Note:
This is a translation of the ESK recommendation entitled “Leitlinie zum sicheren Betrieb eines Endlagers für insbesondere Wärme entwickelnde radioaktive Abfälle”.
In case of discrepancies between the English translation and the German original, the original shall prevail.

RECOMMENDATION of the Nuclear Waste Management Commission (ESK)

Guideline on the safe operation of a disposal facility for in particular heat-generating radioactive waste

CONTENTS

1 General

1.1 Preliminary note

With regard to the future disposal of heat-generating radioactive waste, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU; today: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety – BMUB) published the "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste" as at 30 September 2010 on its website [1]. These Safety Requirements set out the safety standards that a disposal facility for heat-generating radioactive waste in deep geological formations must observe in order to comply with atomic energy legislation. The Safety Requirements may be concretised by guidelines. This includes the present guideline for the safe operation of a disposal facility for in particular heat-generating radioactive waste ("Guideline for Safe Operation").

For the disposal of in particular heat-generating radioactive waste, a site for the construction and operation of a disposal facility is to be searched and selected within the framework of a new statutory procedure [2]. The Site Selection Act (StandAG) mentions rock salt, clay and crystalline rock as possible host rocks. The Federal Government plans to take the disposal facility into operation around the year 2050 [3].

Against this background, at this stage, the "Guideline for Safe Operation" only deals with generic aspects and issues that are of significance for the safe operation of such a disposal facility. The guideline should be developed further continuously in several stages according to the results and progress made in the search for and selection of a site as well as the technical plans for the design and operation of the disposal facility. In this respect, regular review and updating of the guideline at intervals of approximately five years appears to be appropriate.

Facilities for conditioning and product control may be located at the site of the disposal facility. Possible interactions with these facilities must be considered separately.

1.2 Scope of application

The "Guideline for Safe Operation" applies to the safe operation of a disposal facility for in particular heat-generating radioactive waste. The radioactive waste considered comprises, in particular, spent fuel, heat-generating radioactive waste from reprocessing of spent fuel and radioactive waste with negligible heat generation which may not be suitable for emplacement in the Konrad repository [3]. This concerns radioactive waste that owing to its nuclide inventory and/or its chemical composition or the time of its generation is not suitable for emplacement in the Konrad repository.

Furthermore, it is intended to also consider the radioactive waste to be retrieved from the Asse II mine in the search for a site for this disposal facility. The same applies to the depleted uranium that has been generated and will be generated from uranium enrichment if it should not be reutilised. A final decision on the site of the disposal facility for this waste – also considering all technical, economic and political aspects – cannot be made until the criteria for emplacement in the disposal facility have been established in accordance with the Site Selection Act and until there will be sufficient information as regards quantity and nature of the waste to be retrieved from the Asse II mine and the time when it will be retrieved [3].

Operation of a disposal facility refers to all processes from the date of the first delivery of radioactive waste/waste packages to the disposal facility until its final closure and the dismantling of the facilities above ground. This includes a possible retrieval of the waste as planned technical option during the operating phase [1]. Upstream work, such as planning, construction and commissioning of the disposal facility, aspects of physical protection, demonstration of long-term safety and the protection of near-surface groundwater as well as the possible recovery of waste as an emergency measure up to 500 years after the closure of the disposal facility are not part of the "Guideline for Safe Operation".

The safe operation of the disposal facility comprises two areas of requirements:

- The first area includes the assurance of operational safety. To this end, processes are to be defined and measures taken to ensure the protection of the operating staff as well as the technical installations in terms of occupational safety and radiation protection.

- The second area includes the safe handling and emplacement of the waste packages. It must be ensured during the entire operating period until safe closure of the disposal facility that radionuclides do not enter the mine and, via exhaust air, the environment of the facility to an inadmissible level. Given the open access routes to the surface during the entire operating time, special attention must be paid to this requirement in order to also protect the population and the environment.

As part of the planning of a disposal facility for in particular heat-generating radioactive waste, these two areas of requirements are to be concretised. As a first step, this "Guideline for Safe Operation" presents, in general terms, the safety-related boundary conditions and thus the planning requirements and prerequisites that are to be fulfilled to ensure protection of the operating staff, the population and the environment of the facility. Thus, the basic requirements for the safe operation of the disposal facility specify requirements for the development of future technical concepts.

1.3 Protection goals

The radiological protection goals, which the technical design and the operation of the disposal facility for in particular heat-generating radioactive waste have to comply with, include the requirements that

- any unnecessary radiation exposure or contamination of man and environment shall be avoided (§ 6 para. 1 of the Radiation Protection Ordinance – StrlSchV [4]), and

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

The planning of structural or other engineered protection measures against design basis accidents is to be based on the requirements of § 49 StrlSchV.

The fundamental protection goals derived from this, applicable to waste packages, the disposal facility with the technical installations in the surface and underground facilities and the operating phase of the disposal facility, are as follows:

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

On this basis, the following requirements can be derived for operation:

- shielding of ionising radiation in surface and underground facilities,
- design and construction of the facilities such as to enable operation and maintenance,
- safety-oriented organisation and performance of operation,
- safe handling and safe transport of the waste packages,
- design against accidents (design basis accidents),
- measures to mitigate the consequences of beyond design basis accidents, and
- handleability of the waste packages according to the requirements of the concept for retrieval during the operating phase.

In addition to the protection goals listed above, the technical design and operation of the disposal facility for in particular heat-generating radioactive waste have to comply with the protection goals of the mining industry and the requirements for the safe operation of a mine. Accordingly, pursuant to the Federal Mining Act (Bundesberggesetz – BBergG [5],

- the safety of the disposal facility and the staff is to be ensured and
- prevention against dangers arising from mining activities for life, health and third-party property is to be strengthened and compensation for unavoidable damage is to be improved

and the requirements pursuant to the Federal Mining Ordinance (Allgemeine Bundesbergverordnung – ABBergV [6] derived from it are to be fulfilled:

- workplaces shall be designed, constructed, equipped, commissioned, operated and maintained in such a way that workers can perform the work assigned to them without endangering their safety and health or those of others,
- the operation of workplaces when workers are present shall take place under the supervision of a person in charge, and
- work involving a special risk shall be entrusted only to competent staff and carried out in accordance with the instructions given.

Proof is to be provided by facility-specific safety analyses that the necessary precautions have been taken according to the state of the art in science and technology to prevent damage resulting from the operation of the disposal facility; the results of these analyses are to be considered in the design of the disposal facility. For the safety case, care must be taken to ensure sufficient robustness. Moreover, for the operating phase, graded measures are to be planned according to the four levels of defence in depth, i.e. normal operation, abnormal operation, design basis accidents and beyond design basis accidents/events [1]. The safety concept has to outline and justify the potential operational failures and accidents that could occur during operation of the disposal facility. For this purpose, the facility-specific deterministic and probabilistic safety analyses are to be used for the operating phase of the disposal facility. A probabilistic safety analysis and extension of the probabilistic database required for it are to be carried out in parallel to the development of the disposal facility concept [7]. Thus, on the one hand, the concept and the balance of the design of a disposal facility in terms of safety can be optimised in an iterative process already in the planning phase and, on the other hand, the database can continuously be improved and expanded.

Additional requirements exist with regard to the liability for damage, the protection against disruptive actions or other interference by third parties as well as the control of fissile material according to international agreements (safeguards).

2 Disposal facility operation

2.1 Principles of operation

The operation of the disposal facility shall be such that the necessary precautions have been taken according to the state of the art in science and technology to prevent damage. All changes intended during operation are also to be examined with regard to their potential impact on long-term safety. Negative impacts are to be minimised, taking into account the requirements in terms of long-term safety. The relevant regulations, such as BBergG [5] and the Atomic Energy Act – AtG [8] and subordinate ordinances must be observed. This also includes the storage and handling of hazardous materials (e.g. explosives).

The health and safety documents for occupational safety are to be prepared according to the requirements of the legal regulations and subordinate regulations. Moreover, safety instructions are to be specified for all groups of staff in an appropriate and comprehensible manner, adequate first aid facilities provided and necessary safety exercises conducted at regular intervals.

Operation also includes maintenance and repair of structures, systems, and components as well as installations for the detection and control of operational occurrences and design basis accidents, including the elimination of their consequences. In particular, the following operational processes have to be planned and considered for operation of the disposal facility:

- Above ground
  - delivery of the waste packages to the disposal facility,
  - acceptance and handling of the waste packages in the reception area,
  - incoming inspection,
  - preparation for transport to underground, and
  - handling of retrieved waste/waste packages.

In addition, provisions are to be made (rooms, technical measures) for the treatment of waste packages in case they do not meet the waste acceptance requirements.

- Underground
  - excavation of emplacement areas and, if required, additional drifts,
  - transport to underground (ramp or shaft),
  - underground transport,
  - emplacement of waste packages,
  - backfilling and sealing of the emplacement areas,
  - closure of the disposal facility, and,
  - by way of precaution, retrieval of the waste/waste packages as an emergency measure.

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

- all operational processes shall be described clearly,
- interactions between the individual operational processes shall be considered,
- emplacement of waste packages in a largely automated manner shall be pursued,
- the position of the waste packages must be traceable at any time,
- all installations necessary for safe performance of operation shall be specified,
- the parameters relevant for safe operation shall be defined,
- only qualified staff may be used for operation, and
- persons shall be assigned to the operational processes who are authorised accordingly.

Moreover, the necessary administrative prerequisites relating to personnel, organisation and safety have to be established, maintained and documented. For the operating states normal operation, abnormal operation, design basis accidents, beyond design basis accidents/events as well as their management, clear instructions are to be drawn up for the mine book/operating manual. Competencies and responsibilities are clearly to be defined. In the mine book/operating manual, experiences from other facilities are to be considered and the mine book/operating manual is to be updated at regular intervals or after an event.

In particular, the following aspects are to be considered:

- Organisation and management system

  The organisational structure of the disposal facility operator must show clearly defined responsibilities, competencies, powers and communication channels. It must ensure that throughout the entire period of time necessary for safety, the necessary operating staff with the required skills, abilities and experience will be available. To this end, appropriate training/advanced training courses, regular exercises and a forward-looking planning of human resources are to be provided. The disposal facility organisation has to establish a management system, revise it continuously and develop it further. The management system is to be described.

- Quality management

  For the operation of a disposal facility, a quality management (QM) system must be in place that has been adapted to the operational safety requirements. This concept is to be optimised in the course of the construction and operation of the disposal facility. Depending on the defined operating states and the resulting processes, appropriate QM measures are to be derived and specified.

- Modifications

  For modifications to processes and installations, an appropriate modification procedure is to be defined. All structural changes provided during operation are to be reviewed in terms of their potential impact on long-term safety and – depending on the evaluation of the results of the review – to be avoided or adapted accordingly.

- Documentation

  The documentation of the operating phase of the disposal facility includes all information and proofs demonstrating the safe operation of the facility and compliance with the protection goals in terms of radiation protection and mining safety. It includes, in particular, the following:

- mine book/operating manual, testing manual including test reports for safety-relevant structures, systems and components, radiation protection instructions,
- plans, drawings, manufacturer and test certificates as well as safety reviews,
- medical records of staff (for example, medical examinations prior to employment and periodic reviews of health),
- proof of (safety) instructions performed (e.g. use of oxygen equipment), and,
- during operation of the disposal facility, accessible records and subsequent archiving of work locations and working times of the operating staff.

Full sets of documents are to be kept separately, both spatially as well as by means of fire protection, at at least two different appropriate locations. For the storage, maintenance and accessibility of the documentation of the disposal facility, corresponding concepts are to be developed. This also includes, in particular, specifications on the storage of the documentation according to [1] for a period as long as possible.

The documentation on the emplaced material (waste package documentation) is to be treated independently and separated from the documentation on the safe operation of the disposal facility. The current state of knowledge and practices with regard to the documentation of in particular heat-generating radioactive waste are to be checked and – if necessary – updated by requirements on the content and scope of the documentation of such waste products and waste packages as well as its required retention period. This applies, in particular, to the results of safety analyses to be carried out in the future and the concretisation of waste acceptance requirements.

- Periodic safety reviews (PSRs)

  The operator of the disposal facility must regularly conduct a safety review for their facility at intervals of ten years [1]. In this respect, it is not only required to present and evaluate the adaptations to the state of the art in science and technology that may be necessary but also to take account of experience from operation of other comparable facilities and/or parts thereof.

- Ageing management

  For the control of long-term and ageing effects during the operating phase of the disposal facility, an ageing management concept is to be submitted within the licensing procedure and appropriate measures are to be implemented.

- Maintenance and repair

  All installations of the disposal facility, such as cranes above ground, accesses to the underground area with the respective conveyor systems or mechanical equipment underground (including vehicles),

requiring inspections, maintenance or repair have to be readily accessible or have to be made readily accessible by technical means. The spatial conditions have to be such that there is sufficient space available for inspections, maintenance and repair. This also involves the requirement that shielding that might become necessary for reasons of radiation protection can be installed and used temporarily. For the preparation, performance and documentation of this work, a maintenance and repair concept is to be developed whose specifications and provisions are to be included in the mine book/operating manual.

2.2 Requirements for facilities above ground

The facilities above ground necessary for the operation of the repository mine as well as all the facilities and buildings for receipt and acceptance of the waste packages are referred to as surface facilities. This also includes the receiving store which particularly serves to ensure continued emplacement operation. For the design of these facilities, the relevant legal regulations and standards have to be observed. So, for example, the protection goals, especially within the meaning of the AtG [8], the StrlSchV [4] and the BBergG [5] with the relevant subordinate regulations are to be considered for the design of all buildings and parts of the facility which are directly required for the transport, handling or storage of radioactive waste (Chapter 1.3). This also includes installations for the protection of the facility against disruptive actions as well as ventilation and fire protection systems.

For the surface facilities, the safety-related design requirements according to the ESK recommendations on storage [9, 10] are to be applied. Furthermore, shafts and conveyor systems are to be designed such that accidents (e.g. cage crash, crash of transport units, collision of the conveyor frame with shaft fittings) can be excluded or, in the event of a crash, radiation exposure of workers and the general public beyond permissible limits can be excluded, taking into account the waste package characteristics.

When dimensioning the disposal facility site, adequate reserves are to be considered for a potential retrieval of the waste/waste packages in accordance with the retrieval concept.

Waste streams

Only those waste packages may be accepted that meet the waste acceptance requirements for disposal. In order to be able to furnish and substantiate the proofs required for it, appropriate technical measures have to be developed and specified for product control of in particular heat-generating radioactive waste.

The waste packages to be emplaced are basically divided into three waste streams that are characterised by the following features:

- waste packages with radioactive waste with negligible heat generation (including waste packages without sufficient shielding and waste packages with low local dose rate),

- waste packages with heat-generating radioactive waste where the waste containers have a self-shielding effect, and
- waste packages with heat-generating radioactive waste that can be emplaced without shielding.

For the receipt, acceptance and handling of the waste packages from the different waste streams, specific operational processes are to be defined.

2.3 Requirements for surface-to-underground access

For the operation of the repository mine, accesses from the surface to the underground are to be provided. These accesses are used for the transport of the waste packages, the transport of persons and materials, the removal of mining debris heaps produced during excavation of the emplacement areas, as well as for the supply and discharge of air. They must be designed such that all tasks can be fulfilled safely and reliably. In this respect, the measures of emergency management are also to be considered. When concretising the plans for the design of the disposal facility, the number of required accesses must be determined. Here, the basic decision is to be taken whether the access to the repository mine is to be provided exclusively via shafts or is to be supplemented by a ramp.

The accesses to the underground have to be dimensioned according to requirements and must be structurally stable.

2.4 Requirements for underground facilities

The underground work must be planned and organised according to the provisions of the BBergG [5] and the AtG [8] and subordinate rules and regulations. In this respect, a distinction is to be drawn between two operating areas: firstly, the area where the underground cavities are driven to build the emplacement areas (excavation areas) and, secondly, the actual area for emplacement of the waste packages, i.e. the area for emplacement operation. Here, the emplacement area generally follows the excavation area in terms of time and space. Depending on the waste container concept and other boundary conditions, the establishment of radiation protection areas (controlled and supervised areas) in the mine workings is to be examined and determined according to [4].

Particular consideration is to be given to aspects relating to operational safety due to the parallel excavation of underground cavities and the emplacement of waste packages.

Underground cavities are to be driven in a manner designed to minimise any damage to the host rock. When conducting excavation and mine support work, it should be ensured that the barrier effectiveness of later sealing structures is not affected by, for example, damage to the rock.

Drifts, infrastructure facilities and underground side chambers must be planned, built and maintained such that their usability is ensured throughout their service life. This also includes the landing shaft, which is required for the transport of the waste packages and transfer containers through a shaft.

Layout and design of the emplacement areas and the backfilling of residual cavities after emplacement of the waste packages must ensure the safe removal of decay heat.

When planning emplacement fields, drifts and chambers, the space is to be taken into account which is required for the construction of the closure and/or sealing structures.

The installations underground are to be designed such that risks of transport processes are minimised. The drift from the shaft or from the ramp to the emplacement areas and back is to be planned and designed without intersections as far as possible. The traffic management and routing of the transport vehicles must ensure that the transport routes for emplacement can only be used in one direction to avoid accidents.

Size and equipment of infrastructure facilities must ensure that all work necessary for safe operation can be performed. Since it may be required to establish supervised and controlled areas in the mine workings, it is to be defined in the planning at an early stage whether individual facilities (e.g. workshops) have to be provided separately for each area. This also applies to the establishment of appropriate areas within the framework of retrieval of waste/waste packages.

Since according to [1], retrieval of waste/waste packages during the operating phase needs to be considered as a planned technical measure, appropriate planning is to be carried out and an appropriate concept to be developed within the licensing procedure. This concept must comprise all aspects of operational safety for the measures underground, the transport of the retrieved waste/waste packages to the surface as well as their handling above ground. As part of the planning for the retrieval of waste/waste packages it is to be examined whether an additional shaft or an additional ramp could be required for the retrieval and, if so, what measures would have to be taken.

Underground mine ventilation

There have to be stable ventilation conditions throughout the mine workings at any time. This means that the volumes of air currents must not be significantly changed by operational processes (e.g. actuation of air locks, cage winding) or by unplanned disruptions in the ventilation system.

The ventilation system must be designed and ventilation must be controllable such that in the event of operational occurrences and design basis accidents underground, the areas affected can be isolated or air currents diverted such that contamination of the mine workings will largely be avoided and flue gases are discharged in a controlled manner in thermal load cases.

When planning the ventilation system, it is to be examined and determined whether the use of additional and possibly also mobile mine fans could be required in case of operational occurrences and design basis accidents as an additional safety-enhancing measure.

For the ventilation of the mine workings, exhaust ventilation is to be provided with installation of the main mine fan above ground. Due to the negative pressure, all contaminants removed from the mine workings are discharged into the free atmosphere via the main mine fan in a controllable manner or can be led to a possibly required filtering device. Depending on the results of the accident analysis, it is to be checked whether and, if so, where in the exhaust air flow a filtering device is to be provided that can filter all the potentially contaminated air in the event of a release of radioactive substances within the disposal facility.

For ventilation during the excavation of the emplacement areas, blowing auxiliary ventilation is to be provided with installation of the mine fan in the continuously ventilated main drift. During emplacement of waste packages, ventilation is to be switched to exhaust ventilation.

The ventilation system must constantly ensure a stable air flow from the excavation area into the emplacement area. The return air of the emplacement area may have to be led directly to the emplacement shaft/ramps (i.e. to the air exhaust shaft) via a filtering device without getting into contact with other mine openings.

The functional capability of fire doors and ventilation doors must not be impaired.

Emplacement operation

To increase operational safety, emplacement of the waste packages should be automated as far as possible. Emplacement has to take place shortly after excavation of the emplacement areas [1]. Backfilling and sealing of the emplacement areas should also be done shortly after emplacement of the waste packages.

The final position of a waste package in an emplacement field, an emplacement drift or an emplacement chamber is to be recorded and documented and related provisions are to be drawn up.

A concept is to be developed for handling and treatment of radioactive operational waste. Here, a distinction is to be drawn between on-site conditioning and delivery of the waste for external conditioning.

3 Fire protection and fire protection systems

When planning the disposal facility, a fire protection concept is to be developed in analogous application of safety standard KTA 2101, Part 1 [11] and integrated into an emergency plan at the beginning of construction of the facility.

When planning the disposal facility for in particular heat-generating radioactive waste, the installation of a fire alarm panel is to be provided which records and evaluates all fire alarms during the operating phase (fire above ground and underground, including incipient fires) and from which all necessary measures are initiated and monitored.

The fire loads in the disposal facility (i.e. structural and operational fire loads) are to be minimised in order to limit heat release and thermal impact, for example on the mine support, and to limit the risks for the operating staff associated with smoke release to an acceptable level in the event of fire. Preference is to be given to the use of non-combustible or at least flame-retardant materials. In the storage area, the storage of combustible materials is only permitted if these are stored in a condition in which their ignition can be ruled out. Individual areas are to be protected as required with automatic fire detection and extinguishing systems. The design of the fire protection measures has to comply with DIN 4102 [12] and safety standard KTA 2101 [11]. Here, the respective more stringent requirement is to be applied.

It is to be examined whether the use of vehicles with combustion engines can be dispensed with. Vehicles used must be equipped with on-board automatic fire protection systems and regularly checked and maintained.

Stationary and mobile fire-fighting systems and equipment are to be provided, as required, throughout the disposal facility to fight fires (incipient fires included), also considering temporary fire loads. When selecting extinguishing agents, possible consequential damages (e.g. due to corrosion) are to be considered. The operating staff must be trained in fighting fires. Training and exercises are to be repeated regularly.

Number and design of the underground escape and rescue routes have to be determined in compliance with the rules and regulations in terms of mining safety on the basis of the layout and ventilation of the mine workings. For this purpose, an escape route concept is to be developed, which must be updated as the concretisation of the disposal facility planning progresses. In the escape route concept, refuge chambers are also to be considered.

For the purification of combustion gases, appropriate devices are to be provided in the ventilation (for example filters).

The intervention forces, usually a mine rescue team, must have had additional training according to the fire brigade-specific contents for operations involving hazards from radioactive substances.

4 Radiation protection requirements

During operation of a disposal facility for in particular heat-generating radioactive waste, any unnecessary radiation exposure or contamination of man and the environment shall be avoided (Chapter 1.3). In this respect, any radiation exposure or contamination of man and environment shall be minimised, even if below the respective limit, by taking into consideration the state of the art and by taking into account all circumstances of individual cases [4]. For this reason, the handling steps involving workforce are to be reduced as far as possible and largely automated operational processes pursued. To this end, the operational processes are to be optimised and staff deployment concepts to be developed.

For the operation of the disposal facility, an appropriate radiation protection organisation is to be planned and implemented and a radiation protection instruction to be issued which also has to specify the radiation protection measures to be observed. The radiation protection instruction also has to include the measures for

ensuring the technical qualification of the staff in the field of radiation protection and for the promotion of a safety-oriented way of thinking and acting in accordance with the provisions of the Radiation Protection Ordinance [4]. Planning and execution of maintenance, controls and repairs are to be regulated in a procedure for work clearance under consideration of radiation protection aspects.

In the disposal facility, radiation protection areas (supervised areas, controlled areas and, where required, restricted areas as defined in the Radiation Protection Ordinance) are to be provided in accordance with the exposure conditions and to be marked accordingly.

In the radiation protection areas, the local dose or the local dose rate is to be measured and documented at regular intervals.

In working areas where contamination may occur, the room air is to be monitored for control purposes, e.g. by mobile air sample collectors. Circulation areas, persons, workplaces, transport paths and movable objects are to be checked for contamination in an appropriate manner. To eliminate impacts and consequences of operational occurrences and design basis accidents above ground and underground and thus to restore operational safety of the disposal facility, a concept is to be developed which must include, in particular, appropriate measures for the management of contamination occurred and decontamination. For decontamination, organisational provisions are to be specified and adequate means provided or they must be procurable in the short term.

The body dose of occupationally exposed persons in controlled areas is to be determined by means of appropriate official dosimeters and documented. For the performance of work, dosimeters whose results can be read at any time are to be used in addition to the official dosimeters. The radiation measuring devices used and kept available are to be checked for their functional performance and serviced at regular intervals.

For the surface facilities of the disposal facility, an appropriate environmental monitoring programme is to be provided.

5 References

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[3] Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit: Programm für eine verantwortungsvolle und sichere Entsorgung bestrahlter Brennelemente und radioaktiver Abfälle (Nationales Entsorgungsprogramm), Bonn, August 2015

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[9] Empfehlung der Entsorgungskommission (ESK): Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnde radioaktive Abfälle in Behältern (Revidierte Fassung vom 10.06.2013).

[10] Empfehlung der Entsorgungskommission (ESK): Leitlinien für die Zwischenlagerung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung (Revidierte Fassung vom 10.06.2013).

[11] Regel KTA 2101 „Brandschutz in Kernkraftwerken“, Teil 1: Grundsätze des Brandschutzes, Fassung 12/2000 (Regeländerungsentwurf Stand: 11/2014)

[12] DIN 4102, Brandverhalten von Baustoffen und Bauteilen, Teile 1 - 4 (Teil 1: Fassung 05/98; Teil 2: Fassung 09/77; Teil 3: Fassung 09/77; Teil 4: Fassung 03/94, Änderung 06/2014), Beuth Verlag, Berlin