrations will have to be adapted to the changed conditions. In this respect, it is to be considered whether there are specific conditions, operating modes or potential hazards for which particular events are to be postulated or whether events occur under changed boundary conditions that may affect the effectiveness and reliability of installations provided for their control or whether these installations change in their effectiveness.

Any deviations from the overall view of the decommissioning. e.g. extended interruptions of dismantling activities, are to be considered in an updated safety analysis and to be assessed both with a view to safety and to the achievement of the decommissioning objective.

8.3 Events to be analysed

Internal hazards

The following internal hazards are to be analysed with regard to their impacts, also considering the damage prevention measures provided by the design of the facility:

- Internal fire: Possible fires in the facility (including filter fires) with potential activity releases are to be analysed. Considerations include stationary and temporary maximum fire loads in the facility. Separate analyses are required at the latest as part of the work permit procedure for all work involving additional ignition sources (e.g. hot work).

- Leakages from containers with activity-containing media are to be analysed, identifying the container with the greatest radiological hazard potential.

- Furthermore, all cases of leakages and breaks of media-carrying systems are to be analysed that may lead to internal flooding.

- Component failure (e.g. failure of containers with high energy content)

- Drop of loads

  - dropping of containers with releasable radioactive inventory in the stress situation, resulting from the unfavourable combination of drop height, impact position and ground properties,

  - dropping of loads onto containers or systems with releasable radioactive inventory, taking into account the most unfavourable combination of mass and impact characteristics of the loads.

- Events during transport processes (e.g. collision)

- Mutual interference of multi-unit plants and neighbouring facilities at the site

  - collapse of structural parts,
  - failure of containers and parts of the facility with high energy content,
  - failure and malfunctions of shared installations, and
  - retroactive effects from temporarily existing installations (such as overturning of slewing and construction cranes).

- Internal explosions
  It is to be analysed whether formation of an explosive atmosphere in the facility is possible. With regard to the analysis of the effects of a postulated internal explosion, existing precautionary measures are to be considered.

- Chemical impacts
  As far as such impacts, e.g. due to the decontamination techniques or other techniques used, are possible, the impacts on safety-relevant installations are to be examined.

- Failures and malfunctions of safety-relevant installations

  - failures and malfunctions of supply systems (e.g. the electrical energy supply),
  - failures and malfunctions of systems for instrumentation and control and for monitoring (e.g. radiation monitoring),
  - failures and malfunctions of fire protection systems,
  - failures and malfunctions of ventilation systems and installations for the retention of radioactive substances.

External hazards

The following external hazards are to be analysed with regard to their impacts, also considering the damage prevention measures provided by the design of the facility:

- For natural hazards, the load assumptions are to be defined such as to provide coverage or at least such as to correspond to the site-specific conditions. It is to be analysed for the site which natural hazards may be relevant; at least impacts by storm, rain (including heavy rain events), snowfall, snow loads, frost, lightning, flood, exceptional heat waves, biological hazards, forest fires and earthquakes are to be considered.

- For man-made hazards, such as aircraft crash, external explosion, intrusion of hazardous substances and external fire, the load assumptions are also based on the site-specific conditions. Insofar as these events are to be assigned to the beyond-design-basis events, damage extent reduction has been adequately taken into account if the radiological consequences determined under realistic boundary conditions and considering the residue logistics do not necessitate major disaster control measures.

If necessary, appropriate amendments to the decommissioning planning are to be made in order to reduce the potential impacts.

8.4 Safety classification of installations

All installations required to comply with the main safety functions during decommissioning are to be assigned to the safety-relevant installations and must be available with the necessary effectiveness and reliability. If there is still nuclear fuel in the facility, the installations for cooling of the fuel assemblies and their criticality-safe storage have safety significance. For these installations, the requirements from power operation or production mainly continue to apply.

With regard to the confinement of radioactive material and the avoidance of unnecessary radiation exposure, installations with activity-containing media, facilities for the conditioning of radioactive material and installations to protect operating personnel, to protect against inadvertent releases and to reduce direct radiation in the environment of the facility have safety significance. These also include fire protection systems as well as necessary systems for energy supply and instrumentation and control.

When classifying safety-relevant equipment, a distinction may be drawn according to the different dismantling phases. For the decommissioning phase, requirements are to be defined regarding the availability of safety-relevant installations. Here, the authorised discharge levels for radioactive materials and the operationally permissible dose levels for the personnel also have to be taken into account. To comply with the requirements during individual dismantling steps, alternative measures may be necessary in addition, such as ventilation housings.

Classification, reclassification and adaptations of safety-relevant installations to the changed conditions of dismantling require the performance of safety assessments and approvals by the supervisory authority. Here, potential releases of existing radioactive material during disassembly of individual facility components or systems and the potential concentration of radioactive material in containers or in the form of packages in individual room areas are to be considered with a view to the confinement of radioactive material and the avoidance of unnecessary radiation exposure.

The classification of equipment and systems for lifting and handling is based on the potential consequences of their failure for operating personnel and the environment. Here, the impairment of the function of safety-relevant installations or of buildings due to load crashes is also to be considered.

For rebuilt or newly built safety-relevant installations, quality assurance measures are to be defined in specifications, depending on their safety classification.

For safety-relevant installations, the following requirements are to be met:

- The installations must be suitable to detect malfunctions, abnormal occurrences and failures in the facility and to control them with the required reliability and effectiveness.

- Prior to their use, rebuilt or newly built installations with safety relevance are to be subjected to a commissioning test.

- Before shutdown of installations for criticality-safe handling and wet storage as well as for cooling of the fuel it is to be demonstrated that the requirements of the storage licence according to § 6 AtG can also be met without the use of installations of the respective nuclear power plant.

- In order to ensure the operability of the safety-relevant installations, repair and maintenance measures, including functional tests, are to be carried out regularly. Objectives and scope of testing and intervals of in-service inspections are to be defined and laid down in the testing manual.

- Shutdown and dismantling of installations shared with neighbouring nuclear facilities at the site (e.g. dual-unit plant, fuel storage facilities, waste storage facilities, conditioning facilities) need to be reviewed with regard to potential retroactive effects on the neighbouring facilities.

9 Operating procedures

9.1 Operating rules

For the decommissioning of a nuclear facility, the operating procedures are to be included in a decommissioning manual. Structure and contents of the decommissioning manual should be based on nuclear safety standard KTA 1201 [9] and are derived from the operating manual for power operation or production, which is to be adapted to the changed requirements. In particular, regulations relating to personnel and organisation are to be laid down that determine the powers and responsibilities and reflect the transition from power operation or production to decommissioning operation. Furthermore, regulations are to be specified for the decommissioning operation, for the elimination of malfunctions as well as for the control of accidents and, if required, beyond design basis events. Requirements for the collection, sorting, storage and conditioning of wastes and residues as well as for the clearance or removal of the materials produced are to be laid down in a residue and waste regulatory regime.

Throughout the entire duration of decommissioning, the operating procedures, including operating and personnel organisation, are to be reviewed event-specifically and at regular intervals with a view to changing requirements and adapted to the respective requirements and the respective current state of the facility. To this end, an appropriate amendment procedure is to be defined.

For the planning, approval, performance, monitoring and documentation of the activities related to decommissioning, an appropriate work permit procedure (e.g. step-by-step dismantling procedure) is to be defined. The work permit procedure must ensure for all decommissioning activities that

- the safety and availability requirements for all installations necessary during the work will be reviewed and adapted where necessary,

- the safety requirements from radiation protection, occupational health and safety and fire protection as well as physical protection where necessary – including administrative measures – are taken into account and that for subprojects with special importance, the sequence of work steps will be specified in detail,

- the requirements relating to the safe handling and recording of the residues from dismantling are taken into account, and

- all measures relevant for safety and dismantling are described.

The decommissioning manual also has to include the inspection list of the in-service inspections; the contents should be based on nuclear safety standard KTA 1202 [10].

9.2 Safety management

For decommissioning of a facility, an integrated management system is required that is based on the contents of nuclear safety standard KTA 1402 [11]. This management system has to cover all processes, specifications, regulations and organisational aids that are necessary for the planning, performance, review and documentation of safety-relevant tasks. The establishment of an explicit ageing management based on the requirements of nuclear safety standard KTA 1403 [7] may generally be dispensed with in the case of immediate dismantling of the facility if decommissioning is carried out as scheduled.

The planning of dismantling activities must be done in such a way that these can be carried out safely. The implementation must be reviewed accordingly. Improvement opportunities need to be identified particularly for such measures of decommissioning operation that are to be carried out repeatedly in the course of dismantling. Measures that are only carried out once in the course of dismantling must also be analysed in terms of internal and external experience feedback, and lessons learned and opportunities for improvement are to be documented

The management system already established from the operational phase is to be checked with regard to the requirements relating to the decommissioning of a facility and adapted where necessary. As regards the dismantling activities to be carried out, extensive adjustments are required in the processes, among other things regarding dismantling planning and implementation, planning of resources, maintenance and development of competence. The significantly increased amount of radioactive residues produced in the phase of decommissioning and the related requirements regarding residue treatment and logistics also require adjustments to the management system. This is to ensure, among other things, that the residue streams are planned to the extent that the further progress of dismantling, including the provision of adequate

buffer/intermediate storage capacity and involvement of external service providers for the treatment and storage of the radioactive waste, will not be affected.

9.3 Decommissioning documentation

Within the frame of the operating responsibilities towards the supervisory authority, the respective progress of the decommissioning regarding the radioactive inventory and its distribution as well as the state and condition of still existing buildings and installations are to be documented. Together with information on the current status of decommissioning, the related documents are to be submitted to the supervisory authority at regular intervals, but at least once a year.

9.4 Skills and competencies

Skills and competencies needed for the decommissioning of a facility are to be developed. In preparation for the decommissioning operation, the qualification of personnel for decommissioning is to be ensured. Any external personnel involved must also be qualified for activities related to the decommissioning of a nuclear facility. In addition, it must be taken into account that the necessary high level of motivation of the personnel remains ensured until having reached the objective of decommissioning.

10 Documents considered in preparing the guidelines

[1] IAEA Safety Standards
Decommissioning of Facilities
General Safety Requirements Part 6
No. GSR Part 6, 2014

[2] IAEA Safety Standards
Predisposal Management of Radioactive Waste
General Safety Requirements Part 5
No. GSR Part 5, 2009

[3] WENRA Working group on waste and Decommissioning (WGWD)
Decommissioning Safety Reference Levels Report, Version 2.0
November 2011

[4] Leitfaden zur Stilllegung, zum sicheren Einschluss und zum Abbau von Anlagen oder Anlagenteilen nach § 7 des Atomgesetzes vom 26. Juni 2009
Bekanntmachung vom 12.08.2009, BAnz 2009, Nr. 162a

[5] Empfehlung der Entsorgungskommission
ESK-Leitlinien für die Zwischenlagerung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung
Revidierte Fassung vom 10.06.2013

[6] P. Brennecke (Hrsg.), Anforderungen an endzulagernde radioaktive Abfälle (Endlagerungsbedingungen, Stand: Oktober 2010) - Endlager Konrad –
Bundesamt für Strahlenschutz, interner Bericht SE-IB-29/08-REV-1, Salzgitter, Januar 2011

[7] Regel KTA 1403 „Alterungsmanagement in Kernkraftwerken“
(Fassung 11/2010); BAnz Nr. 199a vom 20.12.2010

[8] Sicherheitsanforderungen an Kernkraftwerke vom 22. November 2012
BAnz AT 24.01.2013 B3

[9] Regel KTA 1201: Anforderungen an das Betriebshandbuch (BHB),
(Fassung 11/2009); BAnz. Nr. 3a vom 07.01.2010

[10] Regel KTA 1202: Anforderungen an das Prüfhandbuch (PHB),
(Fassung 11/2009); BAnz. Nr. 3a vom 07.01.2010

[11] KTA
KTA-Regel 1402 „Integriertes Managementsystem zum sicheren Betrieb von Kernkraftwerken“
(Fassung 11/2012); BAnz vom 23.01.2013

Annex: Graph to Chapter 2