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

E S K

Guidelines for the decommissioning of nuclear installations

RECOMMENDATION of the Nuclear Waste Management Commission

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1 Scope of application

These guidelines present the safety requirements to be met during the decommissioning of facilities and parts thereof licensed under § 7 of the Atomic Energy Act (AtG).

They are also applicable to facilities for the storage or 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 §§ 10 and 12 of the Radiation Protection Act (StrlSchG), insofar 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 5] and complement the requirements and specifications of the Decommissioning Guide [6] from a technical point of view.

The specifications made here are based on the premise that the facility to be decommissioned fulfils the requirements of the applicable nuclear rules and regulations, including (where applicable) the Safety Requirements for Nuclear Power Plants (Sicherheitsanforderungen an Kernkraftwerke – SiAnf), within the scope of its operating licence existing prior to decommissioning.

Additional requirements not dealt with here exist with regard to liability for damage, protection against disruptive action or other interference by third parties and, in individual cases, the control of fissile material under the terms of international agreements.

2 Definition of terms

For a better understanding of some of the following definitions, reference is made to the diagram in the appendix *[in the order of the German original text]*.

- **Dismantling concept**
  Description of the main technical and organisational measures for the dismantling of a facility, including their interdependencies, and the anticipated time schedule for implementation of the measures. 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 take place.

- **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 designed and specified use.

- **Installations**
  For the purposes of these guidelines, the term installations refers to all structures, systems and components of a facility.

- **Waste management concept**
  For the purposes of these guidelines, waste management concept is defined as the presentation of the material flows to be expected during the dismantling of a facility, including their quantities, the main processing steps and the 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**
  Waste management planning provides details on the measures described in the waste management concept.

- **Absence of nuclear fuel**
  For the purposes of these guidelines, the absence of nuclear fuel in a facility or a part thereof is defined as the condition in which the fuel assemblies and fuel rods are removed and nuclear fuel is only present in such small quantities that criticality can be excluded and residual heat removal is no longer required. This condition is reached after removal of the fuel assemblies and defective fuel rods from a nuclear power plant.

- **Buffer storage**
  Temporary storage of installations and radioactive material in suitable areas or in suitable rooms for processing (e.g. decontamination, disassembly) or treatment (e.g. conditioning) or keeping them ready for transport.

- **Radioactive residues**
  Radioactive residues are radioactive substances for which the waste management route 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 installations, rubble and removed soil as well as movable objects that are contaminated or activated.

- **Residual operation concept**
  The residual operation concept describes the operation of facilities in particular for compliance with the protection goals, the dismantling of the facility and the associated waste management measures, as well as the handling of incidents.

- **Radiological characterisation**
  Radiological characterisation is understood to mean the determination of the state of a facility as a whole or of parts thereof with regard to 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 is safely enclosed even with reduced monitoring effort.

- **Decommissioning**
  The term “decommissioning” is used as a generic term for all decommissioning-related activities including dismantling.

- **Decommissioning manual**
  The decommissioning manual contains regulations on the decommissioning of a nuclear installation as well as the safety-related and operational facilities required for residual operation and dismantling. The decommissioning manual is also referred to, for example, as the residual operation manual or, furthermore, the operating manual.

- **Decommissioning concept**
  The decommissioning concept is the presentation of the main measures for the decommissioning of a facility as well as for the management of the radioactive residues/waste 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 assessment of the decommissioning (see Chapter 6).

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

- **Disconnection**
  Physical separation of a system, subsystem or component from the residual operation systems after permanent shutdown as a prerequisite for dismantling. Disconnection and permanent shutdown can be implemented in one step.

3 Decommissioning concept

Decommissioning includes all decommissioning-related activities to achieve the decommissioning objective, including dismantling. This objective can be

- the removal of the facility (demolition of the building structures and release of soil areas from supervision under nuclear and radiation protection law),
- the conventional use of the facility after release from supervision under nuclear and radiation protection law, or
- the further use as a facility or installation within the scope of supervision under nuclear and radiation protection law.

When removing the facility, it is possible for building structures (e.g. pile foundations, foundations, parts of basements, possibly backfilled with demolition waste) to remain at the site. From a safety point of view, this is permissible if with the structures remaining at the site compliance with the de minimis concept of clearance (see Chapter 7.3) is demonstrated for all conceivable subsequent uses.

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 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 in terms of decommissioning –updated where required. This concerns

- relevant facility data,
- waste management routes provided, and
- the basic procedure for decommissioning, taking into account the feedback of experience from ongoing and completed decommissioning projects and taking into account the further development of the state of the art as well as changes in 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 in terms of 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 parts; 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 as are necessary in the light of the state of the art in science and technology are to be maintained also after termination of power operation or production. To this end, the installations required have to ensure compliance with the protection goals without any restrictions also after termination of power operation or production.

In preparation for the dismantling of the facility, among other things, the following should be performed as early as possible:

- drawing up plans for complete removal of nuclear fuel and reduction of the radioactive inventory in the systems and components, e.g. by full system decontamination and removal of operational waste as well as of operating media (e.g. boric acid),

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

- planning for the organisation, taking into account the required human resources as well as technical qualification and competences, including planning of the accompanying measures for change management,

- determination of the systems and components required in terms of safety and operation including compliance with the necessary boundary conditions, e.g. inspection concept, maintenance concept, ageing management,

- planning for the adaptation of the operating rules,

- inventory 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:

- complete removal of nuclear fuel,
- reduction of the radioactive inventory in the systems and components, e.g. by full system decontamination and removal of operational waste as well as of operating media (e.g. boric acid),
- adaptation of the operating rules, depending on the facility state such as changes to the organisational structure, relevant processes and responsibilities, the minimum availability of installations, the operating modes of systems, the frequency of in-service inspections, the provisions in the emergency manual,
- taking installations out of operation that are no longer needed for the current facility state as well as for decommissioning, also including installations that had safety significance during power operation or production,
- establishment of areas for logistics (e.g. areas for buffer storage, transport routes),

Before carrying out such measures it is to be demonstrated that they are unobjectionable from the point of view of safety.

5 Radiological characterisation

The required level of detail and accuracy of the radiological characterisation depends on its objective in the course of decommissioning. The first step of the radiological characterisation serves to establish the basis for decommissioning planning. For this purpose, the activity inventory of the facility is to be recorded in sufficient detail to be able to make well-founded statements on accidents, dismantling strategy, quantities of the various waste management routes and possible clearance of buildings and the site, etc. A full system decontamination should be carried out before the start of dismantling to achieve maximum benefit from a radiological point of view and to enable radiological characterisation also of these systems at the earliest possible stage. In addition, it is to be examined – as far as necessary for the dismantling concept and possible under radiation and occupational safety aspects in the first step – whether and how far contamination has penetrated into building structures. Here, it would be appropriate to examine as far as possible at an early stage whether deeply penetrated contamination or activation could lead to deviating approaches regarding the dismantling the facility (statically relevant concrete structures in the area of the containment, floor and bearing wall surfaces in very highly contaminated rooms). Further investigations of the penetration behaviour that will have no influence on the implementation of the overall project or would have to take place under unfavourable radiological conditions can be carried out at a later stage (after dismantling of the main radioactive sources in these room areas).

Later steps of radiological characterisation during dismantling serve to plan concrete measures, e.g. for the protection against external and internal exposure, the selection of optimised techniques for dismantling,

disassembly and decontamination, the validation of calculated activities of radioactive waste, and the determination of nuclide vectors and measurement parameters for decision measurements within the framework of clearance.

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

Just like radiological characterisation, the inventory of hazardous substances is part of the basis for decommissioning planning. For practical reasons, it has proven useful not to plan and carry out these two tasks independently of each other, so that the inventory of flammable, toxic or water-endangering substances can be regarded as a supplement to the radiological characterisation and accordingly should be carried out at the earliest possible stage.

6 Decommissioning planning

Decommissioning planning within the framework of the licensing procedure (see figure in the appendix) must, in particular, contain

- the dismantling concept,
- the waste management concept,
- the residual operation concept,
- the safety analyses,
- the description of the operating rules and the documentation provided for, and
- the description of all necessary measures others than dismantling measures.

If documents already available from power operation are used, this is briefly to be specified.

The **dismantling concept** must include, in particular, the following:

- dismantling steps and dismantling measures for installations including their interdependencies and the anticipated time schedule while avoiding impermissible retroactive effects on safety-related installations,

- dismantling, disassembly and decontamination techniques and the auxiliary equipment needed, and

- description of the procedural regulations for the dismantling of facility parts and components.

The **waste management concept** must include, in particular, the following:

- description and classification of radioactive residues produced,

- waste management for radioactive waste,

- concept for clearance/removal (also considering soil 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 **residual operation concept** must include, in particular, the following items and objectives:

- structures, systems and components required for the residual operation of the facility, their requirements and their classification into safety-relevant installations and required operating systems,
- presentation of the organisational structure at the time when making use of the decommissioning licence,
- description of procedures for shutdown and disconnection of components,
- description of procedures for modifying the facility as well as the mode of operation of systems, and
- fire protection and escape route concept including fire protection measures and technical documentation.

The **safety analyses** serve to demonstrate that precautions have been taken as are necessary in the light of the state of the art in science and technology. Detailed specifications on this can be found in Chapter 8. They cover, among others,

- analysis of the operating processes and the impact on staff and the environment by direct radiation and discharges with exhaust air and waste water,
- protective measures and operational specifications for the protection of staff and the environment from ionising radiation in the event of incidents,
- safety concept for preventing and mitigating the consequences of accidents inside and outside the facility,
- classification of the safety-relevant installations and required operating systems as well as associated requirements, and
- systematic hazard and accident analysis (adjusted to the potential risk during dismantling taking into account the techniques used during dismantling and hazardous materials).

The **description of the operating rules and the documentation provided for** must contain the main documents and specifications of the operating rules and the documentation relevant for decommissioning. Detailed specifications can be found in Chapter 9.

The operating rules contain the regulations on the structural and procedural organisation required for the decommissioning of the facility. These include, for example,

- the decommissioning and residual operation manual,
- the testing manual,
- the documentation of the management system, and
- further supplementary instructions and provisions.

The necessary **measures others than dismantling measures** include, for example, the construction of handling and storage facilities, the construction of new components, the provision of (mobile) equipment for the treatment or conditioning of waste, and changes in the use of rooms.

As part of the decommissioning planning, all measures provided for 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 assessment for the first decommissioning phase. The overall assessment 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 in which the dismantling measures will be implemented is provided for. The overall assessment thus corresponds to the specifications required according to § 19b(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 facility components to be dismantled and space for their handling and the tools used for this purpose (e.g. remote handling equipment) can be provided by removal of components no longer required on a step-by-step basis. Where necessary, the operational transport routes are to be extended or new transport routes created (e.g. installation of new doors and locks).

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

For these measures, too, the retroactive effects on the facility (e.g. on the fire protection concept, radiation protection and physical protection) are to be assessed for their permissibility in each case. Where necessary, adjustments are to be made.

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 components and conditioning of the waste produced, the necessary installations

are to be provided.

For the treatment of the radioactive residues produced, appropriate installations are to be provided with sufficient capacity. As far as possible, sorting should take place as soon as radioactive residues are produced. Alternatively, sorting and treatment of the radioactive residues (disassembly, decontamination, radiological measurements, conditioning) may 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 the choice of external installations adjusted where necessary.

For buffer storage and decay storage of the radioactive residues and storage of the conditioned radioactive waste, sufficient capacity is to be provided on site or in external installations. Depending on the operating time of these areas for buffer and decay storage as well as the nature and the storage duration of the radioactive material in these areas, specifications on the operation of the storage areas including documentation, packaging and inspection of the stored material are to be laid down in the operating rules and procedures (see [7]).

For storage, the requirements according to [8] are to be considered.

Infrastructure and logistics are to be aligned with regard to dose reduction in accordance with § 8(2) StrlSchG.

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 optimisation of exposure of staff and the environment to a level reasonably achievable. 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. Dismantling is to be planned and performed such that the installations necessary for compliance with the protection goals will not be affected in their function and availability.

As a matter of principle, proven dismantling, disassembly and decontamination techniques are to be used for dismantling that are optimised, among other things, with a view to minimising secondary waste and the exposure of staff. New techniques are to be tested and qualified before use (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 occupational exposure by direct radiation.

7.3 Treatment of residues and waste

Dismantling planning has to include the determination of the masses for all materials produced during decommissioning, quantitative allocations of materials to waste management routes and a description of the waste management routes, all based on the operating history, system analyses and specific measurements. Here, decay storage 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 record systems, so that their conditioning state and their whereabouts up to and including the final transfer to third parties can be determined at any time (§ 2 of the Nuclear Waste Management Ordinance (AtEV), §§ 85, 86 and 94 of the Radiation Protection Ordinance (StrlSchV). In addition to the radiological characterisation, the material composition of the radioactive waste is to be documented in detail [9].

For decay storage of facility parts and components, the implementation and duration of decay storage is to be justified, in particular with regard to radiation protection and waste management, and the safety-related advantages of the option selected is to be demonstrated. Furthermore, the waste management objective intended by the deferred decommissioning is to be defined. The data relevant for later decommissioning are to be determined and documented. The change in the composition of the contamination towards radionuclides that are difficult to measure is also to be taken into account.

Clearance of radioactive material

Radioactive substances from practices subject to licensing with negligible activity as well as objects that are or may be activated or contaminated from practices subject to licensing can be cleared within the framework of a clearance procedure if the clearance levels (Appendix 4, Table 1 StrlSchV [10]) are not exceeded and if clearance-specific boundary conditions (Appendix 8 StrlSchV) are met. This includes, for example, any material from controlled areas of nuclear power plants. Material from outside controlled areas is also subject to a clearance procedure if contamination or activation resulting from the handling of radioactive material there is to be suspected due to the operating history or from evidence preservation measurements. The clearance procedures are to be defined according to the type of material and the waste management route provided (see §§ 31 to 42 StrlSchV). The Ordinance distinguishes between unrestricted release, various types of specific clearance and clearance in individual cases. In determining the clearance levels for specific clearance, credit was taken from residue type-specific boundary conditions of further recovery, disposal or reuse (example: clearance for landfill disposal). Since in the current version of the StrlSchV [10] the clearance levels for specific clearances can often be above the exemption levels, an examination of the boundary conditions of

specific clearances is of major importance. The competent authority for a clearance must satisfy itself that compliance with the 10 µSv concept is ensured in the case of specific clearance, taking into account the boundary conditions (e.g. landfill disposal and incineration plants). Similarly, in the case of specific clearance for recycling, it is to be prevented that products enter the economic cycle with a specific activity above the exemption levels. If a specific clearance cannot be completed in accordance with the conditions of the clearance decision (e.g. because a recycler does not accept the material), it is to be ensured by specifications within the clearance procedure that the competent nuclear authority is informed about this circumstance. The material then remain subject to nuclear regulatory supervision.

Due to the transitional provisions of § 187 StrlSchV, the amended levels for unrestricted clearance will only apply from 01.01.2021. All other clearance-specific provisions of the current StrlSchV are not affected by this transitional period.

The clearance procedure usually comprises the procedural steps of radiological characterisation / preliminary examination, dismantling of parts of the facility, decontamination, performance of decision measurements, followed by clearance and conventional waste management. Here, the review of basic data (nuclide vector or measurement parameters derived from the respective nuclide composition, suitability and calibration of the measuring devices, origin of the material and, where appropriate, activity distribution) as well as the performance of control measurements on a random basis is to be provided for. If it is intended to use reference areas that are above the averaging areas of Appendix 8 StrlSchV for the decision measurement, homogeneity of the remaining residual contamination is to be demonstrated within the framework of orientation measurements. All essential procedural steps are to be laid down in a binding manner in the operating rules and procedures, e.g. in the form of clearance schedules and/or work instructions. In a clearance measurement, only the contamination caused by the on-site facilities or installations is to be taken into account. This means that naturally occurring radioactivity or anthropogenic contamination from other sources (nuclear weapons or Chernobyl fallout) can be disregarded in the clearance.

The entire clearance process takes place out under the control of the competent authority or, if applicable, the independent expert consulted by it. The procedures, including all procedural steps, are to be laid down in operating documents that are subject to review and approval by the authorities.

Meanwhile, extensive experience has been gained from various decommissioning procedures regarding clearance. Some issues that have led to discussions in the past are listed below:

- The radiological characterisation and 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 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 rubble, within the framework of a preliminary examination 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 rubble.

- If proof of compliance with the 10 µSv concept is provided (e.g. based on a case-by-case demonstration), foundations or basements backfilled with rubble may remain on the facility site from a radiological point of view. Experience has shown that other provisions (e.g. water law) are affected here, and compliance with these is to be verified additionally. In the case-by-case demonstration for the clearance of soil areas with structures remaining in the soil, the temporal change of the nuclide composition, the technical and natural site characteristics as well as the possible later handling of the remaining structures are to be taken as a basis. Administrative restrictions on use after the end of nuclear regulatory supervision must not be affected.

- Soil areas and excavated soil can be cleared without further boundary conditions if they comply with the clearance levels for the clearance of soil areas (Appendix 4, Table 1, Column 7 StrlSchV). From a radiological point of view, application of the clearance levels for unrestricted clearance (exemption levels) (Appendix 4, Table 1, Column 3 StrlSchV) is only permissible in cases where large-scale reuse of the excavated soil as topsoil/surface soil can be excluded. Low contents of excavated soil in the rubble or clearance of small masses do not necessarily lead to an application of the levels of Appendix 4, Table 1, Column 7. In these cases, the clearance levels for rubble or, in the case of small masses, the levels for unrestricted clearance can be applied.

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

Removal of material from regulatory control

For non-radioactive material (including buildings and soil areas) originating from practices subject to licensing and from areas where contamination or activation can be excluded due to the operating history, it is to be confirmed by control measurements for preservation of evidence that the material to be removed does not fall under the provisions of §§ 31 to 42 StrlSchV. In agreement with the competent nuclear supervisory authority and taking into account the facility-specific conditions, it can be determined which material (such as kitchen waste from the staff canteen, office equipment, etc.) can be removed from the facility site even if no evidence preservation measurements are carried out (e.g. within the framework of a so-called “positive list”).

The absence 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. For the key nuclide, the detection limits of the evidence preservation measurements should be oriented to 10% of the clearance levels to be applied for the respective material (with

the exception of clearance for incineration and landfill disposal and clearance of metal scrap for recycling or buildings for demolition), taking into account the measuring feasibility.

When selecting locations for the evidence preservation measurements, so-called accumulation points are to be determined where any activity present would most likely be found, such as sediment in gullies for drainage from asphalt surfaces. These are to be supplemented by additional random samples from other areas intended for removal.

From the point of view of safety, findings from measurements above the detection limit but below 10% of the clearance levels do not necessarily require 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 absence of 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. As a rule, this leads to the materials originating from this area being completely subjected to a clearance procedure.

Measured radioactivity that is not related to the licensed practices at the site of the facility (e.g. nuclear weapons or Chernobyl fallout as well as naturally occurring radioactivity) does not lead to a classification of the examined substances as "radioactive" and thus does not preclude their removal. At least for soil areas, clearance is not possible without facility-specific specifications on the consideration of nuclear weapons or Chernobyl fallout since here, measured Sr-90 and Cs-137 is unavoidable even in the absence of any contamination from operation of the facility. From a point of view of safety, the discharges from a facility with exhaust air during normal operation do not preclude a removal procedure.

The procedure for removal is to be laid down in operating regulations which are subject to official approval.

7.4 Occupational radiation protection

Many elements of occupational radiation protection during decommissioning of nuclear installations are already of importance during the operation of these facilities and are thus already covered in the operating rules of the respective facility. The following section therefore deals with those aspects of occupational radiation protection that only become more important during decommissioning. Previous experience with decommissioning is taken into account.

The concrete performance of work in the controlled area of a nuclear installation – from radiological characterisation through all modification and dismantling measures to the management of the materials produced – is always the result of a weighing process that is also to be optimised with regard to the radiation protection of the staff, taking into account all circumstances of the individual case and the state of the art in science and technology.

Examples of this are:

- timing and scope of a full system decontamination,
- choice of the respective dismantling, disassembly and decontamination techniques,
- determination of the time and sequence of the respective dismantling, disassembly and decontamination measures, including the associated waste management routes,
- procedure for disassembly and decontamination (e.g. directly at the site of dismantling, in a residue processing centre or externally),
- determination of protective measures (e.g. shielding measures, personal protective equipment, etc.) for the respective dismantling, disassembly and decontamination measures, or
- determination of residue treatment and, if necessary, the location of further storage of treated residues.

Particularly for dismantling and waste management activities, the requirements of operational radiation protection are to be brought in line with, among other things, the technical and scheduling requirements for the planning and performance of the activities.

Experience to date shows that only a small percentage of the collective dose during the dismantling of a facility occurs in individual work sections with dose-intensive activities that are handled in accordance with the special radiation protection procedure of the IWRS II guideline [11]. In order to meet the optimisation requirement of radiation protection, the routine radiation protection procedure must therefore already ensure that the specific features of dismantling are adequately taken into account in the radiation protection instructions routinely referred to for all activities in the controlled area.

For the necessary weighing processes, appropriate criteria and procedures are to be anchored in the operating rules to ensure that radiation protection is taken into account as required during the planning, clearance and performance of activities. Since the weighing processes with the underlying criteria and procedures contribute to compliance with the protection goals, they also have a safety-related significance (see Chapter 8.5). The essential criteria and the results of the weighing processes are to be documented in a verifiable manner.

7.5 Safe enclosure

Nuclear power plants whose authorisation for power operation has expired or whose power operation has ceased permanently and whose operators are contributors to the waste management fund according to § 2(1) of the Waste Management Fund Act (Entsorgungsfondsgesetz – EntsorgFondsG) are to be shut down and dismantled immediately. In individual cases, the competent authority may permit temporary exceptions for parts of the facility to the extent and as long as this is necessary for reasons of radiation protection. In the case of safe enclosure, implementation and duration are to be justified, in particular with regard to radiation protection, and the safety advantages of the chosen option are to be demonstrated.

As part of the decommissioning planning, any measures for the preparation and transfer of the facility or parts thereof to safe enclosure and the measures during this state are to be described. Within the overall assessment 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 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 the safe enclosure of facilities or parts thereof 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.

- When planning the safe enclosure, the change in the composition of the facility contamination towards difficult to measure radionuclides is to be considered with the aim of being able to detect any contamination of personnel and material after safe enclosure with sufficient reliability.

- As a preparatory measure for the phase of safe enclosure, the nuclear fuel is to be unloaded and the fire loads reduced in the same way as for immediate dismantling.

- 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, measures are to be specified for in-service inspections, maintenance and repair and the necessary staff qualified. For installations whose use is planned for later dismantling, measures for conservation and returning to service may be specified as an alternative.

- A periodic safety review of a facility in the phase of safe enclosure is to be carried out every ten years.

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

8 Safety
8.1 Protection goals

During the decommissioning of a facility, precautions against damage are to be taken as are necessary in the light of the state of the art in science and technology. To this end, compliance with the protection goals

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

is to be ensured.

The protection goal “confinement of radioactive material” is understood to mean the control and monitoring of the flow of activity beyond the facility boundaries into the environment. The radioactive material to be confined in this sense includes, in addition to any nuclear fuel still present in fuel assemblies or defective rods, contamination in media, operational waste or parts of the facility as well as radioactivity in activated structures. Compliance with this protection goal is ensured during decommissioning for the residual operating systems, analogously to the operating or production stage, by means of the technical barriers already in place (e.g. defined system limits, pressure differentials) together with measuring devices already in place (e.g. leakage monitoring, emission monitoring). As the dismantling of the facility progresses, it is logical that originally existing barriers and measuring devices are no longer needed and replaced by new installations (e.g. substitute ventilation system), depending on the remaining potential for a violation of the protection goal according to the result of the safety analysis (see Chapter 8.2 et seq.). Compliance with the protection goal is to be ensured during specified normal operation and incidents by technical and administrative measures. In the event of accidents, precautions shall be taken to ensure that the accident planning levels pursuant to § 104 StrlSchV in conjunction with § 194 StrlSchV are complied with for the population.

The protection goal “avoidance of unnecessary exposure, limitation and control of occupational and public exposures” comprises optimising the exposure of the staff and the general public even below the statutory limits during specified normal operation and incidents, taking into account the circumstances of the individual case. These aspects are also addressed in the radiological safety objectives according to Section 2.5 of the Safety Requirements for Nuclear Power Plants [12]. Special precautionary measures for accidents with regard to this protection goal are not required for the population, since the limits for the population can only be exceeded in the event of accidents due to the release of radioactive substances. This is already considered by the precautionary measures in connection with compliance with the protection goal “confinement of radioactive material”.

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

- maintenance of subcriticality, and
- residual heat removal[1].

As far as required from a safety point of view, the relevant requirements of the Safety Requirements for Nuclear Power Plants [12] are also be taken into account in addition to the requirements specified in Chapter 8.2.

The installations and measures required to fulfil the protection goals must be available to the required level of effectiveness and reliability. To what extent installations and measures are required in detail results from the safety analyses defined in Chapter 8.2.

8.2 Requirements for safety analyses

The impacts of residual operation and dismantling on the environment through direct radiation and through discharges with exhaust air and waste water during specified normal operation are to be investigated.

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 and measures, 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 can be 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 incidents and accidents, human error is to be taken into account.

For the analysis, it is to be postulated that in addition there is an independent single failure (e.g. inadvertently open containment isolation, failure of a monitoring device in addition to the initiating event).

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 The classification of installations or measures according to their safety significance is presented in chapters 8.4 and 8.5.

Furthermore, the safety analyses have to take into account and evaluate interdependencies and interactions between different partial steps 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

[1] As long as there is still fuel in the facility, the Safety Requirements for Nuclear Power Plants are to be applied. The corresponding protection goal is “fuel cooling“.

temporary installations are required for the control of the event, it is to be analysed how their failure affects the control of the event.

As long as there are still fuel assemblies or fuel rods in the facility, these are to be considered in the safety analyses (see [13]).

Compliance with the planning levels according to § 104 StrlSchV in conjunction with § 194 StrlSchV is to be demonstrated for all non beyond design basis events.

During the transition from power operation or production to decommissioning and as dismantling progresses, it is to be examined whether any of the safety analyses performed 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 special 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.

In addition, the impacts on the staff due to the operation of the facility, the implementation of decommissioning or in the event of incidents are to be considered on an ongoing basis as well as in relation to modification and dismantling measures within the framework of the work permit procedure and assessed with regard to compliance with the protection goals.

Any deviations from the overall assessment of the decommissioning, e.g. longer interruptions of dismantling activities, are to be considered in an updated safety analysis.

8.3 Events to be analysed

Internal hazards[2]

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 plant (including filter fires) are to be analysed for their impacts on safety (e.g. potential activity releases). The maximum stationary and temporary fire loads in the facility (including open spaces) are to be taken into account. The entirety of all fire protection measures must ensure that even in the event of a random failure of an individual fire protection measure or device, the safety-related functions are not inadmissibly impaired.

[2] In deviation from the Safety Requirements for Nuclear Power Plants (SiAnf), all events occurring / to be handled inside the facility are listed under “internal events” for decommissioning.

- Leakages from containers
  Leakages from containers with activity-containing media are to be analysed with regard to their impacts on safety.

- Internal flooding
  It is to be checked whether flooding can occur in the facility.

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

- Events during the handling of loads
  - dropping of containers with releasable radioactive inventory in the stress situation, resulting from the most unfavourable combination of drop height, impact position and ground properties,
  - collision of loads with 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 operations (e.g. collision of vehicles on the facility site)

- Mutual interference of multi-unit plants and neighbouring facilities at the site
  - collapse of structural parts,
  - failure of containers and components 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

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

- Failures and malfunctions of safety-relevant installations (see Chapter 8.4).

External hazards[3]

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 conservatively for all site-specific conditions. It is to be analysed for the site which natural hazards may be relevant; at least, impacts due to

[3] In contrast to the Safety Requirements for Nuclear Power Plants (SiAnf), no differentiation is made for decommissioning between "external hazards" and "very rare human induced external hazards".

earthquakes, flooding (high water), rain (also heavy rain events), hail, storm (including tornado), snowfall, snow loads, frost, lightning, exceptional heat waves, high or low humidity, biological hazards (e.g. microbiological corrosion) and forest fires are to be considered.

- For man-made hazards such as aircraft crash, external explosion, intrusion of hazardous substances and external fire, the event classifications (design basis accidents or beyond design basis events) and 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, adequate damage extent reduction is given if the radiological consequences determined under realistic boundary conditions as well as under consideration of the residue logistics do not necessitate major disaster control measures [14, 15].

Internal and external hazards must not lead to inadmissible retroactive effects on safety. If necessary, appropriate modifications to the decommissioning planning are to be made to reduce the potential impacts.

8.4 Safety classification of installations

Safety-relevant installations within the meaning of these guidelines are those that are required for compliance with the protection goal “confinement of radioactive material” or that serve to ensure the optimisation of exposure within the framework of the protection goal “avoidance of unnecessary exposure, limitation and control of occupational and public exposures”. In the case of the presence of nuclear fuel, those installations shall be classified as safety-relevant that serve to ensure compliance with the protection goals “maintenance of subcriticality” and “residual heat removal”.

Safety-relevant installations must be available to the required level of 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 optimisation of exposures as well as the avoidance of unnecessary exposure, installations with relevant activity inventories, installations for the conditioning of radioactive material and installations to protect the staff, to protect against inadvertent releases and to reduce direct radiation in the environment of the facility are of safety significance. Especially in the case of modification or dismantling measures of such installations, compliance with the protection goals is to be ensured by appropriate measures (planning, work permit procedures) (see Chapter 8.5).

As a rule, at least the following installations are to be counted among the safety-relevant installations of nuclear fuel-free power reactors during decommissioning:

- stationary ventilation systems for the maintenance of subatmospheric pressure and retention of radioactive substances,
- emergency power supply,
- radiological monitoring systems (exhaust air, waste water, local dose rate),
- leakage control systems,
- fire alarm and fire protection systems,
- alarm systems,
- measuring devices for clearance and removal[4],
- structures for radioactivity confinement and structures in which safety-relevant systems are installed or whose failure may endanger safety-relevant installations,
- lifting and transport equipment, the use or failure of which may endanger safety-relevant installations or lead to radiologically relevant effects[5].

Other installations are generally significant for compliance with the protection goal "avoidance of unnecessary exposure, limitation and control of occupational and public exposures" exclusively for the avoidance of unnecessary exposure. These are not to be assigned to the safety-relevant installations and include, for example, mobile ventilation equipment (mobile filter units) and equipment for radiological monitoring of workplaces. In the event of failure of these installations, substitute equipment is used or, alternatively, the activity on the spot is stopped without the failure by itself violating a protection goal.

The criteria for the classification of the installations are to be defined in the licensing procedure. The current classification of the installations of a facility under decommissioning is to be conclusively documented in plant-specific operating procedures that require approval by the supervisory authority. In this context, it is to be ensured that the classification is kept up to date in accordance with the changing status of the facility and the hazard potential as well as with regard to the remaining protection goals by applying the specified criteria.

The classification of lifting and handling equipment is based on the potential effects of a failure of this equipment in connection with the potentially releasable activity on the staff and the environment (see [16]). The impairment of the function of safety-relevant installations due to drop of loads is also to be taken into account.

The procedure for maintenance, modification and dismantling of the installations is to be chosen depending on the classification. This procedure is to be defined in the licensing procedure. This also includes the introduction of new installations and the change of use of facility areas required in the course of decommissioning.

The following requirements are to be complied with in the context of decommissioning:

[4] The unavailability of a measuring device for clearance or removal does not lead to a violation of protection goals. However, undetected malfunctions of such measuring devices could lead to a violation of the protection goal "confinement of radioactive material".

[5] The unavailability of lifting and transport equipment does not constitute a violation of the protection goals.

- Deviations from specified normal operation must be reliably detected by in-service inspections or technical installations. Servicing and maintenance measures, including functional tests, are to be carried out regularly to ensure the operability of safety-relevant installations. 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 facilities shared with neighbouring nuclear installations 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.

- For rebuilt or newly built safety-relevant installations, quality assurance measures are to be defined in specifications, depending on their safety classification. Rebuilt or newly built installations with safety relevance are to be subjected to a commissioning test prior to their use.

8.5 Safety classification of dismantling measures

The safety classification of installations is based on their functions or tasks during power operation. When these installations are disconnected, this classification no longer applies. The dismantling process is therefore subject to a different classification, which is based, among other things, on radiation protection aspects. This dismantling process extends from the preparatory measures (e.g. scaffolding, creation of interfaces, establishment of new infrastructure for processing, treatment and logistics) to the dismantling itself and the processing of residues and management of the radioactive material.

Compared to power operation, dismantling is a dynamic process with a variety of measures that make it necessary to adapt radiation protection measures. For example, a component that is to be dismantled, no longer has any safety significance from a systems engineering point of view even if it is highly contaminated. However, due to the existing contamination, the handling of the component (dismantling, transport, disassembly, etc.) has a safety-related relevance because it must be carried out in such a way that the remaining protection goals “confinement of radioactive material” and "avoidance of unnecessary exposure, limitation and control of occupational and public exposures” are fulfilled.

Since the safety-related relevance of a dismantling measure depends on a number of factors (radiation, fire protection and occupational safety as well as non-interaction with systems that are still required), it can only be determined on a case-by-case basis, as is the case with the necessary protective measures. Thus, the process or the work permit procedure, with which the necessary protective measures are determined and checked in each individual case, has a safety-related relevance. An appropriate system should be defined for the classification of the dismantling measures, taking into account the above-mentioned points. The availability of the safety-relevant installations must continue to be ensured.

Where nuclear fuel is present, compliance with the requirements of the Safety Requirements for Nuclear Power Plants [12] is to be demonstrated when planning the preparation and implementation of the dismantling measures.

9 Operating rules

The operating rules in the context of decommissioning are usually derived from the operating rules for power operation, taking into account the specific features of decommissioning. The operating rules contain the organisational and procedural regulations required for the decommissioning of the facility. These include, for example, the decommissioning / residual operation manual, the testing manual to be kept in accordance with nuclear safety standard KTA 1202 [17], and the documentation of the management system including the process descriptions. In addition, further facility-specific supplementary documents may exist, such as organisational instructions, operating instructions, engineering procedures, quality instructions or maintenance instructions. The respective scope of application of individual documents is to be defined. In order to ensure a uniform design within the individual document types (e.g. engineering procedures), specifications for the basic structure of these documents are to be defined.

The structure of the organisational documentation is to be described. The amendment procedure for the documents is also to be specified in an appropriate form.

9.1 Decommissioning / residual operation manual

Similar to power operation, the operating regulations for decommissioning a nuclear installation must also be included in a manual. For better differentiation, it is recommended to refer to this manual as decommissioning or residual operation manual. The structure, layout and contents of the decommissioning and residual operation manual should be based on nuclear safety standard KTA 1201 [18].

The decommissioning / residual operation manual should be appropriately derived from the operating manual for power operation.

Overall, the decommissioning / residual operation manual must include at least the following points:

- internal regulations on organisational structure, radiation protection, alarms, fire protection, first aid, control room and shift organisation, work permit and maintenance procedures, guard and access organisation,
- modification procedures including the procedure for the classification and reclassification of installations and the change of use of facility areas,
- procedure for permanent shutdown and disconnection of installations,
- procedure for the implementation of dismantling measures,
- procedure for the radioactive waste management and for the removal/clearance of materials, soil areas and buildings or parts of buildings,

- prerequisites/requirements and conditions for decommissioning,
- testing schedule of in-service inspections,
- specifications and regulations for the operation of the systems, for abnormal operation, and for accident management if still necessary.

Regulations relating to human resources and organisation are to be laid down that define the competencies and responsibilities and reflect the transition from power operation to decommissioning. In this context, both the responsible and otherwise engaged personnel (including required representatives) are to be taken into account. Furthermore, the required control room and shift staffing is to be specified, including a minimum shift and minimum control room staffing. These specifications can be adapted in the supervisory procedure to the respective dismantling progress.

Preparation and performance of decommissioning activities and the maintenance of systems are to be regulated in a maintenance regulation or a disconnection and disassembly regulation. Among other things, the procedure for permanent shutdown and disconnection of installations is to be specified.

An appropriate work permit procedure is to be established for the planning, approval, performance, monitoring and documentation of work associated with decommissioning. The work permit procedure must ensure that

- the safety and availability requirements of all installations with safety significance are reviewed and adapted where necessary,
- the requirements from radiation protection, occupational safety and fire protection as well as physical protection where necessary – including administrative measures – are taken into account and, in the case of subprojects with special significance, the sequence of work steps will be specified in detail,
- the requirements for the safe handling and recording of radioactive residues and conventional waste from dismantling are taken into account, and
- all measures relevant for safety and dismantling are defined and assessed.

Furthermore, in implementation of the waste management concept approved by the authority, the handling of radioactive residues produced during the decommissioning of a nuclear installation are to be described, for example, in a residue and waste regulatory regime until they are utilised without detrimental effects or disposed of as radioactive waste in a procedure regulated by law. The requirements for the collection, sorting, storage and conditioning of radioactive waste and residues as well as for the clearance or removal of the materials produced, soil areas and buildings or parts of buildings are to be specified.

A modification regulation shall specify the procedures to be followed in the event of planned modifications to the facility (e.g. systems, buildings and other installations) or its mode of operation.

Detailed regulations on repetitive activities in connection with dismantling and waste management may be laid down in implementation instructions subordinate to the decommissioning / residual operation manual (e.g. radiation protection instructions). The specifications for the classification of these implementation instructions are to be laid down in the decommissioning / residual operation manual and based on the safety relevance of the regulations for decommissioning.

Furthermore, regulations are to be laid down in the decommissioning / residual operation manual for residual operation and dismantling, for the elimination of malfunctions, for abnormal operation as well as for the control of accidents. This shall also apply to any beyond design-basis events to be taken into account as well as to special events (e.g. serious accidents at work, chemical accidents, severe weather conditions, IT incidents) which may require a special organisational structure to cope with them. To the extent necessary, the existing regulations for incident and emergency management from power operation are to be adapted appropriately.

During decommissioning, the operating regulations, including operational and personnel organisation, are to be reviewed event-based and at regular intervals with regard to changed requirements and adapted to the respective current requirements and the current status of the facility. An appropriate amendment procedure is to be defined for the necessary amendments to the operating rules (e.g. in the modification regulation).

The decommissioning / residual operation manual shall also include the testing schedule of the in-service inspections; the contents should be based on nuclear safety standard KTA 1202 [17], the testing manual for power operation, adapted to decommissioning.

9.2 Management system

According to § 7c AtG, a management system is required for the decommissioning of a facility that gives due priority to safety and is based on the requirements of nuclear safety standard KTA 1402 [19]. Against the background of the generally long decommissioning stage and, in particular, in case of longer interruptions of the dismantling activities, the aspects of ageing management are to be considered taking into account the requirements of nuclear safety standard KTA 1403 [20].

The 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 management system should be derived from the management system already established in the stage of power operation and adapted to the requirements of decommissioning. As regards the dismantling activities to be carried out, continuous 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 decommissioning stage and the associated requirements regarding residue treatment and logistics also require adjustments to the management system.

The planning of dismantling activities must be done in such a way that these activities can be carried out safely. Possibilities for improvement need to be identified in particular for such decommissioning measures that are to be carried out repeatedly in the course of dismantling. Measures that are only carried out once or rarely in the course of dismantling must also be analysed in terms of internal and external experience feedback, and the generic findings gained and improvement possibilities identified must be reflected back into the processes.

The management system also includes the regular review of the safety culture and measures to maintain a high safety culture throughout the remaining operation and dismantling period for both internal and external personnel.

9.3 Documentation of decommissioning/reporting

The documentation of decommissioning should follow the requirements of nuclear safety standard KTA 1404 [21].

Within the scope of the reporting obligations, the information relevant for a description of the progress of decommissioning is to be submitted on the topics of residual operation, dismantling, monitoring and material flow in the context of waste management.

Residual operation

For the phase of residual operation, the current status of the facility with information on modifications or expansions, e.g. also the new infrastructure created for dismantling such as installations for conditioning of waste and their operation, are to be presented. Modifications to the facility may include permanent shutdown and disconnection of installations in preparation for dismantling as well as the use of new residual operation systems.

Reporting of operating data or unavailability of systems is required for the safety-relevant systems. In addition, reporting on chemical monitoring is to be carried out as long as fuel assemblies/fuel rods are still in the spent fuel pool.

Another focus is to be placed on the presentation of the measures taken in response to reportable events and the relevant GRS information notices. With regard to the repair and maintenance work performed and in the case of in-service inspections, all anomalies occurred with a potential for safety-relevant effects are to be considered.

Dismantling

With regard to the dismantling progress in a facility, the dismantling measures carried out are to be described with information, e.g. on the procedure and implementation. These should also be presented in the context of

the sequence and interfaces of the individual work sections and phases of dismantling. In addition, an outlook on the planned dismantling measures is to be presented.

Radiological monitoring

When presenting the measures of radiological monitoring, both the personnel and the environment are to be considered. With regard to the personnel, the exposure during the performance of the work for residual operation, dismantling and waste management is to be recorded. In this context, the findings made and anomalies identified during incorporation monitoring are also to be taken into account. With regard to environmental monitoring, information is to be provided on the discharges of radioactive substances with air and water.

Waste management

The information on the material flow in the area of waste management during dismantling is used to track further processing and distribution of the dismantled (radioactive) residues to the waste management routes, the whereabouts of the radioactive waste and the description of whether this takes place on site or at external service providers. In addition, the acquisition and delivery of other radioactive materials (e.g. sources) must also be reported. As long as there are fuel assemblies/fuel rods in the facility, this inventory is also to be reported.

Looking to the future, a forecast of the total radioactive waste generated must also be made. In this context, information on the non-radioactive hazardous substances present at the site is also required.

Final report

Once the decommissioning objective has been achieved, a final report is to be submitted in accordance with the Decommissioning Guide [6], summarising how the decommissioning concept has been implemented and the decommissioning objective achieved.

9.4 Personnel, organisation and competencies

A personnel and organisational concept is to be developed to ensure appropriate organisational structures for safe residual operation and decommissioning and to ensure the provision of appropriate resources and competencies for all phases of decommissioning. Here, the corresponding requirements of nuclear safety standards KTA 1402 [19] are to be taken into account.

The competencies required for the residual operation and decommissioning of a facility (technical, methodological and social competencies) are to be built up and their maintenance must be ensured throughout

the entire stage of decommissioning of the facility. The need for adjustments regarding the individual competency is to be reviewed and adjusted regularly and with foresight throughout the entire stage of residual operation and decommissioning of the facility. Accompanying measures for knowledge transfer and feedback of experience are to be planned and implemented. Both the responsible and the otherwise engaged personnel are to be considered here, regardless of whether being internal or external personnel.

The relevant guidelines on technical qualification for power operation and post-operation are also to be applied to decommissioning in accordance with the requirements defined by the competent supervisory authority until the respective decommissioning objective has been achieved.

In this context, successive adaptation of the requirements to be imposed is possible in the nuclear supervisory procedure. For example, when the nuclear fuel is removed from the plant, the requirements for individual functions of the responsible personnel can be reduced or no longer apply.

Furthermore, it is be ensured that the necessary high level of motivation of the personnel as well as a high safety culture in the organisation and among the personnel employed (internal and external personnel) continue to be maintained until having achieved the decommissioning objective. The requirements of nuclear safety standard KTA 1402 [19] relevant in terms of technical qualification are to be taken into account for the specific case of application until the decommissioning objective has been achieved.

Until achieving the decommissioning objective, it must be ensured that instructions on and control of decommissioning activities, including, among others, those of external personnel, is carried out at all times by officially certified qualified personnel (e.g. in radiation protection).

10 References

[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] IAEA Safety Standards
Decommissioning of Nuclear Power Plants, Research Reactors and Other Nuclear Fuel Cycle Facilities
Specific Safety Guide
No. SSG-47, 2018

[4] IAEA Safety Standards
Decommissioning of Medical, Industrial and Research Facilities
Specific Safety Guide
No. SSG-49, 2019

[5] WENRA Working group on waste and Decommissioning (WGWD)
Decommissioning Safety Reference Levels Report, Version 2.2
April 2015

[6] Leitfaden zur Stilllegung, zum sicheren Einschluss und zum Abbau von Anlagen oder Anlagenteilen nach § 7 des Atomgesetzes vom 23. Juni 2016
Bekanntmachung vom 23. Juni 2016, BAnz AT 19.07.2016 B7

[7] Regel KTA 3604: Lagerung, Handhabung und innerbetrieblicher Transport radioaktiver Stoffe (mit Ausnahme von Brennelementen) in Kernkraftwerken
Regeländerungsvorlage, Fassung 2020-09

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

[9] P. Brennecke (Hrsg.), Anforderungen an endzulagernde radioaktive Abfälle (Endlagerungsbedingungen, Stand: Dezember 2014) – Endlager Konrad –
Bundesamt für Strahlenschutz, SE-IB-29/08-REV-2, Salzgitter, Februar 2015

[10] Strahlenschutzverordnung vom 29. November 2018 (BGBl. I S. 2034, 2036), die durch Artikel 1 der Verordnung vom 27. März 2020 (BGBl. I S. 748) geändert worden ist

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[12] Sicherheitsanforderungen an Kernkraftwerke vom 22. November 2012
Neufassung vom 03.03.2015; BAnz AT 30.03.2015 B2

[13] Anforderungen bei einer passiven Kühlung der Brennelemente im Lagerbecken
Anlage zum Ergebnisprotokoll der 509. Sitzung der Reaktor-Sicherheitskommission (RSK) am 27.03.2019

[14] Empfehlung der Strahlenschutzkommission
Rahmenempfehlung für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen, 19./20.02.2015
Veröffentlicht im BAnz AT 04.01.2016 B4

[15] Notfall-Dosiswerte-Verordnung vom 29.11.2018
BGBl. I S. 2034, 2172

[16] Regel KTA 3902: Auslegung von Hebezeugen in Kernkraftwerken
Regeländerungsentwurf, Fassung 2019-11

[17] Regel KTA 1202: Anforderungen an das Prüfhandbuch (PHB)
(Fassung 11/2017); BAnz. vom 17.05.2018

[18] Regel KTA 1201: Anforderungen an das Betriebshandbuch (BHB)
(Fassung 11/2015); BAnz. vom 29.04.2016

[19] Regel KTA 1402: Integriertes Managementsystem zum sicheren Betrieb von Kernkraftwerken
(Fassung 11/2017); BAnz vom 17.05.2018

[20] Regel KTA 1403: Alterungsmanagement in Kernkraftwerken
(Fassung 11/2017); BAnz vom 05.02.2018

[21] Regel KTA 1404: Dokumentation beim Bau und Betrieb von Kernkraftwerken
(Fassung 11/2013)

Appendix: Diagram to visualise the relationship between concepts and plans