Note:
This is a translation of the statement entitled
"ESK-Stresstest für Anlagen und Einrichtungen der Ver- und Entsorgung in Deutschland
Teil 1: Anlagen der Brennstoffversorgung, Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle, Anlagen zur Behandlung bestrahlter Brennelemente".
In case of discrepancies between the English translation and the German original, the original shall prevail.

E S K

STATEMENT of the Nuclear Waste Management Commission (ESK)

ESK stress test for nuclear fuel cycle facilities in Germany*

Part 1:
Nuclear fuel supply facilities, storage facilities for spent fuel and heat-generating radioactive waste, facilities for the treatment of spent fuel

Contents

*Translator's note: In the German original, the terms "Anlage" and "Einrichtung" are used. Both terms are translated by "facility" since, in this Statement, reference is always made to a facility of the nuclear fuel cycle (NFCF).

1 Background information and request for advice

The earthquake off the Japanese coast on 11.03.2011 and the subsequent flooding caused by a tsunami triggered a nuclear disaster at the Fukushima site. Although the initiating events of the nuclear disaster in Japan, especially the magnitude of the earthquake and the height of the tidal wave, are not directly applicable to conditions in Europe and Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) considers it necessary, as a consequence of these events, to not only perform a robustness assessment for German nuclear power plants, but also a stress test for spent fuel and radioactive waste management facilities in Germany. The same applies to the plants for uranium enrichment in Gronau and fuel fabrication in Lingen.

Against this background, the BMU commissioned the NUCLEAR WASTE MANAGEMENT COMMISSION (ESK) by letters dated 22.06.2011 [1] and 18.07.2011 [2] to develop appropriate review concepts for facilities in operation or under construction for the treatment, storage and disposal of spent fuel, heat-generating and other types of radioactive waste and for the plants for uranium enrichment in Gronau and fuel fabrication in Lingen.

With this stress test, it is expressly not intended to assess the design requirements reviewed as part of the licensing procedure. Instead, with this statement, the ESK assesses the robustness of facilities against impacts that go beyond the design requirements in the licensing procedure. In this way, it is investigated how the facilities behave under beyond design basis loads and whether a sudden rise of the radiological effects outside the facility (cliff edge effect) due to the failure of components or measures is foreseeable. For this purpose, existing precautionary measures and accident management measures provided are also considered in the stress test (see Chapter 4).

At the beginning of its consultations, the ESK identified, in agreement with the BMU, the existing facilities in Germany to be examined in the stress test. There are considerable differences between the facilities with regard to their radioactive inventories, technical situation and licensing procedures performed so that the ESK applied an internal classification of the facilities according to the following six facility categories:

- URENCO uranium enrichment plant in Gronau, ANF fuel fabrication plant in Lingen,
- 12 on-site storage facilities*, storage facility north (ZLN), Gorleben fuel storage facility, Ahaus storage facility, and Jülich storage facility,
- facilities for the treatment of spent fuel (PKA, WAK)
- storage facilities for low- and intermediate-level radioactive waste,
- conditioning facilities for low- and intermediate-level radioactive waste, and
- repositories for radioactive waste (Asse II mine, Morsleben repository for radioactive waste (ERAM) and repository Konrad mine).

In order to ensure separation of functions between the REACTOR SAFETY COMMISSION (RSK) and the ESK, it was determined in a co-ordination meeting with the BMU on 31.05.2012 that the power reactors,

*Translator's note: In the German national reports for the CNS and the Joint Convention referred to as "on-site interim storage facilities"; according to the IAEA Safety Glossary, "*Storage* is by definition an interim measure …" and " … should not be described as *interim storage*"

including spent fuel pools, the research reactors in Berlin, Mainz and Munich as well as the wet storage facility of the Obrigheim plant (KWO) will be consulted on by the RSK and the fuel cycle facilities will be the subject of ESK consultations. As soon as radioactive substances from operational use in nuclear power plants (NPPs) are put into long-term storage within the NPP or are processed for it (raw waste, conditioned waste), they fall within the area of tasks of the ESK.

Due to the large number and diversity of facilities to be considered as well as the wide range of radioactive inventories to be considered in the stress test, the ESK divided its statement into two parts. This first part starts with only assessing the robustness of nuclear fuel supply facilities, storage facilities for spent fuel and heat-generating radioactive waste and facilities for the treatment of spent fuel against beyond design basis events. The robustness of storage facilities for low- and intermediate-level radioactive waste, conditioning facilities for low- and intermediate-level radioactive waste and repositories for radioactive waste (Asse II mine, Morsleben repository for radioactive waste (ERAM) and repository Konrad mine) will be assessed by the ESK in a later statement.

Issues related to the physical protection of facilities are not considered in the framework of this review (in this regard, physical protection is to be understood as the active and passive measures to prevent impacts from interference by third parties). The impacts of chemotoxic substances are not considered as part of this request for advice either.

2 Consultations

Requests for advice [1] and [2] were presented to the ESK at its 20th ESK meeting on 25.08.2011. The ESK has then set up the ad hoc working group AG SÜ (*Arbeitsgruppe SICHERHEITSÜBERPRÜFUNG - AG SÜ*) which initially agreed on the approach at its ten (one- or two-day) meetings from September 2011 to January 2013 (see Chapter 3), then formulated a list of questions [3] with load cases to be postulated and assessment criteria (stress levels, degrees of protection) for the ESK stress test (see Chapter 5) and finally, based on the written answers by the operators [4-18] and explanations by the competent *Land* authorities, prepared a draft statement. With the terms "stress level" and "degree of protection", the ESK follows the approach applied in the stress test of the RSK [19], according to which "stress level" is used in connection with measures against natural and postulated hazards and the term "degree of protection" for man-made hazards to be considered additionally as defined in the RSK catalogue of requirements. This draft was submitted to the ESK for further consideration and adoption at its 32nd meeting on 14.03.2012.

3 Approach

As a basis for the implementation of the stress test, the ESK initially developed the list of questions [3] which was submitted by the BMU to the competent nuclear licensing and supervisory authorities of the *Länder* on 30.05.2012 with the request to forward it to the operators of the facilities concerned for answering. This questionnaire also includes, in addition to questions on the load cases earthquakes, flooding, heavy rain, other

weather-related events, loss of electrical power, internal fires, external fires, aircraft crashes and blast waves, the stress levels and degrees of protection referred to by the ESK in its assessment. Thus, the assessment criteria were defined before carrying out the stress tests.

In the meetings of the AG SÜ working group, the robustness of the facilities was discussed and assessed systematically, i.e. on the basis of the predefined criteria and load cases (stress levels, degrees of protection). The written answers of the operators as well as statements of the competent supervisory authorities [4-18] but also oral explanations given by some supervisory authorities at the meetings of the AG SÜ were used as a basis for the consultations. In some cases, open questions were answered by the competent *Land* authority subsequent to the meetings [5, 8, 12, 15].

Unlike with nuclear power plants, there are usually no detailed studies on beyond design basis accident sequences and their impacts for nuclear fuel cycle facilities. In its assessment (see Chapters 6 to 9), the ESK has therefore taken into account the validity of the statements. Here, a distinction was made between

- documents reviewed in the supervisory/licensing procedure that contain statements on the situation regarding the stress level,
- documents of the operator not reviewed in a supervisory or licensing procedure, and
- assessments by the operator based on existing expert knowledge (without substantiation by other written documents).

4 Assessment criteria

Assessment criteria of the ESK in the stress test are the following questions:

a) Will the vital functions be maintained at the different stress levels?
b) What maximum effects are realistically conceivable at the different stress levels?
c) Are cliff edge effects foreseeable and have they been considered?
d) On what basis was the assessment made and is it plausible and comprehensible?

In its list of question [3], the ESK provided information at the end of each complex of questions as to which stress level the ESK will apply for its assessment. Concerning the complexes of questions regarding "aircraft crash" and "gas cloud explosion", degrees of protection are used as assessment criteria in analogy to the stress test of the RSK [19].

Since the stress test must also consider long lasting failures, the usual safety functions checked are not comprehensive enough. The ESK therefore uses the term "vital functions" (all functions important for maintaining – also in the long term – the safety of the facility).

A "cliff edge effect" occurs if a sudden rise in the radiological effects outside the facility is registered that is due to the failure of components or measures caused by a load that exceeds the design basis load.

The ESK list of questions [3] also addresses precautionary measures and their failure. By analogy to the technical terms used in connection with nuclear power plants, precautionary measures are to be understood as those measures that prevent a certain failure event from occurring, e.g. because the failure is excluded due to special quality-assuring measures. In a stress test, on the other hand, it also has to be examined how the situation might develop should such a precautionary measure fail after all.

Furthermore, [3] also deals with accident management measures. By analogy to the technical terms used in connection with nuclear power plants, accident management measures are to be understood as those measures that following the occurrence of a beyond design basis event sequence can still limit the consequences, either by mitigating intervention in the further sequence of events or by partial limitation of the release. Only those measures can be subsumed under accident management measures that were explicitly planned in advance and which are laid down in corresponding instructions or can immediately be realised. External disaster response measures are not to be understood as accident management measures here.

5 Questions and stress levels in the ESK stress test

The following shows the list of questions of the ESK of 29.05.2012. It was sent to the competent nuclear licensing and supervisory authorities of the *Länder* by the BMU on 30.05.2012.

A On earthquakes

1 Was a seismic design considered within the licensing procedure?
What earthquake intensity was the facility designed to withstand?
Was the design according to DIN or KTA?
Have any earthquake-related expert reports been prepared (seismological, structural); if so, what was the essential result?

2 Does the seismic design also rest on precautionary measures? If so, on which ones? What will happen if the precautionary measures fail?

3 How does the plant behave in the event of a beyond design basis earthquake (stress level)?
Are there any related studies? Are there any qualitative considerations on how the facility will behave in connection with this level or what damage mechanisms may occur? To what extent may precautionary measures fail or become ineffective in such a case?

4 Are there any considerations for the potential damage mechanisms in connection with the stress level that may be applied from other load cases? If so, what do they take into account?

5 Does the stress level include any interdependent combinations with other load cases that may occur as a consequential effect and have to be taken into account (e.g. subsequent fire)?

6 Are there any accident management measures provided? Can these still be carried out in the event of an earthquake according to the stress level? In what way is the feasibility at the stress levels influenced?

7 Are there any studies available that deal with the question of soil liquefaction in an earthquake at the site?

Basic level: the design earthquake or otherwise the seismic zonation according to DIN 4149.

Stress level: increase of the intensity of the earthquake by 1 compared with the basic level.

B On flooding

1 Against what flood levels (principle of annuality) has the facility been designed? Which measures are provided in this respect?
What conditions will there be in the event of a design flood within the grounds of the facility and on its access road?

2 Is the design against flooding also based on precautionary measures? If so, what are they? What will happen if the precautionary measures fail?

3 How does the plant behave at the stress level for flooding (beyond the design basis)? Are there any related studies? Are there any qualitative considerations on how the facility will behave in connection with this level or what damage mechanisms may occur (here, the failure of precautionary measures also has to be considered)?

4 Are there any accident management measures provided? Can these still be carried out in the event of a flooding according to the stress levels? In what way is the feasibility at the stress levels influenced?

Basic level: the design basis flood.

Stress level 1: For sites located on rivers: a discharge rate that is higher by a factor of 1.5 compared with the design flood. For sites located near tidal waters: a flood that is one metre higher compared with the design flood.
In this context, consequential impacts on the stability of dykes and other protective measures also have to be considered.

Stress level 2: For sites located on rivers: a discharge rate that is higher by a factor of 2 compared with the design flood. For sites located near tidal waters: a flood that is two metres higher compared with the design flood.
In this context, consequential impacts on the stability of dykes and other protective measures also have to be considered.

Stress level 3: Risk was/has to be excluded site-specifically.

C On heavy rain

1 What heavy-rain events were considered in the design? What consequences ensue in this context for the facility? What measures are provided for such a case?

2 Is the design against heavy rain also based on precautionary measures? If so, what are they? What will happen if the precautionary measures fail?

3 How does the plant behave at the stress level for heavy rain?
Are there any related studies? Are there any qualitative considerations on how the facility will behave in connection with this level or what damage mechanisms may occur?

4 Are there any accident management measures provided? Can these still be carried out in the event of heavy rain according to the stress level? In what way is the feasibility at the stress level influenced?

Basic level: The design of the facility against heavy rain corresponds to the rain yield $r_{5,5}$ according to DIN.

Stress level: The safety of the facility will not be impaired also in case of heavy rain with a rain yield of $r_{5,100}$ according to DIN.

D On other weather-related events:

The other weather-related events have to be considered each for itself for the respective facility in question. What has to be considered on any account is:

- storms – also including hurricanes,
- hail,
- snow loads,
- freezing rain, and
- lightning stroke.

It may be that due to local conditions there will be additional weather-related events that have to be considered.

(*Note: answers to be provided separately for each individual kind of weather-related event*):

1 Which of these events was the plant designed to withstand? What corresponding measures are provided? What will the conditions at the site and of the access road be like in these events?

2 Which weather-related events have to be additionally considered due to local conditions?

3 Is the design against other weather-related events also based on precautionary measures? If so, what are they? What will happen if the precautionary measures fail?

4 How does the plant behave at the stress level, i.e. beyond the corresponding design provisions?
Are there any related studies? Are there any qualitative considerations on how the facility will behave in connection with this level or what damage mechanisms may occur?

5 Are there any accident management measures provided? Can these still be carried out in the event of weather-related events according to the stress level? In what way is the feasibility at the stress level influenced?

Basic level: Corresponding design according to DIN.

Stress level: Load cases clearly beyond the corresponding design.
(qualitative consideration taking into account the corresponding potential damage mechanisms).

E On the loss of electrical power:

1 What safety functions or other important functions and systems are dependent on a supply of electrical power? *(Please provide full list.)*

2 How is the electrical power supply and, if any, the emergency/backup power supply for these systems structured? (Explanation by the basic circuit diagrams or verbally; what is important is, amongst others, the clear presentation of which supplies are multiply or diversely available and which exist only once.)

3 *For facilities with emergency/backup power supply:* For what operating times is the emergency/backup power supply designed, including the supply with fuels and auxiliary supplies? What operator actions are necessary at what time to start up and maintain the emergency/backup power supply? Are there any provisions for operation of the emergency/backup power supply beyond the design duration?

4 *For facilities without emergency/backup power supply:* Are there any plans or provisions for the re-establishment of the electrical power supply?

5 How will the plant behave in a longer-lasting total loss of offsite power and emergency/backup power supply?

6 Are there any accident management measures provided? Can these still be carried out according to the stress levels? In what way is their feasibility at the stress levels influenced?

Basic level: Design of the facility.

Stress level 1: Loss of the normal electrical power supply for three days.

Stress level 2: Loss of the normal electrical power supply for one week.

Stress level 3: In addition to stress level 2, loss of emergency power supply for one day.

F On internal fires:

1 What internal fires were considered in the design? What consequences ensue for the facility? What measures are provided?

2 Is the design against internal fires also based on precautionary measures? If so, what are they? What will happen if the respective precautionary measures fail?

3 How will the plant behave at stress level 1 for internal fires?
Are there any related studies? Are there any qualitative considerations on how the facility will behave in connection with this level or what damage mechanisms may occur?

4 Are there any accident management measures provided to limit the consequences? Are they still feasible in the event of an internal fire at stress level 1? In what way is their feasibility at stress level 1 influenced?

Basic level: Design of the facility.

Stress level 1: Fire lasting an hour longer than provided by the facility design. *Note: With this formulation, the ESK intended to cover situations with fire loads for longer fire duration.*

Stress level 2: Due to the limited fire loads, fires lasting longer than provided by the facility design are generally not possible.

G On external fires:

1 Does the facility border on woodland areas and/or on built-up areas where increased fire loads exist and/or on traffic routes along which larger fire loads (which ones?) are regularly transported?

2 What external fires were considered in the design? What consequences ensue for the facility? What measures are provided?

3 Is the design against external fires also based on precautionary measures? If so, what are they? What will happen if the respective precautionary measures fail?

4 How will the plant behave at stress level 1?
Are there any related studies? Are there any qualitative considerations on how the facility will behave in connection with this level or what damage mechanisms may occur?

5 Are there any accident management measures provided to limit the consequences? Are they still feasible in the event of a fire at stress level 1? In what way is their feasibility at stress level 1 influenced?

Basic level: Design of the facility.

Stress level 1: Fire in the area bordering on the facility lasting an hour longer than provided by the facility design.

Stress level 2: Due to the limited fire loads in the area bordering on the facility, any fires or fires lasting longer than provided by the facility design are generally not possible.

H On aircraft crashes:

1 Have the effects of an aircraft crash on the facility been taken into account? If so, what aircraft crashes were assumed in the consideration or in the design? What consequences will ensue from the mechanical as well as the thermal loads ensuing from the events considered?

2 Does the facility lie in the approach path of an airport?

The assessment criteria for a postulated aircraft crash are divided into three degrees of protection. Here, a distinction is made between the mechanical (aircraft impact) and the thermal (kerosene fire) degree of protection in connection with a crash of an aircraft comparable to a Starfighter (degree of protection 1), load-time diagram according to the RSK Guidelines (Phantom) or a medium-sized commercial airliner (degree of protection 2) and additionally a large commercial airliner (degree of protection 3).

Mechanical degree of protection 1:
Maintenance of the vital functions in case of a crash of a military aircraft of the Starfighter type.

Thermal degree of protection 1:
Maintenance of the vital functions at the postulated spillage and fire of fuels in case of a crash of a military aircraft of at least the Starfighter type.

Mechanical degree of protection 2:
Maintenance of the vital functions at the load-time function according to the RSK Guidelines or a load-time function of a medium-sized commercial airliner.

Thermal degree of protection 2:
Maintenance of the vital functions at the postulated spillage and fire of fuels in case of a crash of a Phantom or a medium-sized commercial airliner.

Mechanical degree of protection 3:
Design with the load-time function according to the RSK Guidelines as well as maintenance of the vital functions at a load-time function of a large commercial airliner.

Thermal degree of protection 3:
Maintenance of the vital functions at the postulated spillage and fire of fuels in case of a crash of a large commercial airliner.

I On blast waves

1 Has the facility been designed to withstand a blast wave? On what boundary conditions was the design based?

2 What effects have to be expected in case of a much stronger blast wave than provided for in the design?

3 What amounts of explosive gases have to be expected in the surroundings of the facility (gas cargo vessels, lorries or freight trains with gas freight)? At what distance?

4 For facilities with no special design: What damage may occur due to a blast wave if this cannot be excluded?

The assessment criteria for a postulated blast wave are divided into three degrees of protection.

Degree of protection 1:
It is ensured under the aspect of robustness that vital functions are maintained in the case of impacts according to the requirements of the guideline of the Federal Ministry of the Interior (BMI) for the protection against blast waves, even including any possible consequential damage and the possible loss of personnel as a consequence of the impact.

Degree of protection 2:
If a blast wave occurs that is more intense by 20 % (pressure distribution curve) compared with degree of protection 1, the vital functions are ensured, even including any possible consequential damage and the possible loss of personnel as a consequence of the impact. Infrastructure destructions are taken into account here, also taking possible consequential damage into account. Accident management measures may be considered if these are designed against such impacts or can be obtained from outside the facility in time.

Degree of protection 3:
In the surrounding area and at the site, stationary as well as temporary sources of explosive gases that have a release potential that poses a risk to vital functions are practically excluded.

6 Assessment of nuclear fuel supply facilities

6.1 ANF fuel fabrication plant in Lingen (BFL)

Facility description

The facility manufactures fuel assemblies for light water reactors with low-enriched uranium. The main processing steps of the nuclear fuel are:

- uranium hexafluoride (UF_6) dry conversion (emptying of the UF_6 containers, conversion of UF_6 to uranium dioxide)
- pellet production (addition of additives to the uranium dioxide powder, pressing into green compacts, sintering of the green compacts to produce pellets; grinding of the pellets), and
- fuel assembly fabrication (filling of the pellets into cladding tubes; welding of the cladding tubes, fuel element assembly, fuel assembly cleaning, fuel assembly packaging).

The U-235 enrichment of uranium processed at the BFL varies between 0.20 mass % (depleted uranium) up to a maximum of 5 mass % U-235.

On the premises of BFL, there is nuclear fuel and/or other radioactive material as well as radioactive residues and waste located in the following safety-relevant buildings:

- production building (nuclear manufacturing processes and dry conversion),
- UF_6 storage hall, and
- waste storage facility.

In the following, these parts of the facility are considered together. Nuclear fuel can be located outside the building at the ISO container transhipment point or on the open space for parking of vehicles loaded with nuclear fuel.

Facility concept

The design of the BFL is based on the following protection goals:

- confinement, retention and shielding of radioactive material,
- minimisation and control of the discharge of radioactive material,
- minimisation and control of radiation exposure and contamination of the operating personnel,
- assurance of subcriticality,
- prevention of fires and explosions, or their early detection and effective control,
- prevention of release of uranium hexafluoride.

Basis of assessment
The assessment was primarily based on the response from the operator ANF of 31.07.2012 [7] and the electronic message from the Lower Saxony Ministry for the Environment, Energy and Climate Protection dated 07.12.2012 [8]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test for the BFL were taken into account.

A Earthquake

Design
The design against earthquakes was considered within the licensing procedures. During the construction of the facility it was demonstrated that the building of nuclear production withstands a horizontal acceleration of 1 m/s^2. Further verifications performed under consideration of nuclear safety standard KTA 2201 showed that the buildings and equipment being safety-relevant with regard to the compliance with the protection goals withstand a design basis earthquake of intensity VII. In a later seismic hazard assessment it was demonstrated that a design basis earthquake intensity of VI is to be applied for the BFL site.

Precautionary measures
The design against earthquakes is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
For this site, the design against earthquake is to be based on an earthquake intensity of I = VI. The verifications performed for the design basis earthquake also cover beyond design basis earthquake of intensity I = VII. Radiologically, the other parts of the facility are covered by the considerations on aircraft crash (Section H).

Applicability of damage mechanisms
There are no considerations from other load cases regarding potential damage mechanisms that can be applied to the stress level earthquake.

Combinations with other load cases
The potential consequential impacts of a beyond design basis earthquake in combination with other load cases are covered by the considerations in Section H.

Accident management measures
Accident management measures to bring the facility into a safe state are described in the alarm regulation of the operating manual. According to the description of the seismic impacts in the MSK scale it is expected that these measures can also be carried out after earthquakes of intensity VII.

Soil liquefaction
According to a seismic hazard assessment, soil liquefaction is not to be expected.

Summary assessment on earthquakes
The safety-relevant buildings are designed to withstand earthquakes. In the licensing procedure it could be demonstrated that sufficient margins are available that cover a higher intensity level. Cliff edge effects are not to be expected. Thus, the stress level for earthquake is complied with. The main vital functions of the BFL are maintained and ensure compliance with the protection goals. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. The ESK does not see any impairment of the operability of the facility by earthquakes.

B Flooding

Design
Within the licensing procedure it was established for the site that the premises are to be regarded as flood-safe referred to the 100-year flood of the river Ems.

Precautionary measures
The design against flooding is not based on precautionary measures.

Behaviour at the stress level
Due to the geographical conditions, a risk to the site located 40 m above sea level from flooding is excluded.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
Due to the geographical conditions for this site, no measures for flood protection are required. Cliff edge effects are not to be expected. The ESK notes that stress level 3 is complied with.

C Heavy rain

Design
The flat roofs of the production building, the roof drains and emergency drainage were designed for a rainfall intensity of $r_{5,5}$ = 342 l/(s·ha) in accordance with DIN 1986-100.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
In case of a postulated event with stress levels for heavy rain for this site $r_{5,100}$ = 639 l/(s·ha), rainwater is discharged to the premises. This may lead to localised accumulations of water with a height of a few centimetres.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The assumed rainfall for the design of the facility will have no impact on compliance with the protection goals. Due to the spatial arrangement of production and storage buildings and the technical installations containing fissile material within the buildings, rainwater seeping in through the doors will not lead to an impairment of the protection goals at the stress level. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The stress level is complied with.

D Other weather-related events

Design
The other weather-related events mentioned are not design-relevant load cases for BFL. The buildings were designed according to conventional standards (DIN standards).

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design of the lightning protection and against wind loads is not based on precautionary measures. For maintenance of specified normal operation, the operating manual includes precautionary measures regarding snow loads, hail and freezing rain.

Behaviour at the stress level
There is no identifiable impairment of compliance with the protection goals.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The buildings of the BFL are designed against external hazards, such as wind and snow loads and lightning. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. Thus, the stress level is complied with for all weather-related events.

E Loss of electrical power

Safety functions dependent on power supply
The following systems are dependent on power supply:

- criticality detection and warning system,

- fire alarm systems,
- loudspeakers,
- CO_2 extinguishing system,
- gas detection systems,
- emergency lighting, and
- HF/UF_6 detection system.

Design of the power supply
There are three types of power supply available:

- normal power (10 kV supply from the national grid, available twice, low voltage, available one time),
- emergency busbars (supplied from the 10 kV grid; in the event of loss of offsite power supply, it is supplied from the diesel generator set), and
- emergency power supply (accumulators; charged by chargers from the emergency busbars).

Design of the emergency and backup power supply
The operating times of emergency power supply are designed as follows:

- criticality detection and warning system, loudspeakers: 72 hours,
- fire alarm systems, CO_2 extinguishing system: 30 hours,
- emergency lighting: 3 hours,
- HF/UF_6 detection system: 30 minutes, and
- gas detection system: 30 minutes.

The backup power supply is available for at least ten hours.

Behaviour in case of longer-term total loss of power supply
In case of loss of normal power supply, the valves for all flammable gases are automatically closed. They also do not open again when backup power supply starts. At the same time, the nitrogen valves open automatically so that inertisation of the process installations is reached within 30 minutes. The UF_6 valves are also automatically closed. The facility is in a safe state (fail-safe principle). For reasons of occupational health and safety, the facility will be evacuated.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
The design of the electrical power supply and the emergency and backup power supply complies with the requirements. In case of loss of normal power supply, the facility will be in a safe state after 30 minutes. With regard to emergency power supply, criticality detection will be ensured for three days, emergency lighting for three hours, and the gas detection system for 30 minutes, as well as backup power supply for ten hours. Furthermore, the BFL is equipped with battery-powered hand-held devices for gas detection.

The ESK assumes that an appropriate supply with fuels can also be organised for longer periods. Thus, the ESK holds the view that stress level 2 can be confirmed. The ESK requested the competent supervisory authority to examine what procedures are provided to verify the safe state of the facility after loss of power. The process has meanwhile been initiated [8]. After successful implementation of the procedures, stress level 3 could be confirmed.

F Internal fires

Design
The design is based on the early detection of an incipient fire. The operator states that for prevention, detection and fighting of incipient fires, structural (e.g. fire compartments, for the most part use of non-combustible materials), technical (e.g. fire alarm system, portable fire extinguishers) and organisational (e.g. fire fighting plan in the operating manual, the plant's on-site fire brigade) measures are provided.

Precautionary measures
Measures are provided to prevent a fully developed fire. These include, in particular, staff trained to handle small fire extinguishers and the plant's on-site fire brigade.

Behaviour at the stress level
If the precautionary measures should not be successful, it is not excluded that in certain areas an incipient fire flashes over into a fully developed fire. It is stated for the stress level that also in case of a beyond design basis internal fire, the radiation exposure in the environment will in any case be below the accident planning value.

Accident management measures
There are no accident management measures provided.

Summary assessment on internal fires
The ESK holds the view that according to the available information, only the basic level can be confirmed since a fully developed fire in a fire compartment cannot be excluded if precautionary measures fail. In an overall assessment, however, it is to be considered that no excess of the accident planning values is to be expected in case of a fully developed fire in a fire compartment.

G External fires

Site-specifically adjacent fire loads
The area of the facility borders on woodland areas but not on traffic routes on which larger fire loads are regularly transported. The heat radiation emitted from a forest fire does not cause undue impairment of interiors and containers either.

Design
The design of the facility considers forest fires in the surrounding area of the facility, including flying sparks. Spread of a forest fire on safety-relevant buildings and installations is prevented by structural, technical and organisational measures.

Precautionary measures
The design is not based on precautionary measures.

Behaviour at the stress level
Irrespective of the duration of the forest fire, there will be no spread of an external fire to safety-relevant installations of the BFL due to the fire protection measures taken.

Accident management measures
There are no accident management measures provided.

Summary assessment on external fires
Due to the technical, structural and organisational measures taken during the design phase of the facility, the ESK confirms stress level 1. Cliff edge effects are not to be expected.

H Aircraft crash

Consideration of impacts
The operator notes that due to the low probability of occurrence (the site is not located in the vicinity of airfields) and the limited radiological impacts (maximum effective dose in the area of the nearest residential buildings of about 10 mSv), a design of the facility against aircraft crash is not required. This was most recently confirmed by the licensing authority in 2009. Radiologically, the considerations prior to the construction of the facility regarding the impacts of a high-speed military aircraft can also be deemed as covering the crash of a large civil aircraft.

Location in an airport approach path
The facility is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The facility is not explicitly designed against aircraft crash. Therefore, no thermal or mechanical degree of protection is reached for the facility. In an overall assessment, however, it is to be considered that in case of an aircraft crash, the radiological impacts on the nearest residential buildings will remain limited to a maximum of 10 mSv.

I Blast wave

Design
The facility is located at such a distance from potential sources of explosive substances (other plants, traffic routes) that occurrence of blast waves influencing the facility is not to be feared. This was most recently confirmed in 2008 by the licensing authority. Blast waves potentially occurring inside the plant (gas tank storage facility) are covered by the design against wind loads.

Impacts of stronger blast waves
There are no scenarios conceivable that may result in stronger blast waves.

Site-specific amounts of explosive gases
Larger amounts of explosive gases are not to be expected in the immediate vicinity of the plant. The distance to an underground gas pipeline is 250 m, the distance to the nearest major road (railway line) is 1,500 m.

Potential damage in case of facilities with no special design
A blast wave that could cause damage is excluded.

Summary assessment on blast waves
The facility is not explicitly designed against damage from blast waves. Due to the fact that blast waves that could cause damage are excluded, the ESK confirms degree of protection 3.

6.2 Uranium enrichment plant of company Urenco in Gronau (UAG)

Facility description
The UAG is a uranium enrichment plant based on the gas centrifuge principle. It is used to enrich natural uranium and depleted uranium to the required content for use in light water reactors of up to 6 % U-235.

Plant expansion was carried out in two main phases. The UAG-1 covers all parts of the plant up to a capacity of 1,800 t SWU/a (SWU stands for “separative work unit”, a key variable to describe the capacity of uranium enrichment plants). This plant section was commissioned in 1985 with an initial annual capacity of 400 t SWU/a and, in late 2005, reached its full capacity of 1,800 t SWU/a. In February 2005, the UAG-2 was granted a licence for construction and operation according to which the plant's capacity was expanded to a total of 4,200 t SWU/a by September 2011.

As input material (feed), uranium hexafluoride (UF_6) is used. Enrichment takes place in centrifuge cascades. At the UAG-1, the uranium hexafluoride is transferred to the centrifuge cascades by heating the transport containers in autoclaves to about 70 °C so that the uranium hexafluoride can be liquefied and drawn off as a gas. At the UAG-2, withdrawal takes place through sublimation at 500 mbar from the solid phase.

At the two exits of the centrifuge cascades, the gaseous uranium hexafluoride is transferred into cooled containers, either through desublimers cooled down to 70 °C or pumps, where the uranium hexafluoride desublimes at the walls.

For storage, there are on-site capacities for 10,000 t of feed, and 1,250 t of product, and 38,100 t of tails in the form of uranium hexafluoride

Construction and operation of the UAG are based on licences according to § 7 of the Atomic Energy Act (AtG), taking into account the Safety Requirements for Nuclear Fuel Supply Facilities, Part I "Safety Requirements for Uranium Enrichment Plants Based on the Gas Ultra Centrifuge Principle" ("*Sicherheitsanforderungen für Kernbrennstoffversorgungsanlagen, Teil I "Sicherheitsanforderungen für Urananreicherungsanlagen nach dem Gasultrafzentrifugenprinzip"*) [21].

From the safety requirements for gas centrifuge uranium enrichment plants [21] applicable to the UAG, the following general protection goals with which the technical design and operation of the plant must comply are derived:

- safe confinement and retention of radioactive material,
- assurance of subcriticality, and
- avoidance of unnecessary radiation exposure and dose rate.

Major design features of the UAG are:

- operation of the main plant components under negative pressure,
- prevention of release of radioactive material during specified normal operation,
- limitation and minimisation of potential accidental releases through multi-barrier principle,
- fail-safe principle,
- no residual heat, and
- no fission products.

Basis of assessment
The assessment by the ESK is primarily based on the letter from the competent supervisory and licensing authority [4] with Annexes 1 and 2 and a supplementary letter from the operator to the competent authority [5, Annex 1]. Moreover, the results of informational talks with the competent licensing authority on the stress test for the UAG were taken into account.

With regard to the intention of the stress tests, only potential nuclear risks were considered for the UAG but not issues related to the chemical toxicity.

A Earthquake

Design
Due to the sensitivity of the centrifuge to vibrations, the UAG was built on a site that is located outside the earthquake zones in Germany according to DIN 4149 and DIN EN 1998-1/NA. Nevertheless, relevant parts of

the plant were designed to withstand earthquakes or subjected to seismic safety assessments respectively.

As part of the licensing procedure for the UAG-2, a design basis earthquake of intensity I = VI-VII was defined. These parameters were used as a basis for the design of the buildings and plant parts of the UAG-2 and the verification of stability of the buildings of the UAG-1 designed against earthquakes under consideration of nuclear safety standard KTA 2201.1.

For parts of the UAG-1 not designed against earthquakes, it was demonstrated in the framework of the licensing procedure that the doses at the plant fence determined according to the incident calculation bases (*Störfallberechnungsgrundlagen*) remain far below 50 mSv.

Precautionary measures
Precautionary measures are specified in the operating manual of the UAG. These mainly concern the procedure for external hazards (earthquakes, pressure wave) and the behaviour in case of UF_6 release. In the event of a failure of precautionary measures, the measures of the on-site emergency preparedness plan become effective.

Behaviour in the event of beyond design basis earthquakes
Based on plausibility considerations, the operator states that the UAG-2 has sufficient safety margins also in case of beyond design earthquakes of intensity level I = VII to VIII, and that the UAG-1, too, will withstand the more intense earthquake without significant damage. Significant damage and damage to the infrastructure of the UAG that cannot be remedied in the short term are not to be expected for the beyond design basis earthquake either so that the effectiveness of precautionary measures will be maintained.

Applicability of damage mechanisms
There are no considerations from other load cases regarding potential damage mechanisms that can be applied to the stress level earthquake.

Combination with other load cases
Based on the seismic design and the low fire loads in the plant, the operator explains in a plausible manner that also in the event of a beyond design basis earthquake and subsequent fire no higher radiation exposure is to be expected than previously assumed, especially since in case of a fire, further distribution of pollutants and thus a reduced pollutant concentration would occur. This also agrees with the results of analyses on the consequences of a fire in combination with an aircraft crash (see Section H).

Corresponding considerations on possible fire events and higher UF_6 releases in combination with external hazards were performed for the UAG-1 which showed no undue radiation exposure in the environment.

Accident management measures
There is an on-site emergency preparedness plan describing all the technical and organisational measures for hazard prevention and damage mitigation. These relate to the internal and external alarm and the appropriate measures to be taken.

The UAG has a fire brigade which is permanently on site in squad size so that the plant is not directly dependent on external aid in case of external hazards. The fire station is designed to withstand earthquakes. In addition to the permanently installed fire extinguishers, there are also several alternate extinguishing options available to the fire brigade. Rescue and supply vehicles can reach the plant via various access routes.

It can be assumed that the accident management measures can also be carried out at the stress level.

Soil liquefaction
The question of soil liquefaction was considered in geotechnical reports and taken into account during construction accordingly.

Summary assessment on earthquakes
Although the UAG was built at a site located outside the earthquake zones in Germany, the safety-relevant buildings and plant components were designed to withstand earthquakes. The operator plausibly explained that the UAG has sufficient design margins also in the event of a beyond design basis earthquake and subsequent fire.

Cliff edge effects are not to be expected. It is to be assumed that the precautionary and accident management measures can also be carried out at the stress level. Thus, the ESK considers the stress level to be complied with for the UAG although the seismic design is below the acceleration of 0.1 g as required in the EU stress test.

B Flooding

Design
The UAG site is located inland with no major rivers nearby. In accordance with the safety requirements, the plant is located at a flood-free site. Nevertheless, a 10,000-year flood was considered within the licensing procedure in 2004 according to nuclear safety standard KTA 2207. The design of the plant ensures safe confinement of radioactive material and criticality safety even in case of flooding.

Precautionary measures
With regard to flooding, the design of the plant is not based on precautionary measures as this is not necessary due to the site location and the design. The plant fire brigade permanently available on site was already mentioned in Section A.

Behaviour at the stress level
As part of the stress test, a study was commissioned to determine the water level reached in a scenario with a discharge rate 1.5 times the discharge rate of a 10,000-year flood. The expert comes to the conclusion that the site and the access road are not at risk of being flooded even in case of this extreme event.

Accident management measures
With regard to flooding, the design of the plant is not based on accident management measures as this is not necessary due to the site location and the design.

Summary assessment on flooding
Due to the geographical conditions (receiving water with a very small catchment area, terrain), the ESK notes that the UAG complies with stress level 3. Cliff edge effects are not to be expected.

C Heavy rain

Design
The verification performed for the rainwater drainage system of the UAG was based on a model rainfall with a precipitation duration of 30 minutes and a rainfall of 20.6 mm. Here, the maximum amount of precipitation is 9.9 mm in five minutes, thus covering the rainfall intensity corresponding to basic level $r_{5,5}$ at the Gronau site with a precipitation of 7.9 mm. The plant has no internal rainwater downpipes.

Precautionary measures
With regard to heavy rain, the design of the plant is not based on precautionary measures as this is not necessary due to the geographical conditions.

Behaviour at the stress level
In case of heavy rain according to the stress level ($r_{5/100}$), the required retention volume amounts to 2,150 m^3 approximately. Since the effective volume of the existing retention basin is 19,700 m^3, the plant still has substantial design margins even at the stress level.

Accident management measures
With regard to heavy rain, the design of the plant is not based on accident management measures.

Summary assessment on heavy rain
Also in the case of heavy rain, flooding of the plant is not to be feared due to the geographical situation. Moreover, the rainwater retention basin has significant margins and plant safety is not compromised due to the design even if flooding is postulated (see Section B). Thus, the ESK notes that the UAG complies with the stress level with regard to heavy rain.

D Other weather-related events

Design
The operator considered the required load cases in detail. The design complies with DIN regulations (basic level). In addition, experiences with the hurricane Kyrill (18./19.01.2007) and the snowfall event in the Münsterland region (25./26.11.2005) were evaluated.

Site-specific weather-related events
Weather-related events beyond the design basis are not to be feared.

Precautionary measures
The operating manual of the UAG includes regulations for the handling of UF_6 packages in the outdoor area in case of weather-related influences. However, these are mainly due to the chemotoxic properties of the material.

Behaviour at the stress level
A comparison of the higher loads due to blast waves with respect to the design against weather-related influences and the design of lightning protection equipment against lightning current parameters which can only be reached in mountainous regions and for very tall buildings in Southeast Asia shows that the UAG has significant design margins.

Accident management measures
Due to the robustness of the plant against other weather-related events beyond the design, no accident management measures are provided and not necessary either.

Summary assessment on other weather-related events
The UAG is designed to withstand the impacts from storm, snow and frost/ice and has significant margins also in case of beyond design basis events. Special site-specific weather events are not to be postulated.

Thus, the ESK notes that the UAG complies with the stress level regarding other weather-related events. Cliff edge effects are not to be expected.

E Loss of electrical power

Safety functions dependent on power supply
Since the UAG is designed according to the fail-safe principle, release of radioactive material cannot occur even in case of a total loss of supply from the grid and emergency power supply during normal operation. In such a case, the enrichment process is interrupted immediately.

According to the operating manual of the UAG, safety-relevant systems are those that serve to identify and control design basis events. These are, among others,

- active safety installations with emergency power supply:

  - ventilation in the UTA-1 separation plant and in the TI-1 building in case of incidents,
  - the functions of the GAN exhaust system, equivalent to those of the ventilation in case of incidents, in the UTA-2 separation plant and in the TI-2 building in case of activity release, and
  - emergency power generators and uninterruptible power supply for active safety installations, and the monitoring and alarm systems stated below.

- installations for monitoring and alerting:

  - radiation monitoring, fire alarm systems, criticality alarm system, earthquake instrumentation, alarm and call system, and
  - fire protection systems and equipment in all buildings with safety-relevant installations.

In accordance with the safety requirements, power supply to these monitoring and alarm systems is designed as an uninterruptible power supply and redundantly.

Design of the power supply
Electrical energy is supplied to the UAG via two redundant lines connected to the local 110 kV grid. Via the 110 kV outdoor switchyard, each of these two supply lines can provide the total plant power through two redundant 110/10-kV outdoor transformers with an electrical capacity of 40 MVA each.

Should the above installations not be available, diesel emergency power supplies and uninterruptible power supply (UPS) will ensure electrical power supply for the following consumers:

- safety-relevant consumers,
- availability-relevant consumers, and
- consumers of investment protection.

Emergency power for the UAG is supplied by a total of six diesel generators. For the UTA-1 separation plant and the TI-1 building, there are four emergency diesel generators available with 1,000 kVA each, one of them serving as a backup diesel generator. For the UTA-2 separation plant and the TI-2 building, there are two redundant emergency diesel generators available with 2,900 kVA each.

The diesel generators are designed as normal standby generators and start automatically in case of loss of normal power supply. In the diesel buildings, each diesel generator has a space that is separated by fire-resistant partitions. This ensures both a spatial and functional separation of redundancies.

The uninterruptible power supply is used to provide battery-buffered electrical power for safety-relevant consumers for a specified period of autonomy (15 minutes) in case of loss of the low voltage grid, which provides power supply during normal operation and emergency power operation.

Design of the emergency and backup power supply
The level of the fuel storage tanks is checked weekly. In addition, there are automatic alarm signals sent to the central control room if values fall below specified levels. Refilling of the fuel storage tank in response to it ensures that fuel is always available for operation for at least 64 hours.

The measures of the operating personnel to be taken after a loss of offsite power are defined in operating instructions. In case of a foreseeable loss of offsite power lasting longer than only a few hours, refilling of fuel is provided. Consumers where interruption of power supply is admissible for a period of up to 40 seconds are supplied via emergency power supply. If power supply must be available for a consumer without interruption, this consumer is supplied via the uninterruptible power supply. The uninterruptible power supply is designed for an autonomy period of 15 minutes.

The emergency/backup power supply complies with the Safety Requirements for Nuclear Fuel Supply Facilities, Part I.

Behaviour in case of longer-term total loss of power supply
The UAG is designed according to the fail-safe principle. This means that even in case of a total loss of supply from the grid and emergency power supply it is automatically transferred into a safe state so that there will be no releases of radioactive material.

From the point of view of the ESK, the snowfall event in the Münsterland region of 25./26.11.2011 can be understood as an experimental stress test. There was a loss of power supply to the UAG lasting several days during which all systems and measures functioned as designed. The plant was shut down according to the fail-safe principle as provided by design, while temperature and pressure conditions were regulated such that clogging of the pipes by solidified UF_6 was prevented. Monitoring systems could continue operation with battery backup.

Accident management measures
Due to the fail-safe principle, accident management measures are not required for the UAG.

Summary assessment on the loss of electrical power
The UAG has an emergency/backup power supply that complies with the Safety Requirements for Nuclear Fuel Supply Facilities, Part I “Safety Requirements for Uranium Enrichment Plants Based on the Gas Ultra Centrifuge Principle”.

Due to the design of the UAG according to the fail-safe principle, neither the loss of normal power supply nor the loss of emergency/backup power supply will lead to releases of radioactive material. Thus, the ESK considers stress level 3 to be complied with for the UAG.

For better understanding, however, the ESK recommends to clarify how long battery-operated safety systems can be operated and whether the plant operating procedures include checklists/procedures for the case that the plant has already been transferred into a safe state and measures to monitor this condition are to be performed.

F Internal fires

Design

By structural, technical, operational and organisational measures, the UAG is designed and operated so that fires and explosions are prevented. This is achieved by having implemented the following fire prevention measures:

- A fire is prevented by passive fire protection measures (structural design, creation of fire compartments, minimisation of fire loads, lightning protection).

- Effective fire fighting in case of fire can be provided by active fire protection measures (fire alarm system with automatic and manual spray deluge systems, gas extinguishing system, small mobile extinguishers, smoke and heat exhaust ventilation systems).

For fire suppression, Urenco has an on-site fire brigade, officially recognised by the district government of Münster (*Bezirksregierung Münster*), which can quickly fight incipient fires.

The buildings of the UAG were designed and constructed such that fire compartments were created according to the process-related requirements with a fire resistance of at least 90 minutes. In some fire compartments, the fire loads are so low that the fire durations determined according to DIN 18230 are below the fire resistance duration of the individual fire compartments and a fire remains limited to the fire compartment concerned.

As further protective measure, a fire alarm system is in place to automatically detect any incipient fire and to limit fire propagation to the initial fire compartment by actuation of fire dampers.

In the licensing procedures of the UAG, local fire was examined in accordance with the safety requirements, also postulating fire events in the area of systems where there is radioactive material with component failure and release of radioactive material. Even with conservative assumptions, the radiation exposure resulting from the enveloping fire event lies well below the limits of § 50 of the Radiation Protection Ordinance (StrlSchV) in conjunction with § 117 (16) of the Radiation Protection Ordinance (StrlSchV).

Precautionary measures

The design of the UAG is based on fire prevention measures. Moreover, the operating manual of the UAG specifies measures to prevent any incipient fire or to minimise the consequences of a fire.

The plant design against internal fires is also based on precautionary measures, such as the plant’s on-site fire brigade, supply of water for fire fighting via ring main system, water storage pond for fire fighting, various access routes and operating instructions in case of a fire. In the event of a failure of precautionary measures, the measures of the on-site emergency preparedness plan become effective.

Behaviour at the stress level
Due to the design of the plant with minimisation of the fire loads, the passive and active fire protection measure, and the measures specified in the operating manual it is ensured that fires in the plant have a maximum duration of 90 minutes; this was also considered in the design basis.

Accident management measures
Accident management measures are specified in the on-site emergency preparedness plan to limit the consequences of internal fires. These can be taken at any time since fires with durations beyond the design basis are not possible.

Summary assessment on internal fires
From the point of view of the ESK, fires with longer durations than those considered in the design basis can be ruled out for the UAG. Thus, the UAG complies with stress level 2.

G External fires

Site-specifically adjacent fire loads
There are no built-up areas adjacent to the UAG with increased fire loads. The nearest forest, as the largest natural fire potential, is about 175 meters from the tails storage facility. Further, there are no traffic routes in the immediate vicinity of the UAG on which larger fire loads are regularly transported. For these reasons, the operator states that no spread of an external fire to the UAG is to be considered.

The competent supervisory authority also states that the distances to neighbouring facilities and the amount of extinguishing agent available are so large that it can be assumed that any fire spread can be prevented by the plant's on-site fire brigade.

Design
The design of the building was carried out in accordance with § 35 of the building code for North Rhine-Westphalia (BauO NRW). Due to the large distances to adjacent buildings and facilities, external fires spreading to the UAG were not considered. The roof of the building is resistant to flying sparks and radiant heat.

Precautionary measures
Due to the environmental situation, no special precautionary measures are provided against external fires. However, the UAG has a fire brigade which is permanently on site and operating instructions for the behaviour in case of internal fires (see Section F).

Behaviour at the stress level
Due to the environmental situation, the operator states that danger to the plant from external fires is not to be feared. The competent supervisory authority also states that the distances to neighbouring facilities and the amount of extinguishing agent available are so large that it can be assumed that any fire spread can be prevented by the plant's on-site fire brigade.

Accident management measures
There are no special precautionary measures provided against external fires. However, the UAG has a fire brigade which is permanently on site and operating instructions for the behaviour in case of internal fires (see Section F).

Summary assessment on external fires
Due to the limited fire loads in the area adjacent to the UAG, danger to the plant caused by external fires is not to be postulated. Thus, the ESK considers stress level 2 to be complied with for the UAG. Cliff edge effects are not to be expected. However, the ESK recommends paying attention to possible consequences for the UAG in case of future changes in local construction planning.

H Aircraft crash

Consideration of impacts
The accidental crash of an aircraft was postulated within the licensing procedure for the 4,500 t SWU/a plant, considering various possible accidents and aircraft types.

Location in an airport approach path
The UAG is not located in the approach path of an airport. The nearest airport (Twente) is around 14 km away.

Summary assessment on aircraft crashes
The ESK comes to the conclusion that at present a clear classification cannot be made on the basis of the various studies submitted to the ESK[1]. However, it is clear that in the considered scenarios no cliff edge effect is to be expected with regard to releases.

I Blast wave

Design
The main plant components of the UAG are designed against blast wave. The design of the UAG considers the failure of gas pipes on the premises and in the area, the explosion of a truck filled with 12 t pressure-liquefied hydrocarbons and a tank car filled with 60 t pressure-liquefied hydrocarbons, as well as the failure of a 1-m^3-compressed air reservoir.

Impacts of stronger blast waves
The operator plausibly explained that, due to the conservative design boundary conditions (tank capacity of the

[1] On this issue, there are documents requiring confidentiality which were not considered here.

tankers actually used one third of the volume considered in the design as a maximum, leading to a design margin of 15-17 %) and the design margins of the building structures based on engineering assessment, the plant can withstand much larger blast waves than realistically to be postulated.

Site-specific amounts of explosive gases
In the surrounding area and at the UAG site, there are no stationary sources of explosive gases. Temporary sources are realistically to be excluded but were considered in the design of some buildings (conservatively).

Potential damage in case of facilities with no special design
For the plant components of the UAG-1 not designed against blast waves, source terms were determined in the accident analyses and it was demonstrated by means of dispersion calculations performed according to the incident calculation bases (*Störfallberechnungsgrundlagen*) that the doses to be expected at the plant fence remain far below 50 mSv.

Summary assessment on blast waves
The main plant components are designed to withstand blast waves. The assumptions considered in the design are very conservative. Stationary sources of explosive gases at the site and in the surrounding area do not exist. Thus, regarding blast waves, the ESK confirms degree of protection 3 for the UAG.

7 Assessment of storage facilities for spent fuel and heat-generating radioactive waste

7.1 Protection concept

The storage facilities for spent fuel and heat-generating waste considered here comprise a total of 16 storage facilities which fall within the scope of applicability of the ESK recommendation “Guidelines for dry cask storage of spent fuel and heat-generating waste” (“*Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnder radioaktiver Abfälle in Behältern*”) [22]. Dry storage of spent fuel from light water, high temperature as well as prototype and research reactors is performed, as is the case with canisters with vitrified fission product solutions from the reprocessing of spent fuel, in tightly sealed metal transport and storage casks (TLBs) (*Transport- und Lagerbehälter* - TLB).

The TLBs consist of a thick-walled cask which is tightly sealed with a monitored double-lid closure system consisting of two independent lid barriers with metallic seals. In most cases, there are cooling fins at the outer shell to ensure safe passive heat removal. For protection against weather-related influences, a protective plate is mounted to the secondary lid.

At the time of their emplacement in the storage facility, the TLBs have an approval under traffic law as a type B (U) package according to the dangerous goods regulations. It was demonstrated for the TLBs in the configuration being relevant under traffic law that they withstand, in part cumulative, test conditions of traffic law and that the shielding function, criticality safety and tightness are maintained according to the protection goals under traffic law.

The design of the TLBs ensures that during storage under the conditions of specified normal operation and design basis events, the fundamental protection goals

- safe confinement of radioactive material,
- safe removal of decay heat,
- assurance of subcriticality, and
- avoidance of unnecessary radiation exposure

are reliably met. The design of the casks also ensures that even in case of beyond design basis events, no severe accident management measures according to the basic recommendations for disaster control will be required.

The TLBs are stored in a hall which serves, within their approved design, as a structural installation for the storage of the TLBs and is equipped, in particular, for cask transport, leak tightness monitoring, cask maintenance, as well as for radiation protection measurements and fire fighting. The storage hall is designed such that the heat resulting from decay in the casks can safely be removed. Appropriate openings in the walls of the building and in the roof allow natural convection. Due to the structural design of the storage hall, there is a reduced radiation exposure in the environment from direct and scattered radiation. The annual local dose at the fencing is far below the limit according to § 46 of the Radiation Protection Ordinance (StrlSchV) of an effective dose of 1 mSv/a for members of the general public.

Regarding the structural design of the storage facilities, a distinction can be drawn between the STEAG concept (wall thickness approx. 1.2 m, one-nave building), implemented at the sites Brokdorf, Brunsbüttel, Grohnde, Krümmel, Lingen and Unterweser, and the WTI concept (wall thickness approx. 0.85 m, two-nave building), implemented at the sites Biblis, Grafenrheinfeld, Gundremmingen, Isar and Philippsburg. At the Neckarwestheim site, the storage halls were built in the form of storage tunnels. While the storage facilities Gorleben and Greifswald already constructed before correspond to the precursors of the WTI concept, the AVR cask storage facility in Jülich was built directly adjacent to the existing storage hall II.

As part of the nuclear licensing procedure for the dry storage of inventories, the necessary verifications were performed for specified normal operation as well as for the design basis accidents to be postulated and the beyond design basis events to be considered. In particular, it was demonstrated that the construction of the casks ensures the required safety with respect to design basis accidents and beyond design basis events.

7.2 On-site storage facilities

7.2.1 Philippsburg on-site storage facility

Basis of assessment

The assessment was primarily based on the letter from the Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector dated 31.08.2012 [13] and the response from the operator EnBW of 30.08.2012 [13, Annex 1]. Moreover, the results of informational talks with the competent supervisory and

licensing authority on the stress test for the Philippsburg on-site storage facility were taken into account.

A Earthquake

Design
The design against earthquake was considered within the licensing procedure. The KKP storage facility is designed for a design basis earthquake with a horizontal peak ground acceleration of 2.1 m/s^2. The storage building was designed in accordance with the provisions of the KTA.

The seismic conditions at the site of the KKP storage facility were analysed on behalf of the EnKK under consideration of historic earthquakes and metrological investigations and assessed to be conservative. The conservatism and validity of the design spectrum used were confirmed by the Federal Institute for Geosciences and Natural Resources.

Precautionary measures
Precautionary measures were not considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes
The storage facility is designed to withstand a design basis earthquake. The maximum design intensity is in a range for which no serious damage to the building is to be expected also in case of an earthquake with an intensity level higher by 1 than this intensity. This is due to the conservative approach to the definition of the design basis (nuclear safety standard KTA 2201) as well as to the margins in the models and calculation methods used.

Applicability of damage mechanisms
There are no appropriate considerations from other load cases regarding potential damage mechanisms that can be applied to the stress level earthquake.

Combinations with other load cases
a) Superposition of earthquake and fire:
Earthquake-induced fires with undue thermal stresses on the casks are excluded due to the low fire loads within the storage facility and adequate fire fighting measures for fires outside the storage facility in the event of earthquakes at the basic level and the stress level.
b) Superposition of earthquake and flooding:
When postulating a lock break due to an earthquake, a tidal wave starting from upstream would have to be expected. For the determination of the design basis flood level, the postulated tidal wave which would occur in case of the assumed destruction of the dams above the power plant site has already been evaluated. This tidal wave would be small due to the location and the stored water content of the dams compared to flooding from precipitation and snow melt.

Accident management measures
There are no accident management measures provided.

Soil liquefaction
The topic of soil liquefaction caused by earthquake-induced vibrations was dealt with by the Federal Waterways Engineering and Research Institute (*Bundesanstalt für Wasserbau - BAW*) in connection with the construction of the KKP-2 nuclear power plant. Since the subsurface conditions described therein confirmed the results of the subsoil investigations for the storage facility and filling has a high soil density and a comparable permeability, liquefaction under earthquake loading can be excluded in the area of the storage facility.

Summary assessment on earthquakes
The building structure of the KKP storage facility is designed to withstand earthquakes in accordance with nuclear safety standard KTA 2201 so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 2.1 m/s^2 exceeds the minimum acceleration of 0.1 g required by the EU (= 1 m/s^2). The ESK considers the margins existing due to the KTA design not to be sufficiently quantified to confirm compliance with the stress level for the building. Due to the construction, however, it can reasonably be expected that confirmation is possible, but the casks would ensure compliance with the protection goals also in case of a postulated collapse of the storage building.

The main vital function of the Philippsburg storage facility is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes either.

The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The design flood on which the design of the storage facility is based has, in accordance with nuclear safety standard KTA 2207, a return period of 10^4 years and was determined for the Philippsburg site with 99.9 m above sea level. Due to the amendment of nuclear safety standard KTA 2207, the boundary conditions were reviewed under consideration of current discharge events and the design basis flood level of 99.9 m above sea level was confirmed. This flood level does not require any measures. The design basis water level of 99.9 m above sea level is 0.4 m below the altitude of the power plant site of 100.3 m above sea level and, as a minimum, 0.55 m below the accesses to the power plant buildings and to the storage facility (100.45 m above sea level). The postulated design basis flood would cause no damage at the power plant site. The accesses to the buildings would be fully available. Reductions with regard to power supply and the availability of working materials are not to be expected. The access roads to the storage facility at the power plant site are passable.

Precautionary measures
The design against flooding is not based on precautionary measures.

Behaviour at the stress level
Basic level: For the design basis flood level, a maximum peak discharge of 7,000 m³/s was calculated. In case of a peak value of 5,000 m³/s and higher, the main dykes to the left and the right of the Rhine would be flooded in the section considered and the water of the design basis wave would flow into the floodplain to the left and right of the Rhine. Taking into account the discharge cross section thus postulated to be larger, the relevant water level at the KKP site would reach a height of 99.40 m above sea level. Additional consideration of an orographic lift with 0.50 m finally results in the maximum height of the design basis water level of 99.90 m above sea level.

Stress levels 1 and 2: In case of a peak discharge increased by a factor of 1.5 and 2.0 of 10,500 m³/s and 14,000 m³/s respectively, the water level would rise. Since the main dykes to the left and the right of the Rhine would already be flooded, the water level would depend on the local conditions, the size of the retention surfaces and the time spans involved. Studies on the water levels reached in case of increased peak discharge are not available. The protective functions of the cask are maintained independent of the water level.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed. Ingress of water into the storage building would not impair the protective function of the TLBs.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels 1 or 2 also depends on the presentation of additional verifications and their confirmation.

Cliff edge effects are not to be expected. Although the design of the storage building only complies with the basic level, the ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
The roof surfaces of the storage building and the downpipes were designed for a rainfall intensity of 300 l/(s·ha) in accordance with DIN 12056 and DIN 1986-100. The buried rainwater pipes were designed for a

rainfall intensity of 152 l/(s·ha) and a rain frequency of 0.5/a for the entire sealed surface in the area of the storage facility.

The assumed rainfall intensity will have no impacts on the storage facility. To ensure rainwater runoff, the roof drains are regularly checked and cleaned.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
When postulating an event with stress level for heavy rain, overloading of the roof outlets and downpipes could occur, thus resulting in an accumulation of water on the roof beyond the design basis. In extreme cases, rainwater could enter the loading or storage area of the storage facility via the threshold of the roof exit or via the exhaust openings. On the roof surface of the access and supply area, the water would accumulate up to the attic and then run off via the attic. When postulating overloading of the buried rainwater pipes and resulting flooding of the outside facilities, the ingress of rainwater into the storage building would not have to be postulated since the outside facilities are located about 15 cm below the ground level of the storage building and the accumulating water would run off into the lower areas of the KKP power plant site outside the fence of the KKP storage facility.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the storage building roof surfaces against weather-related impacts roughly corresponds to the basic level. The design of the buried rainwater pipes does not comply with the basic level but does not lead to a flooding of the storage facility due to the spatial layout of the buildings. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
The other weather-related events stated are no design-relevant load cases for the Phillipsburg storage facility.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by weather-related events is excluded due to the robust construction of the storage hall.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The on-site storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is not to be expected due to the robust construction of the storage hall.

All site-specific measures implemented for the drainage of water and maintenance of accessibility to the building are to be understood as precaution for the protection of property. Precautionary and accident management measures are not required. A failure of the storage building postulated nonetheless would not compromise compliance with the protection goals. Protection against mechanical loading would be represented by the TLBs, heat removal from the casks would also be ensured if the casks would temporarily be buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The postulated loss of power supply would not have safety-relevant impacts on the casks and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Design of the power supply

Electrical power supply in the storage facility is divided into three supply qualities:

- Normal grid connection:
  Via this grid connection, those components are supplied with power whose failure has no impacts on the overall facility in case of voltage interruption.

- Backup power supply:
  In case of failure of the normal grid connection, power supply is automatically switched to another grid connection or to the independent diesel-based backup power supply. Here, switchover is not uninterruptible. Components subject to more stringent requirements regarding their availability are connected to this supply. After voltage restoration, the components may restart automatically.

- Uninterruptible power supply (UPS) backup power supply:
  In case of loss of normal power supply, power supply is automatically switched to the diesel-based backup grid. The period of switchover is bridged by a UPS system. Those components are connected to this supply which should be supplied without interruption due to their technical requirements.

Design of the emergency and backup power supply
Backup power supply via another grid connection is not limited in time. The operating time of diesel-based backup power supply is designed for a period of 17 hours. The actual operating load is, however, well below the design basis value. Therefore, a much longer operating time of the backup power supply system than 17 hours is to be expected. For this period, fuel and further auxiliary supplies are available in sufficient quantities. For a further period, refuelling would be possible. The consumption of the auxiliary supplies is so low that no refilling would be necessary here for a longer period of time. Refilling would be possible from inventories at the KKP with an own tanker.

Behaviour in case of longer-term total loss of power supply
The postulated loss of power supply would not have safety-relevant impacts on the casks and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
The postulated loss of power supply would not have safety-relevant impacts on the casks and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as cask monitoring system and fire alarm system, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
The design is based on a fire of a transport vehicle in the entrance area. The postulated fire would not affect the tightness of the TLBs. A vehicle fire would immediately be detected by the staff and controlled by fire fighting measures (initial fire fighting by staff or available on-site fire brigade).

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

Accident management measures
There are no accident management measures provided.

Summary assessment on internal fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. The tightness of the TLBs would also be ensured in case of postulated impacts by fire. In addition, effective preventive fire protection in the storage areas of storage facilities is realised by only admitting negligible fire loads within the storage areas. Compliance with this preventive fire protection is ensured by administrative regulations. Due to the limited fire loads in the area adjacent to the facility, fires beyond the design basis are not possible.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
The area of the facility does not border on woodland areas, not on built-up areas with increased fire loads and not on traffic routes on which larger fire loads are regularly transported.

Design
The design considers wildfires (wasteland) outside the facility. Due to the distance between storage building and security fence of at least 60 m, there will be no consequences for the facility. Fire extinguishing systems to

fight such wildfires are in place.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible.

Accident management measures
There are no accident management measures provided.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, immediate danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the surrounding area. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of a postulated crash of a high-speed military aircraft were considered for the storage facility and are covered by the design of the TLBs. In addition, the impacts of a postulated crash of a commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The Philippsburg on-site storage facility is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal

impacts were also examined. The examinations performed by the Federal Office for Radiation Protection (BfS) showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. For the aspect “aircraft crash”, the ESK holds the view that the requirements of the mechanical and thermal degree of protection 3 are fulfilled due to the design of the TLBs.

I Blast wave

Design
The storage facility is not designed to withstand pressure waves from chemical reactions since there are no materials and installations at the facility site and its immediate vicinity that can cause an explosion with significant impacts on the stability of the storage facility, or the minimum distances according to the Guideline for the Protection of Nuclear Power Plants are complied with, respectively.

Impacts of stronger blast waves
Due to the seismic design of the building, protection is generally also given against blast waves. In case of a failure of the building structure postulated nonetheless, energy from the pressure wave would be dissipated by the building structure and its failure so that only a reduced impact on the cask would have to be postulated. The cask is designed to withstand blast waves and compliance with the protection goals will also be ensured when postulating the collapse of the storage building.

Site-specific amounts of explosive gases
Larger amounts of explosive gases are not to be expected in the immediate vicinity of the storage facility. The distance to the Rhine is 750 m and the distance to the nearest major road is 1,100 m.

Potential damage in case of facilities with no special design
Collapse of the storage building may occur. The mechanical loads for the casks are covered by the considerations on aircraft crash.

Summary assessment on blast waves
Although there may be explosives at the site (e.g. liquid gas tankers on the Rhine), these can cause no impacts affecting the TLBs in their function. Earthquake-induced damage to the buildings themselves cannot result in an undue impairment of heat removal from the TLBs.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.2 Neckarwestheim on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector dated 31.08.2012 [13] and the response from the operator EnBW of 30.08.2012 [13, Annex 2]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test for the Neckarwestheim on-site storage facility were taken into account.

A Earthquake

Design
The Neckarwestheim storage facility (ZL GKN) was designed against earthquakes in the framework of the licensing procedure. Within the licensing procedure, the structural design of the ZL GKN was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of 1.95 m/s^2, were considered in the structural design of the storage building.

Precautionary measures
Precautionary measures were not considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes
The storage facility is designed to withstand a design basis earthquake. The maximum design intensity is in a range for which no serious damage to the building is to be expected also in case of an earthquake with an intensity level higher by 1 than this intensity. This is due to the conservative approach to the definition of the design basis (nuclear safety standard KTA 2201) as well as to the margins in the models and calculation methods used.

Applicability of damage mechanisms
There are no appropriate considerations from other load cases for potential damage mechanisms that can be applied to the stress level earthquake.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated since

- fires in the tunnel area are prevented because there are no installations that release flammable substances in case of loss of integrity, and the spread of fires outside the tunnel areas to it does not occur,

- there are no systems in the storage facility with high energy potential (pressure, temperature) that could explode after an earthquake event, and

- a drop of heavy loads onto the TLBs is to be excluded or, in case of postulated drop, the impacts are covered by those from an aircraft crash.

Accident management measures
There are no accident management measures provided.

Soil liquefaction
The ZL GKN is founded on rock or rock-like subsoil. Soil liquefaction can therefore be excluded.

Summary assessment on earthquakes
The entire building structure of the ZL GKN is designed against earthquakes so that a failure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 1.95 m/s^2 exceeds the minimum acceleration of 0.1 g required by the EU (=1.0 m/s^2).

The ESK considers the margins existing due to the KTA design not to be sufficiently quantified to confirm compliance with the stress level for the building. Due to the construction, however, it can reasonably be expected that confirmation is possible, but the casks would ensure compliance with the protection goals also in case of a postulated collapse of the storage building.

The main vital function of the ZL GKN is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes.

The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
For the ZL GKN, the 10,000-year flood was defined as design basis flood. The 10,000-year flood is 16 cm above the top level of the foundation plate of the storage facility and above the remaining areas of the power plant site at +172.66 m above sea level.

According to nuclear safety standard KTA 2207, both structural protection measures and organisational/administrative measures come into consideration for the implementation of flood protection. As a structural protection measure, stop log closures at the gates and doors of the entrance building with a height of 1,050 mm are used. These are installed in time when required by the operating personnel as specified in the

operating manual. The concrete of the foundation plate and of the outer walls of the entrance building are waterproof.

Precautionary measures
The design against flood is based on precautionary measures.

Behaviour at the stress level
For the Neckarwestheim site, a design basis flood of 172.66 m above sea level was determined in accordance with nuclear safety standard KTA 2207. For the design basis flood level, a maximum peak discharge of 3,000 m³/s was calculated. The protection level was set at 173.50 m above sea level. Thus, the protection level is 840 mm above the design basis water level. This corresponds to a 100,000-year flood.

In case of a peak discharge increased by a factor of 1.5 and 2.0 of 4,500 m³/s and 6,000 m³/s respectively, the water level would rise. There are no studies available on this issue. The protective functions of the TLBs are maintained independent of the water level.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed. Ingress of water into the storage area would not impair the protective function of the TLBs.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels 1 or 2 also depends on the presentation of additional verifications and their confirmation.

Cliff edge effects are not to be expected. Although the design of the storage building only complies with the basic level, the ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
The roof surfaces of the ZL GKN entrance building and the downpipes were designed for a rainfall intensity of 300 l/(s·ha) in accordance with DIN 12056 and DIN 1986-100. On the roof, additional rainwater drains were installed through emergency drains with open discharge outlet onto the ground (gargoyles). The assumed rainfall intensities will have no impacts on the storage facility. To ensure rainwater runoff, the roof drains are regularly checked and cleaned.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
When postulating an event with stress level for heavy rain, overloading of the roof outlets and downpipes could occur but not an accumulation of water on the roof beyond the design basis since this is prevented by roof drainage through the additional rainwater drains. When postulating overloading of the buried rainwater pipes and resulting flooding of the outside facilities, ingress of rainwater into the entrance building of the storage facility may occur.

Should no drain be possible at all, the water will accumulate up to the attic and run off via the attic. The surface load resulting from this flood level does not exceed the statically permissible value for the roof construction.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. In addition, the design against earthquakes ensures a large margin against increased loads.

In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
The other weather-related events stated are no design-relevant load cases for the storage facility.

Site-specific weather-related events
Hydrological conditions in the rock:
Due to the two-tunnel design of the ZL GKN, a drainage system is in place which prevents the ingress of mountain water into the tunnel tubes and the entrance hall.

Landslides:
Due to its properties, landslides at the steep walls of the former quarry can be excluded. At most, rock falls would have to be expected which do not lead to an impairment of the protective functions. Moreover, a retaining wall was erected in the area of the exit gate. Air intakes cannot be buried.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
Potential weather-related events beyond the design basis are in any case covered by the verifications performed within the licensing procedure for the load cases earthquake, aircraft crash, blast wave and fire. Thus, resistance is ensured with regard to the stress level.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The GKN storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure resulting from weather-related events is excluded due to the robust construction.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The postulated loss of power supply would not have safety-relevant impacts on the casks and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Design of the power supply

Electrical power supply in the ZL GKN storage facility is divided into three supply qualities:

- normal grid connection,
- backup power supply, and
- uninterruptible power supply (UPS) backup power supply.

Design of the emergency and backup power supply
At the GKN, the electrical installations in the storage facility are supplied via the emergency diesel generators of the GKN II plant. The required load is considered in the design of the emergency power supply in the GKN II plant and ensures, in accordance with the requirements of nuclear rules and regulations, an autonomy period of at least 72 hours. The actual period of autonomy, however, is significantly longer due to the lower power consumption than considered in the design.

Behaviour in case of longer-term total loss of power supply
The postulated loss of power supply would not have safety-relevant impacts on the casks and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
The monitoring systems, such as storage cask monitoring system, fire alarm system and local dose rate monitoring, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
The design is based on a fire of a transport vehicle in the entrance building. The postulated fire would not affect the tightness of the TLBs. A vehicle would immediately be detected by the staff and controlled by the fire fighting measures (initial fire fighting by staff or available on-site fire brigade).

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

Accident management measures
There are no accident management measures provided.

Summary assessment on internal fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the properties of the TLBs, compliance with the protection goals is ensured. In addition, effective preventive fire protection in the storage areas of the ZL GKN is realised by only admitting negligible fire loads within the storage areas. Compliance with this preventive fire protection is ensured by administrative regulations.

Due to the limited fire loads, fires beyond the design basis are, in principle, not possible. The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
The ZL GKN does not border on woodland areas, not on built-up areas with increased fire loads and not on traffic routes on which larger fire loads are regularly transported.

Design
The quarry wall adjacent to the storage facility is overgrown with bushes and trees. Postulated fire in this area, however, does not pose a danger to the storage facility since it would be detected at an early stage by the physical protection service (*Objektsicherungsdienst - OSD*) and then fought by the on-site fire brigade.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
Spread of external fires to the storage facility is excluded by appropriate zones with low fire loads in the surrounding area.

Accident management measures
There are no accident management measures provided.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in

the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of a postulated crash of a high-speed military aircraft were considered for the ZL GKN. Both the storage building and the TLBs are designed to withstand aircraft crashes. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The ZL GKN is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design as a tunnel storage facility represents a special protection against aircraft crash. Major accident management measures would thus not become necessary.

Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached would neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire.

The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
The components of entrance hall and tunnel of the ZL GKN were designed to withstand pressure waves according to the load-time function specified in the pressure wave guideline of the Federal Ministry of the Interior (BMI) with an excess peak pressure of 0.45 bar. Consequential damages resulting from higher pressure waves, e.g. collapse of the social wing and the escape building, to the remaining components are not to be expected. The design concept allows the collapse of the vent stack. In this case, heat removal is ensured to one side via the entrance hall.

Impacts of stronger blast waves
Due to the location of the GKN site, natural protection is already given. The shortest distance of an external explosion location to the entrance building of the storage facility to be considered is greater than 300 m. Protection against pressure waves from chemical reactions is always given by the TLB, and a postulated collapse of the entrance building has no undue impacts on heat removal and leak tightness either.

Site-specific amounts of explosive gases
The Neckar waterway was considered as an enveloping explosion source. Due to the location of the GKN site, natural protection is already given. The shortest distance to the entrance building of the storage facility to be considered is greater than 300 m.

Potential damage in case of facilities with no special design
Not applicable.

Summary assessment on blast waves
The blast wave is a two-dimensional impact on the building structure. Due to the seismic design of the building, protection is also generally given against a postulated blast wave. Due to the design as tunnel storage facility, only a reduced impact on the casks is generally to be postulated. The TLBs are designed to withstand blast waves and compliance with the protection goals will also be ensured when postulating the collapse of the entrance building.

Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function. Earthquake-induced damage to the buildings themselves cannot result in an undue impairment of heat removal from the TLBs.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.3 Gundremmingen on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Bavarian State Ministry of the Environment and Public Health dated 06.09.2012 [18] and the response from the operator of 25.07.2012 [18, Annex 3].

A Earthquake

Design
Within the licensing procedure, the Gundremmingen storage facility was designed against earthquakes in accordance with nuclear safety standard KTA 2201.1. The seismic load assumptions for the erection of the storage facility are identical to the seismic load assumptions on which the planning of the Biblis fuel storage

facility was based. Since the intensity at the Biblis site is greater than the intensity at the Gundremmingen site, the approach is enveloping, i.e. it is on the safe side. Accordingly, the Gundremmingen storage facility is designed for a design basis earthquake with a horizontal peak ground acceleration of 2.6 m/s^2.

The seismic conditions at the site of the Gundremmingen storage facility as well as conservatism and validity of the design spectrum used were confirmed by the Federal Institute for Geosciences and Natural Resources.

Precautionary measures
Precautionary measures were not considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes
The storage facility is designed to withstand a design basis earthquake. The maximum design intensity is in a range for which no serious damage to the building is to be expected also in case of an earthquake with an intensity level higher by 1 than this intensity. This is due to the conservative approach to the definition of the design basis (nuclear safety standard KTA 2201) as well as to the margins in the models and calculation methods used.

Applicability of damage mechanisms
Also in case of an earthquake with beyond design basis intensity (stress level), there will be no damages jeopardising the protection goals.

Combinations with other load cases
Within the licensing procedure, potential consequential impacts of an earthquake were also considered conservatively.

Accident management measures
Also in case of an earthquake event according to the stress level, no accident management measures are required for compliance with the protection goals.

Soil liquefaction
Possible damage to the Gundremmingen storage facility caused by localised soil liquefaction due to an earthquake is excluded by the Federal Institute for Geosciences and Natural Resources.

Summary assessment on earthquakes
The building structure of the Gundremmingen storage facility is designed to withstand earthquakes in accordance with nuclear safety standard KTA 2201 so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 2.6 m/s^2 exceeds the minimum acceleration of 0.1 g required by the EU (= 1 m/s^2). The ESK considers the margins existing due to the KTA design not to be sufficiently quantified to confirm compliance with the stress levels for the building. Due to the construction, however, it can reasonably be expected that confirmation is possible, but the casks would ensure compliance with the protection goals also in case of a postulated collapse of the storage building.

The main vital function of the Gundremmingen storage facility is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The water level of the Danube at the site is 429.5 m above sea level. The elevation of the Gundremmingen storage facility is 433.10 m above sea level. Due to the altitude of the storage building for the storage facility, there is a permanent flood protection up to the 100-year flood. In addition, the operating manual includes regulations to prevent flooding of the storage site in case of occurrence of the 1,000- or 10,000-year flood by temporary flood protection measures. In the event of a 10,000-year flood, the access road as well as the facility site will be flooded up to height of about 23 cm.

Precautionary measures
The design against flood is based on precautionary measures.

Behaviour at the stress level
All protection goals are complied with also at the stress level for flood (beyond the design).

Accident management measures
Also in case of flooding according to the stress level, no accident management measures are required for compliance with the protection goals.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed. Ingress of water into the storage area would not impair the protective function of the TLBs.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels 1 or 2 also depends on the presentation of additional verifications and their confirmation.

Cliff edge effects are not to be expected. Although the design of the storage building only complies with the basic level, the ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
To protect the casks against corrosion and with regard to the durability of the building, the Gundremmingen storage facility was protected against ingress of water from outside. The rainwater drainage system was designed during the construction of the building in accordance with DIN 1986, edition March 1995, Part 2, with a design basis rainfall $r_{5,5} = 300$ l/(s·ha) for buried sewers and downpipes.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
The site of the Gundremmingen storage facility is heaped and drained effectively. The measures resulting from the design against groundwater (sealing of walls and penetrations) also protect against the impacts of heavy rain. Also in case of stress level heavy rain, no damage to the building is to be feared. Should, as a result of a heavy rain event of the stress level, water enter the storage facility, the protection goals remain to be complied with.

Accident management measures
For compliance with the protection goals, no accident management measures are required. The measures provided to prevent ingress of water only serve to protect personnel and property.

Summary assessment on heavy rain
The design of the storage facility roof surfaces against weather-related impacts roughly corresponds to the basic level. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the storage facility, load assumptions according to DIN 1055 applicable at that time were considered in the design. For the design of the storage facility, special loads, such as design basis earthquake and blast wave, were taken into account. These load cases result in higher loads than those specified in DIN 1055 so that the loads from weather-related events are not only covered but that there is even a considerable degree of robustness.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
According to the approved structural design (HOCHTIEF), no major damage mechanisms are to be expected also above the stress level. For additional loads due to high wind speeds and extreme snow loads on the roof and the exterior walls, the static requirements are fulfilled since the entire building was designed against the blast wave load case in accordance with the guideline of the Federal Ministry of the Interior (BMI) 1975.

Accident management measures
For compliance with the protection goals, no accident management measures are required.

Summary assessment on other weather-related events
The Gundremmingen storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is not to be expected due to the robust construction of the storage hall.

All site-specific measures implemented for the drainage of water and maintenance of accessibility to the building are to be understood as precaution for the protection of property. Precautionary and accident management measures are not required. A failure of the storage building postulated nonetheless would not compromise compliance with the protection goals. Protection against mechanical loading would be represented by the TLBs, heat removal from the casks would also be ensured if the casks would temporarily be buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
For compliance with the protection goals, no safety systems are required that depend on power supply. The following other safety-relevant systems are supplied with power:

- cask monitoring system,
- fire protection systems and equipment including fire alarm system,
- safety-relevant ventilation systems,
- emergency power and backup power supply systems and systems for uninterruptible emergency power supply, and
- crane control systems for limiting the lifting height.

Compliance with the protection goals will also be ensured in case of failure of these systems.

Design of the power supply
For compliance with the protection goals, no safety systems are required that depend on power supply. This also applies to the systems listed above as other safety-relevant systems.

Design of the emergency and backup power supply
For compliance with the protection goals, no safety systems are required that depend on power supply. This also applies to the systems listed above as other safety-relevant systems.

Behaviour in case of longer-term total loss of power supply
A total loss of power supply and the emergency/backup power supply for a longer period of time has no safety significance since compliance with the protection goals is also ensured without electrical energy.

Accident management measures
For compliance with the protection goals, no accident management measures are required.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as cask monitoring system and fire alarm system, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F On internal fires

Design
According to the licence, internal fires were classified as non-hazardous with regard to safety. For the storage facility, a fire protection concept was developed for personal protection, for preventing the development of a fire as far as possible and for preventing spread of fire, which was reviewed and approved within the licensing procedure. The concept ensures fast and effective fire fighting. The fires considered in the design will have no consequences for the emplaced casks.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level

The fire loads in the Gundremmingen storage facility are not sufficient to jeopardise the integrity of the casks in case of stress level 1. An independent accident analysis was performed within the nuclear licensing procedure and the mechanical and thermal loads for the casks resulting from potential design basis accidents were analysed. The fire loads in the storage facility are low due to the structural design of the storage facility and the amounts of combustible material stored there. Due to the small fire inventory, only localised fires may occur.

Accident management measures

For compliance with the protection goals, no accident management measures are required. The measures provided against fires only serve to protect personnel and property.

Summary assessment on internal fires

The storage concept of the Gundremmingen storage facility comprises structural fire protection measures, fire fighting equipment, fire alarm systems and operating rules. The storage hall is constructed as a separate fire compartment with only very low fire loads. Also in the entry hall, there are only limited fire loads. In the loading hall, temporarily stay of a transport vehicle is possible. To minimise the risk of fire, the towing vehicle will be uncoupled immediately after positioning of the transport vehicle and driven out of the hall.

The fire protection required for the Gundremmingen storage facility is mainly covered by the properties of the casks. The on-site fire brigade is adequately equipped for the required fire fighting in the Gundremmingen storage facility.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads

The Gundremmingen storage facility does not border on woodland areas and/or on built-up areas with increased fire loads and not on traffic routes on which larger fire loads are regularly transported.

At the site of the Gundremmingen nuclear power plant, there is no area with dense tree population within a 20 m radius of the storage facility which could be affected by a wildfire. Denser stands of trees only exist outside the outer perimeter at a distance of more than 100 m from the Gundremmingen storage facility. The spread of a forest fire to the storage facility can be prevented by appropriate fire fighting measures. Furthermore, spread of a fire from an adjacent building is not to be postulated due to the low fire loads in the immediate vicinity of the storage facility and in the storage halls and due to the possibility of intervention by the fire brigade.

Design
The Gundremmingen storage facility is also designed against fires outside the storage facility. There will be no consequences for the facility. Impacts of an external fire on the storage facility are not given due to the massive monolithic building structure.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible.

Accident management measures
Since impacts on the Gundremmingen storage facility caused by external fires are not given, accident management measures to limit the consequences are not required.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of a postulated crash of a high-speed military aircraft were considered for the Gundremmingen storage facility and are covered by the design of the TLBs. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The Gundremmingen storage facility is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash

of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
The Gundremmingen storage facility is designed to withstand blast waves. In accordance with the guideline of the Federal Ministry of the Interior (BMI), the derivation of the pressure wave is based on the explosion of a gas amount which is released during an accident of a liquid gas tanker.

Impacts of stronger blast waves
Also in case of much stronger blast waves than those on which the design of the storage facility is based, no impacts in terms of jeopardising the protection goals are to be expected since the mechanical loads for the TLBs from pressure waves are low.

Site-specific amounts of explosive gases
In the immediate vicinity of the power plant, there is no handling of explosive substances.

Potential damage in case of facilities with no special design
Due to the design, this issue is not relevant for the Gundremmingen storage facility.

Summary assessment on blast waves
Blast waves and impacts caused by hazardous substances were also considered as beyond design basis events. The storage building is stable regarding the load case pressure waves from chemical reactions and the integrity of the casks is maintained. In the surrounding area of the Gundremmingen storage facility, there is no handling of explosive substances. The safety distances to gas pipelines and transport routes are sufficiently large.

The ESK notes that due to the site-specific conditions, no massive blast wave can occur so that degree of protection 3 can be confirmed. Cliff edge effects are not to be expected.

7.2.4 Isar on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Bavarian State Ministry of the Environment and Public Health dated 06.09.2012 [18] and the response from the operator of 08.08.2012 [18, Annex 1].

A Earthquake

Design

The Isar storage facility (KKI BELLA) is located in an almost earthquake-free area. The area is not to be assigned to an earthquake zone according to DIN 4149 or DIN-EN-1998. The storage building and the TLBs are designed against the earthquake load case. Within the licensing procedure, the structural design of the KKI BELLA was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS).

The corresponding seismic load assumptions, such as a horizontal acceleration of 1 m/s^2, were considered in the structural design of the storage building.

Precautionary measures

Precautionary measures do not have to be considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes

The storage building is designed against the earthquake load case. According to the operator, margins are available that cover at least one intensity level more. In addition, the protective functions of the TLBs will also be ensured in case of an earthquake with an intensity increased by a factor of 1 compared to the design basis earthquake. In particular, confinement of the radioactive material and residual heat removal from the TLBs in case of being buried (debris load) and stability of the TLBs will be ensured.

Applicability of damage mechanisms

Damage mechanisms are not to be expected.

Combinations with other load cases

Consequential impacts from interdependent combinations with other load cases are not to be postulated; the impacts are covered by those of an aircraft crash.

Accident management measures

There are no accident management measures provided.

An on-site emergency preparedness plan is not required due to the impacts to be expected in case of incidents, and it was demonstrated within the licensing procedure that no major accident management measures will be required in case of beyond design basis events.

Soil liquefaction

The danger of soil liquefaction at the site can be excluded.

Summary assessment on earthquakes
The building structure of the KKI BELLA is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 1 m/s² corresponds to the minimum acceleration of 0.1 g required by the EU. The ESK considers the margins existing due to the KTA design not to be sufficiently quantified to confirm compliance with the stress levels for the building. Due to the construction, however, it can reasonably be expected that confirmation is possible, but the casks would ensure compliance with the protection goals also in case of a postulated collapse of the storage building.

The main vital function of the KKI BELLA is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The assessment of the site-specific conditions within the licensing procedure showed that the site of the KKI BELLA is not prone to flooding and thus no structural measures for flood protection are required.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
In case of runoff volumes larger than those of the 1,000-year flood, breaking of a dam may occur in the upstream area of the site with distribution of the runoff water over a large area so that flooding of the storage building is to be excluded. Postulated flooding of the TLBs does not jeopardise the compliance with the protection goals.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed. Foundation and stability of the storage building will not be impaired by flooding either.

Ingress of water into the storage building would also not impair the protective function of the TLBs.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels depends on the presentation of additional verifications and their confirmation. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
According to the operator, rain impacts were considered in the design of the KKI BELLA in accordance with DIN 1045 and DIN 1055-1. It was demonstrated in the framework of the licensing procedure that weather-related influences were adequately taken into account in the building design.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
According to the operator, the safety of the KKI BELLA will not be impaired also in case of heavy rain with a rainfall intensity of $r_{5,100}$ in accordance with DIN 1986-100.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the storage facility roof surfaces against weather-related impacts roughly corresponds to the basic level. The DIN standards referred to by the operator do not apply to heavy rain. However, the ESK holds the view that it can be assumed that the impacts and influences on the storage facility from other natural hazards also cover the heavy rain event. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the KKI BELLA, load assumptions according to DIN 1055 applicable at that time were considered in the design. For the design of the storage facility, special loads, such as design basis earthquake and blast wave, were taken into account. These load cases result in higher loads than those specified in

DIN 1055 so that the loads from weather-related events are not only covered but that there is even a considerable degree of robustness.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
With regard to other weather-related events, the design is not based on precautionary measures.

Behaviour at the stress level
The loads from other external hazards such as, in particular, earthquakes are higher than those from load cases beyond the structural design with regard to other weather-related events so that these are covered by them. Also in case of other weather-related events according to DIN 1055, the facility behaves as designed due to the available margins in the structural design.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The KKI BELLA storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is not to be expected due to the robust construction of the storage hall. A failure of the storage building postulated nonetheless would not compromise compliance with the protection goals. Protection against mechanical loading would be represented by the TLBs, heat removal from the casks would also be ensured if the casks would temporarily be buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
To ensure the protective functions of the TLBs, no electrically powered systems are required. As a passive system, the TLB with pressure switch as part of the sealing barriers does not require any electrical power supply.

Power supply for the electrical installations of the on-site storage facility is adequately ensured by normal power supply, backup power supply and uninterruptible power supply (UPS) for all load cases to be postulated. A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel.

Design of the power supply
The normal grid switchgears of the KKI BELLA are supplied with energy via a normal grid switchgear of the KKI 1. Main distribution and connection to the supply grids takes place via the low-voltage switchgear of the KKI BELLA.

Backup power for the KKI BELLA is supplied from a backup power diesel generator located in the southwest extension of the storage building. In case of voltage interruption, the main distribution is disconnected from the grid via tie breakers, and the emergency standby power system will start automatically.

In case of unavailability of the normal grid and the backup power switchgears, the following systems are supplied from a central UPS:

- higher-level I&C,
- radiation monitoring systems and equipment,
- permanent lighting, and
- communications technology.

The following systems are provided with an autonomous, internal UPS:

- cask monitoring system,
- fire alarm system, and
- emergency lighting.

Design of the emergency and backup power supply
Without refuelling, the backup diesel generator is designed for 17 hours of operation. Personnel actions to start the diesel generator are not required.

Behaviour in case of longer-term total loss of power supply
The protective functions of the TLBs will not be affected by it. Other important systems that depend on power supply will no longer be available, but their function is not required to maintain the protective functions of the TLBs. A failure of the systems can be compensated by administrative measures, such as inspections or measurements with mobile devices.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as cask monitoring system and fire alarm system, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by

administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
For the design, fires in the storage hall and in the loading area were examined. The other areas of the building were protected according to their use and the fire loads in them and separated from the loading and storage area in accordance with the fire protection regulations. The structural design of the storage building includes the use of mainly non-combustible or flame-resistant materials as a preventive fire protection measure. Furthermore, the building was divided into fire compartments. A fire alarm system was installed in the KKI BELLA. For fire fighting, portable fire extinguishers as well as supply of water are available via external hydrants.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
A fire in the storage hall for a period of more than one hour is only conceivable as a smouldering fire with a low pyrolysis rate. Such a low pyrolysis rate cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Operating personnel will permanently be present as long as the transport vehicle stays in the loading area so that a fire can be immediately detected and fought with the available extinguishing agents and equipment. Should, however, a postulated vehicle fire last longer than one hour, so this will only be possible with a reduced pyrolysis rate which cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Accident management measures
Accident management measures are not required.

Summary assessment on internal fires
The storage concept of the KKI BELLA comprises structural fire protection measures, fire fighting equipment, fire alarm systems and operating rules. The storage hall is constructed as a separate fire compartment with only very low fire loads. Also in the entry hall, there are only limited fire loads. In the loading hall,

temporarily stay of a transport vehicle is possible. To minimise the risk of fire, the towing vehicle will be uncoupled immediately after positioning of the transport vehicle and driven out of the hall. The fire protection required for the KKI BELLA is mainly covered by the properties of the casks.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
Denser stands of trees only exist outside the premises of the KKI-1 and KKI-2 on which the KKI BELLA is sited. Their distance from the storage building is more than 100 m.

Design
A fire occurring in stands of trees outside the premises of the KKI can be fought effectively with the available fire extinguishing equipment so that spread of a forest fire to the KKI BELLA is prevented. Impacts of external fires on the KKI BELLA are thus not to be assumed. Special design features therefore do not arise for the plant.

Precautionary measures
Protection of the facility against the consequences of external fires does not require any precautionary measures.

Behaviour at the stress level
The duration of fires outside the facility has no influence on the design of the facility. Therefore, a fire duration of one hour more does not influence the impacts on the facility either.

Accident management measures
Accident management measures are not required.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of a postulated crash of a high-speed military aircraft were considered for the KKI BELLA and are covered by the design of the TLBs. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The KKI BELLA is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Blast wave was considered as beyond design basis event in the licensing procedure. The storage building is not designed to withstand blast waves. The TLB designed against the blast wave load case in accordance with the guideline of the Federal Ministry of the Interior (BMI) fulfils the protective function against the impacts of blast waves. In particular, confinement of the radioactive material and residual heat removal are appropriately ensured for the TLBs in case of being buried (debris load).

Impacts of stronger blast waves
According to the examination performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure, severe accident management measures will not be required in the event of blast waves since in this case even the accident planning value according to § 49 of the Radiation Protection Ordinance (StrlSchV) will be complied with. In case of a collapse of the storage building, activity releases resulting from debris falling onto the TLBs are not excluded. The radiological impacts due to these activity releases are covered by the results on the impacts from aircraft crashes.

Site-specific amounts of explosive gases
The safety distances to industrial facilities, gas pipelines and transport routes are sufficiently large so that undue loads on the TLBs cannot occur.

Potential damage in case of facilities with no special design
The TLBs are designed against the blast wave load case.

Summary assessment on blast waves
The ESK notes that due to the site-specific conditions, no massive blast wave can occur so that degree of protection 3 can be confirmed. Cliff edge effects are not to be expected.

7.2.5 Grafenrheinfeld on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Bavarian State Ministry of the Environment and Public Health dated 06.09.2012 [18] and the response from the operator of 08.08.2012 [18, Annex 2].

A Earthquake

Design
The Grafenrheinfeld storage facility (KKG BELLA) is located in the Northern Bavaria zone, an almost earthquake-free area. The area is not to be assigned to an earthquake zone according to DIN 4149 or DIN-EN-1998. The storage building and the TLBs are designed against the earthquake load case. Within the licensing procedure, the structural design of the KKG BELLA was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of $1\ m/s^2$, were considered in the structural design of the storage building.

Precautionary measures
Precautionary measures do not have to be considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes
The storage building is designed against the earthquake load case. According to the operator, margins are available that cover at least one intensity level more. In addition, the protective functions of the TLBs will also be ensured in case of an earthquake with an intensity increased by a factor of 1 compared to the design basis earthquake. In particular, confinement of the radioactive material and residual heat removal from the TLBs in case of being buried (debris load) and stability of the TLBs will be ensured.

Applicability of damage mechanisms
Damage mechanisms are not to be expected.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated; the impacts are covered by those of an aircraft crash.

Accident management measures
There are no accident management measures provided. An on-site emergency preparedness plan is not required due to the impacts to be expected in case of incidents, and it was demonstrated within the licensing procedure that no major accident management measures will be required in case of beyond design basis events.

Soil liquefaction
The danger of soil liquefaction at the site can be excluded.

Summary assessment on earthquakes
The building structure of the KKG BELLA is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 1 m/s^2 corresponds to the minimum acceleration of 0.1 g required by the EU. The ESK considers the margins existing due to the KTA design not to be sufficiently quantified to confirm compliance with the stress levels for the building. Due to the construction, however, it can reasonably be expected that confirmation is possible, but the casks would ensure compliance with the protection goals also in case of a postulated collapse of the storage building.

The main vital function of the KKG BELLA is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The KKG BELLA (top level of the hall floor) is located at a height of 206.60 m above sea level at a distance of about 800 m from the eastern bank of the river Main. The water level of the Main is maintained at 203.00 m above sea level by the damming of the Garstadt barrage. The high water level of the 1,000-year flood is 205.50 m above sea level. For a 10,000-year flood, this leads to a water level of about 206.50 m above sea level.

The assessment of the site-specific conditions within the licensing procedure showed that the site of the KKG BELLA is not prone to flooding and thus no structural measures for flood protection are required.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
Postulated flooding of the TLBs will not compromise compliance with the protection goals.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed. Foundation and stability of the storage building will not be impaired by flooding either. Ingress of water into the storage building would also not impair the protective function of the TLBs.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels depends on the presentation of additional verifications and their confirmation. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
According to the operator, rain impacts were considered in the design of the KKG BELLA in accordance with DIN 1045 and DIN 1055-1. It was demonstrated in the framework of the licensing procedure that weather-related influences were adequately taken into account in the building design.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
According to the operator, the safety of the KKG BELLA will not be impaired also in case of heavy rain with a rainfall intensity of $r_{5,100}$ in accordance with DIN 1986-100.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. The DIN standards referred to by the operator do not apply to heavy rain. However, the ESK holds the view that it can be assumed that the impacts and influences on the storage facility from other natural hazards also cover the heavy rain event. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the KKG BELLA, load assumptions according to DIN 1055 applicable at that time were considered in the design. For the design of the storage facility, special loads, such as design basis earthquake and blast wave, were taken into account. These load cases result in higher loads than those specified in DIN 1055 so that the loads from weather-related events are not only covered but that there is even a considerable robustness.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
The loads from other external hazards such as, in particular, earthquakes are higher than those from load cases beyond the structural design with regard to other weather-related events so that these are covered by them. Also in case of other weather-related events above the design according to DIN 1055, the facility behaves as designed due to the available margins in the structural design.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The structural design of the KKG BELLA against other weather-related events complies with the applicable regulations and standards so that resistance is ensured according to the basic level. Other weather-related events, such as storm (also including hurricane), hail, snow loads, freezing rain and lightning, are generally no design-relevant load cases for the KKG BELLA. Due to weather-related events, load cases such as flood, loss of electrical power and fire may occur which, just as a postulated failure of the storage building, will not compromise compliance with the protection goals. Potential weather-related events beyond the design basis are covered by the verifications performed within the licensing procedure for the load cases earthquake, aircraft crash, blast wave and fire.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply

To ensure the protective functions of the TLBs, no electrically powered systems are required. As a passive system, the TLB with pressure switch as part of the sealing barriers does not require any electrical power supply.

Power supply for the electrical installations of the on-site storage facility is adequately ensured by normal power supply, backup power supply and uninterruptible power supply (UPS) for all load cases to be postulated. A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel.

Design of the power supply

Power for the KKG BELLA is supplied from two separate station service supply busbars of the KKG via two switchable supply lines. Each line alone covers the total power requirements of the storage facility. Main distribution and connection to the supply grids takes place via the low-voltage switchgear of the KKG BELLA.

Backup power for the KKG BELLA is supplied from a backup power diesel generator located in the southwest extension of the storage building. In case of voltage interruption, the main distribution is disconnected from the grid via tie breakers, and the emergency standby power system will start automatically.

In case of unavailability of the normal grid and the backup power switchgears, the following systems are supplied from a central UPS:

- higher-level I&C,
- radiation monitoring systems and equipment, and
- communications technology.

The following systems are provided with an autonomous, internal UPS:

- cask monitoring system,
- fire alarm system,
- emergency lighting, and
- loudspeaker 2.

Design of the emergency and backup power supply
Without refuelling, the backup diesel generator is designed for 17 hours of operation. Personnel actions to start the diesel generator are not required.

Behaviour in case of longer-term total loss of power supply
The protective functions of the TLBs will not be affected by it. Other important systems that depend on power supply will no longer be available, but their function is not required to maintain the protective functions of the TLBs. A failure of the systems can be compensated by administrative measures, such as inspections or measurements with mobile devices.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as cask monitoring system and fire alarm system, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
For the design, fires in the storage hall and in the loading area were examined. The other areas of the building were protected according to their use and the fire loads in them, and separated from the loading and storage area in accordance with the fire protection regulations. The structural design of the storage building includes the use of mainly non-combustible or flame-resistant materials as a preventive fire protection measure. Furthermore, the building was divided into fire compartments. A fire alarm system was installed in the KKG BELLA. For fire fighting, portable fire extinguishers as well as supply of water are available via external hydrants.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
A fire in the storage hall for a period of more than one hour is only conceivable as a smouldering fire with a low pyrolysis rate. Such a low pyrolysis rate cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Operating personnel will permanently be present as long as the transport vehicle stays in the loading area so that a fire can be immediately detected and fought with the available extinguishing agents and equipment. Should, however, a postulated vehicle fire have a duration of more than one hour, so this will only be possible with a reduced pyrolysis rate which cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Accident management measures
Accident management measures are not required.

Summary assessment on internal fires
The storage concept of the KKG BELLA comprises structural fire protection measures, fire fighting equipment, fire alarm systems and operating rules. The storage hall is constructed as a separate fire compartment with only very low fire loads. Also in the entry hall, there are only limited fire loads. In the loading hall, temporarily stay of a transport vehicle is possible. To minimise the risk of fire, the towing vehicle will be uncoupled immediately after positioning of the transport vehicle and driven out of the hall.

The fire protection required for the KKG BELLA is mainly covered by the properties of the casks. The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
Denser stands of trees only exist outside the premises of the KKG on which the KKG BELLA is sited. Their distance from the storage building is more than 100 m.

Design
A fire occurring in stands of trees outside the premises of the KKG can be fought effectively with the available fire extinguishing equipment so that spread of a forest fire to the KKG BELLA is prevented. Thus, impacts of external fires on the KKG BELLA are not to be postulated so that this does not result in special design features for the facility.

Precautionary measures
Protection of the facility against the consequences of external fires does not require any precautionary measures.

Behaviour at the stress level
The duration of fires outside the facility has no influence on the design of the facility. Therefore, a fire duration of one hour more does not influence the impacts on the facility either.

Accident management measures
Accident management measures are not required.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of a postulated crash of a high-speed military aircraft were considered for the KKG BELLA and are covered by the design of the TLBs. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The KKG BELLA is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Blast wave was considered as beyond design basis event in the licensing procedure. The storage building is not designed to withstand blast waves. The TLB designed against the blast wave load case in accordance with the guideline of the Federal Ministry of the Interior (BMI) fulfils the protective function against the impacts of blast waves. In particular, confinement of the radioactive material and residual heat removal will be appropriately ensured for the TLBs in case of being buried (debris load).

Impacts of stronger blast waves
According to the examination performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure, severe accident management measures will not be required in the event of blast waves since in this case even the accident planning value according to § 49 of the Radiation Protection Ordinance (StrlSchV) will be complied with. In case of a collapse of the storage building, activity releases resulting from debris falling onto the TLBs are not excluded. The radiological impacts due to these activity releases are covered by the results on aircraft crashes.

Site-specific amounts of explosive gases
The safety distances to industrial facilities, gas pipelines and transport routes are sufficiently large so that undue loads on the TLBs cannot occur.

Potential damage in case of facilities with no special design
A blast wave resulting from a postulated accident of a liquid gas tanker on the Main at a distance of about 860 m from the KKG BELLA leads to a maximum pressure load of 43 mbar on a side wall of the storage building. The TLBs are designed against the blast wave load case.

Summary assessment on blast waves
Due to the seismic design of the storage building, protection is generally also given against blast waves. In case of a failure of the building structure postulated nonetheless, energy from the pressure wave will be dissipated by the building structure and its failure so that only a reduced impact on the casks would have to be postulated. The TLBs are designed against the blast wave load case, and compliance with the protection goals will also be ensured when postulating the collapse of the storage building.

Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function. Earthquake-induced damage to the buildings themselves cannot result in an undue impairment of heat removal from the TLBs.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.6 Biblis on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Hessian Ministry for the Environment, Energy, Agriculture and Consumer Protection dated 27.08.2012 [11] and the response from the operator of 08.08.2012 [11, Annexes 1 and 2].

A Earthquake

Design
Within the licensing procedure, the Biblis storage facility was designed against earthquakes in accordance with nuclear safety standard KTA 2201.1. The intensity of the design basis earthquake of "7.75 +/-0.5" MSK is confirmed by the expert assessment by the Federal Institute for Geosciences and Natural Resources. This intensity is based on an exceedance probability of approx. 10^{-5}/a.

All engineering seismological parameters for the Biblis site, including the resulting horizontal peak ground acceleration of 2.6 m/s^2, were confirmed as being sufficiently conservative by the Federal Institute for Geosciences and Natural Resources.

Precautionary measures
The design of the Biblis storage facility is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
According to the operator, the design spectra and design bases used in the licensing procedure are conservative so that impacts on the integrity and the protection concept of the TLBs are not to be feared in case of a beyond design basis earthquake. For earthquakes, at most local failure was to be assumed which prevents heat removal from individual TLBs.

Applicability of damage mechanisms
In the licence, aircraft crash, pressure waves from chemical reactions and impacts caused by hazardous substances were considered as beyond design basis events.

Combinations with other load cases
Within the licensing procedure, potential consequential impacts of an earthquake were also considered conservatively.

Accident management measures
For the Biblis storage facility, there are no accident management measures provided regarding the earthquake load case.

Soil liquefaction
Possible damage to the Biblis storage facility caused by localised soil liquefaction due to an earthquake is excluded by the Federal Institute for Geosciences and Natural Resources.

Summary assessment on earthquakes
The building structure of the Biblis storage facility is designed to withstand earthquakes in accordance with nuclear safety standard KTA 2201 so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 2.6 m/s^2 exceeds the minimum acceleration of 0.1 g required by the EU (= 1 m/s^2). The ESK considers the margins existing due to the KTA design not to be sufficiently quantified to confirm compliance with the stress level for the building. Due to the construction, however, it can reasonably be expected that confirmation is possible, but the casks would ensure compliance with the protection goals also in case of a postulated collapse of the storage building.

The main vital function of the Biblis storage facility is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The storage facility is designed for a 100-year flood of 91.00 m above sea level and a 10,000-year flood of 91.5 m above sea level.

At the Biblis site, the dyke top on the left bank of the Rhine is flooded if a water level of 91.20 m above sea level is reached, and the left bank dyke top if a water level of 91.50 m above sea level is reached. Flooding of the hinterland resulting from dyke overtopping will not lead to water levels at the site of the Biblis storage facility that exceed the height of the right-bank dyke top at Rhine kilometre 455.2. This applies regardless of the actually occurring runoff so that the design basis flood (10,000-year flood) is to be assumed with a height of 91.50 m above sea level.

As operational measures, the activities in the storage facilities will be discontinued, the outer gates and doors closed and the stop log inserted in accordance with the operating manual when reaching 90.80 m above sea level and above.

The accessibility of the site is given via a dam up to a water level up to 91.50 above sea level. In case of higher water levels, access to the buildings would have to be gained by watercraft or helicopter.

Precautionary measures
Should the operational measures (stop log) fail, water enters the building. Since the TLBs themselves are waterproof, this would have no impact on the integrity of the TLBs.

Behaviour at the stress level
The protection goals are complied with also at the stress level for flood (beyond the design).

Accident management measures
There are no accident management measures provided for the storage facility regarding the flood load case.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed. Ingress of water into the storage area would not impair the protective function of the TLBs.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels 1 or 2 also depends on the presentation of additional verifications and their confirmation. Cliff edge effects are not to be expected. Although the design of the storage building only complies with the basic level, the ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
To protect the casks against corrosion and in view of the durability of the building, the Biblis storage facility was protected against ingress of water from outside. The rainwater drainage system was designed during the construction of the building in accordance with DIN 1986, edition March 1995, Part 2, with a design basis rainfall $r_{5,5} = 300$ l/(s·ha) for buried sewers and downpipes.

Precautionary measures
The design against heavy rain is not based on precautionary measures. The building is designed to withstand roof loads from much greater load cases. The technical design of the sealing (retention level and piping layout) also considers heavy rain.

Behaviour at the stress level
During heavy rain, rainwater would be retained on the roof, as expected, leading to a water level on the roof of about 7 cm which would run off again after the heavy rain phase. Due to the design specified, no damage mechanisms are to be feared. A heavy rain event does not lead to flooding of the power plant site since even in case of failure of the rainwater drainage system, the water will run off into the lower-level area around the power plant. Should, as a result of a heavy rain event of the stress level, water enter the storage facility, the protection goals remain to be complied with.

Accident management measures
For the Biblis storage facility, there are no accident management measures provided regarding the load case heavy rain.

Summary assessment on heavy rain
The design of the storage facility roof surfaces against weather-related impacts roughly corresponds to the basic level. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the storage facility, load assumptions according to DIN 1055 applicable at that time were considered in the design.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
Also above the stress level, no major damages are to be expected. For additional loads due to high wind speeds and extreme snow loads on the roof, the static requirements are fulfilled since the entire building was designed against the load case blast wave 0.15 bar, which corresponds to a load of 15 kN/m^2.

Accident management measures
There are no accident management measures provided for the storage facility regarding the load case other weather-related events.

Summary assessment on other weather-related events
The Biblis storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is not to be expected due to the robust construction of the storage hall.

All site-specific measures implemented for the drainage of water and maintenance of accessibility to the building are to be understood as precaution for the protection of property. Precautionary and accident management measures are not required. A failure of the storage building postulated nonetheless would not compromise compliance with the protection goals. Protection against mechanical loading would be represented by the TLBs, heat removal from the casks would also be ensured if the casks would temporarily be buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The safety functions (protection goals) of the TLBs are not dependent on the power supply of the storage facility. Thus, all power consumers supplied from the backup grid relate to other important functions and systems. Compliance with the protection goals will also be ensured in case of failure of these systems.

Design of the power supply
Power supply in the storage facility is divided into a normal power supply and an emergency standby power system. In case of loss of supplies, the diesel generator of the emergency standby power system will start automatically and supplies all power consumers connected to the emergency standby power system. In addition, a UPS system supplies all other important systems that depend on power supply.

Design of the emergency and backup power supply
As designed, the emergency standby power system has fuel and auxiliary supplies for 17 hours. Adding the nominal capacity of the connected consumers, the diesel generator is only loaded with approximately 60 % of the potential load. Thus, the calculated period of autonomy is extended, compared to the design, to about 28 hours with the fuels and auxiliary supplies available in the Biblis storage facility. To maintain the function of the emergency standby power system, activities by staff are generally not required, except for refuelling and refilling of the lubricating oil.

Behaviour in case of longer-term total loss of power supply
A loss of power supply for a longer period of time has no safety-relevant impacts on the facility and on the TLBs and their radioactive inventories.

Accident management measures
There are no accident management measures provided for the on-site storage facility regarding the load case loss of power.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness. The monitoring systems, such as cask monitoring system and fire alarm system, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design

According to the licence, internal fires were classified as non-hazardous with regard to safety. For the storage facility, a fire protection concept was developed for personal protection, for preventing the development of a fire as far as possible and for preventing spread of fire, which was reviewed and approved within the licensing procedure. The concept ensures fast and effective fire fighting. The fires considered in the design (fire involving a loaded transport unit and fire in the room where the backup power generator is located) will have no consequences for the emplaced casks.

Precautionary measures

For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level

The fire loads in the Biblis storage facility are not sufficient to jeopardise the integrity of the casks in case of stress level 1. An independent accident analysis was performed within the nuclear licensing procedure and the mechanical and thermal loads for the casks resulting from potential design basis accidents were analysed. The fire loads in the storage facility are low due to the structural design of the storage facility and the amounts of combustible material stored there. Due to the small fire inventory, only localised fires may occur.

A fire occurring in the room where the backup power generator is located can be extinguished from outside of the two rooms using a semi-stationary extinguishing system without opening these rooms to the loading hall. Thus, a fire in the tank or diesel room cannot spread to other areas of the storage facility.

Accident management measures

There are no accident management measures provided for the storage facility regarding the load case internal fire.

Summary assessment on internal fires

The storage concept of the Biblis storage facility comprises structural fire protection measures, fire fighting equipment, fire alarm systems and operating rules. The storage hall is constructed as a separate fire compartment with only very low fire loads. Also in the entry hall, there are only limited fire loads. In the loading hall, temporarily stay of a transport vehicle is possible. To minimise the risk of fire, the towing vehicle will be uncoupled immediately after positioning of the transport vehicle and driven out of the hall. The fire protection required for the Biblis storage facility is mainly covered by the properties of the casks.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads

The storage facility Biblis is located within the outer perimeter of the Biblis nuclear power plant. Thus, it does not border on woodland areas, not on built-up areas with increased fire loads and not on traffic routes on which larger fire loads are regularly transported. Denser stands of trees only exist outside the outer perimeter at a distance of more than 60 m. In the immediate vicinity of the Biblis storage facility, there are only small fire loads.

Design

For the design of the Biblis storage facility, two fire scenarios outside the facility were considered. A fire scenario was analysed for an area outside the outer perimeter in a dense stand of trees at a distance of more than 60 m. Another fire scenario was considered within the outer perimeter in a neighbouring building. In both cases, there will be no consequences and no measures required for the storage facility.

Precautionary measures

The design against external fires is not based on precautionary measures.

Behaviour at the stress level

Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible.

Accident management measures

For the Biblis storage facility, there are no accident management measures provided regarding the load case external fire.

Summary assessment on external fires

The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of a postulated crash of a high-speed military aircraft were considered for the Biblis storage facility and are covered by the design of the TLBs. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The storage facility Biblis is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
The building structure of the Biblis storage facility was designed to withstand a blast wave of 0.15 bar, as considered within the licensing procedure. Due to the large distances to potential explosion sources (Rhine fairway at a distance of approximately 400 m), the higher design basis values of the guideline of the Federal Ministry of the Interior (BMI) are not required for the stable design of the storage building.

Impacts of stronger blast waves
Also in case of much stronger blast waves than those on which the design of the storage facility is based, no impacts in terms of jeopardising the protection goals are to be expected since the mechanical loads for the TLBs from pressure waves are low.

Site-specific amounts of explosive gases
In the immediate vicinity of the power plant, there is no handling of explosive substances.

Potential damage in case of facilities with no special design
Due to the design, this issue is not relevant for the Biblis storage facility.

Summary assessment on blast waves
The blast wave represents a two-dimensional impact on the building structure. Due to the seismic design of the building, protection is generally also given against blast waves. In case of a failure of the building structure postulated nonetheless, energy from the pressure wave will be dissipated by the building structure and its failure so that only a reduced impact on the casks would have to be postulated. The TLBs are designed against the blast wave load case and compliance with the protection goals will also be ensured when postulating the collapse of the storage building.

Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function. Earthquake-induced damage to the buildings themselves cannot result in an undue impairment of heat removal from the TLBs.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.7 Grohnde on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Lower Saxony Ministry for the Environment, Energy and Climate Protection dated 10.09.2012 [6] with comments and notes [6, Annex 1] and the response from the operator E.ON Kernkraft GmbH of 03.08.2012 [6, Annex 7]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test were taken into account.

A Earthquake

Design
The site of the Grohnde storage facility (ZL KWG) is not to be assigned to an earthquake zone according to DIN 4149 or DIN-EN-1998. The storage building and the TLBs are designed against the earthquake load case. Within the licensing procedure, the structural design of the ZL KWG was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of 0.95 m/s^2, were considered in the structural design of the storage building.

Precautionary measures
Precautionary measures do not have to be considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes
The storage building is designed against the earthquake load case. According to the operator, margins are available that cover at least one intensity level. Further margins are available due to the structural design of the storage building against aircraft crash and blast wave. In addition, the protective functions of the TLBs will also be ensured in case of an earthquake with an intensity increased by a factor of 1 compared to the design basis earthquake. In particular, confinement of the radioactive material and residual heat removal from the TLBs in case of being buried (debris load) and stability of the TLBs will be ensured.

Applicability of damage mechanisms
Damage mechanisms are not to be expected. The relevant basis for the design of the storage facility components are the load cases aircraft crash and blast wave.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated; the impacts are covered by those of an aircraft crash.

Accident management measures
There are no accident management measures provided. An on-site emergency preparedness plan is not required due to the impacts to be expected in case of incidents, and it was demonstrated within the licensing procedure that no major accident management measures will be required in case of beyond design basis events.

Soil liquefaction
The danger of soil liquefaction at the site can be excluded.

Summary assessment on earthquakes
The building structure of the ZL KWG is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 0.95 m/s^2 approximately corresponds to the minimum acceleration of 0.1 g required by the EU. The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the load case of a beyond design basis earthquake. A collapse of the storage building is not to be postulated.

The main vital function of the ZL KWG is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design

The ZL KWG is located at an altitude of ground level 72.20 m above sea level. For the top level of the hall floor and the entrance, there is a height of 72.35 m above sea level. The calculated water level for a 100-year flood is 71.07 m above sea level so that the ZL KWG is permanently protected against it. For the 10,000-year flood with a water level of 73.00 m above sea level it is provided to prevent the ingress of water into the building by temporary measures. Also in case of water ingress there would be no damage to the hall or the casks. All safety-related systems would not be impaired in their function.

Precautionary measures

It is provided to prevent the ingress of water into the building by temporary measures. These precautions serve to protect personnel and property. A failure of the precautions taken against flood does not lead to safety-relevant impacts since the TLBs fulfil the protection goals.

Behaviour at the stress level

Postulated flooding of the TLBs will not compromise compliance with the protection goals.

Accident management measures

There are no accident management measures provided.

Summary assessment on flooding

For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. The measures taken are usual precautions to protect personnel and property against ingress of water. They are irrelevant for the safe storage of the TLBs since the casks themselves are waterproof and corrosion-protected and cannot start floating due to postulated flooding of the contamination-free storage area. The protection goals will also be complied with in case of water ingress into the storage area. Foundation and stability of the storage building will not be impaired by flooding either.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels depends on the presentation of additional verifications and their confirmation. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
According to the operator, rain impacts were considered in the design of the ZL KWG in accordance with DIN 1045 and DIN 1055-1. It was demonstrated in the framework of the licensing procedure that weather-related influences were adequately taken into account in the building design.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
According to the operator, the safety of the ZL KWG will not be impaired also in case of heavy rain with a rainfall intensity of $r_{5,100}$ in accordance with DIN 1986-100.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. The DIN standards referred to by the operator do not apply to heavy rain. However, the ESK holds the view that it can be assumed that the impacts and influences on the storage facility from other natural hazards also cover the heavy rain event. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the ZL KWG, load assumptions according to DIN 1055 applicable at that time were considered in the design. For the design of the storage facility, special loads, such as earthquake, blast wave or aircraft crash, were taken into account. These load cases result in higher loads than those specified in DIN 1055 so that the loads from weather-related events are not only covered but that there is even a considerable degree of robustness.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
The loads from both natural hazards (earthquake, flooding) and man-made hazards (blast wave, aircraft crash) are higher than those from load cases beyond the structural design with regard to other weather-related events so that these are covered by them. Also in case of other weather-related events beyond the design basis according to DIN 1055, the facility behaves as designed due to the available margins in the structural design.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The structural design of the ZL KWG against other weather-related events complies with the applicable regulations and standards so that resistance is ensured according to the basic level. Other weather-related events, such as storm (also including hurricane), hail, snow loads, freezing rain and lightning, are generally no design-relevant load cases for the ZL KWG. Due to weather-related events, load cases such as flood, loss of electrical power and fire may occur which, just as a postulated failure of the storage building, will not compromise compliance with the protection goals. Potential weather-related events beyond the design basis are covered by the verifications performed within the licensing procedure for the load cases earthquake, aircraft crash, blast wave and fire.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
To ensure the protective functions of the TLBs, no electrically powered systems are required. As a passive system, the TLB with pressure switch as part of the sealing barriers does not require any electrical power supply. Power supply for the electrical installations of the on-site storage facility is adequately ensured by normal power supply, backup power supply and uninterruptible power supply (UPS) for all load cases to be postulated. A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel.

Design of the power supply
The normal grid switchgears of the ZL KWG are supplied with energy via a normal grid switchgear of the KWG. Alternatively, additional supply is available from the 30 kV station. The backup power grid of the ZL KWG is supplied from the emergency grid of the KWG with availability of another alternative supply. Switching is performed manually.

In case of unavailability of the normal grid and the backup power switchgears, the following systems are supplied from a central UPS:

- higher-level I&C,
- radiation monitoring systems and equipment, and
- communications technology.

The following systems are provided with an autonomous, internal UPS:

- cask monitoring system,
- fire alarm system, and
- emergency lighting.

Design of the emergency and backup power supply
Backup power for the ZL KWG is supplied from the emergency grid of the KWG. The emergency diesel generators of the KWG have already been assessed in the context of the RSK stress test for nuclear power plants. Without refuelling, the emergency diesel generators are designed for 72 hours of operation. Personnel actions to start the emergency diesel generators are not required.

Behaviour in case of longer-term total loss of power supply
The protective functions of the TLBs will not be affected by it. Other important systems that depend on power supply will no longer be available, but their function is not required to maintain the protective functions of the TLBs. A failure of the systems can be compensated by administrative measures, such as inspections or measurements with mobile devices.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Other important systems that depend on power supply do not serve to maintain the protection goals. They fulfil monitoring tasks in the framework of cask storage (e.g. monitoring of cask leak tightness, fire detection, radiation protection). A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
For the design, fires in the storage hall and in the loading area were examined. The other areas of the building were protected according to their use and the fire loads in them and separated from the loading and storage area in accordance with the fire protection regulations. The structural design of the storage building includes the use of mainly non-combustible or flame-resistant materials as a preventive fire protection measure. Furthermore, the building was divided into fire compartments. The entire storage area is monitored by an automatic fire alarm system. For fire fighting, portable fire extinguishers as well as supply of water are available via external hydrants.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
A fire in the storage hall for a period of more than one hour is only conceivable as a smouldering fire with a low pyrolysis rate. Such a low pyrolysis rate cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Operating personnel will permanently be present as long as the transport vehicle stays in the loading area so that a fire can be immediately detected and fought with the available extinguishing agents and equipment. Should, however, a postulated vehicle fire have a duration of more than one hour, so this will only be possible with a reduced pyrolysis rate which cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Accident management measures
Accident management measures are not required.

Summary assessment on internal fires
The storage concept of the ZL KWG comprises structural fire protection measures, fire fighting equipment, fire alarm systems and operating rules. The storage hall is constructed as a separate fire compartment with only very low fire loads. Also in the entry hall, there are only limited fire loads. In the loading hall, temporarily stay of a transport vehicle is possible. To minimise the risk of fire, the towing vehicle will be uncoupled immediately after positioning of the transport vehicle and driven out of the hall.

For the special case of fire in the truck lock it is important to note that this could only be relevant for the very short period of time during which the TLB on the transport vehicle and the towing vehicle stay in the truck lock at the same time. The thermal impact on the sealing area of the cask would, however, also then be definitely smaller than in the event of an aircraft crash with subsequent fire for which control was demonstrated.

The fire protection required for the ZL KWG is mainly covered by the properties of the casks. The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
Denser stands of trees only exist outside the outer perimeter at a distance of more than 40 m from the storage building.

Design
A fire occurring in stands of trees outside the premises of the ZL KWG can be fought effectively with the available fire extinguishing equipment. Thus, impacts of external fires on the ZL KWG are not to be postulated so that this does not result in special design features for the facility.

Precautionary measures
Protection of the facility against the consequences of external fires does not require any precautionary measures.

Behaviour at the stress level
The duration of fires outside the facility has no influence on the design of the facility. Therefore, a fire duration of one hour more does not influence the impacts on the facility either.

Accident management measures
Accident management measures are not required.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of a postulated crash of a high-speed military aircraft were considered for the ZL KWG and are covered by the design of the TLBs. Due to the design of the storage building of the ZL KWG against aircraft crash, additional protection is achieved. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The ZL KWG is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Blast wave was considered as beyond design basis event in the licensing procedure. The stability of the storage building and the integrity of the TLBs are not endangered by blast waves. The storage building and the TLBs are designed against the blast wave load case in accordance with the pressure wave guideline of the Federal Ministry of the Interior (BMI). The TLBs fulfil the protective function against the impacts of blast waves.

Impacts of stronger blast waves
The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the blast wave load case. A collapse of the storage building is not to be postulated. Also in case of a much stronger pressure wave than designed it can be assumed that the protective functions of the TLBs will be ensured. In particular, the confinement of radioactive material and residual heat removal from the TLBs in case of being buried (debris load) will be ensured.

Site-specific amounts of explosive gases
The safety distances to industrial facilities, gas pipelines and transport routes are sufficiently large so that undue loads on the TLBs cannot occur.

Potential damage in case of facilities with no special design
The ZL KWG and the TLBs are designed against the blast wave load case.

Summary assessment on blast waves
The ESK notes that due to the site-specific conditions, no massive blast wave can occur so that degree of protection 3 can be confirmed. Cliff edge effects are not to be expected.

7.2.8 Emsland on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Lower Saxony Ministry for the Environment, Energy and Climate Protection dated 10.09.2012 [6] with comments and notes [6, Annex 1] and the response from the operator of 31.07.2012 [6, Annex 6]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test were taken into account.

A Earthquake

Design
In the framework of the licensing procedure, the Emsland storage facility (ZL KKE) was designed against the same earthquake as the Emsland nuclear power plant (KKE). Within the licensing procedure, the structural design of the ZL KKE was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of 1.2 m/s^2, were considered in the structural design of the storage building.

Precautionary measures
Against the background of compliance with the protection goals, the seismic design of the ZL KKE is based, in particular, on the verifications performed within the scope of the design. Thus, no special precautionary measures are required to control the consequences of a design basis earthquake except for the verification calculations.

Behaviour in the event of beyond design basis earthquakes
The design spectra and design bases used in the licensing procedure are conservative. Further margins are available due to the structural design of the storage building against aircraft crash and blast wave so that undue impairment of the protection goals is not to be expected also in case of a beyond design basis earthquake.

Special precautionary measures are neither required to control the consequences of a beyond design earthquake nor for the design basis earthquake. Thus, failure of precautionary measures is not to be postulated.

Applicability of damage mechanisms
Also for the stress level, no major damage mechanisms are expected that could jeopardise the protection goals.

Combinations with other load cases
In the licence of the storage facility, superposition of load cases was also assessed. In this context, the consequences of an earthquake for the ZL KKE were adequately investigated and also apply to the stress level. So, for example, loss of power supply due to an earthquake also does not contribute to jeopardising the protection goals since cask integrity is not dependent on power supply and heat removal is ensured passively by natural convection.

Fires are also to be postulated for an earthquake at the stress level and the design basis earthquake. However, the impacts of fires remain limited to an extent that they can be considered as harmless because danger to the casks is not possible due to the minimisation of fire loads.

Potential blocking of the supply air system, which is not designed to withstand seismic loads, by facade panels falling down can also be removed by using the clearing equipment available on site. Blocking of the air supply is not critical in terms of time and there is no urgent need to remove a potential blocking (grace time at least two days). Therefore, the supply air system can be safely uncovered without restrictions also at the stress test level.

Accident management measures
For the ZL KKE, there are no special accident management measures provided after an earthquake event.

Soil liquefaction
Soil liquefaction at the Lingen site can be excluded.

Summary assessment on earthquakes
The building structure of the ZL KKE is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 1.2 m/s^2 exceeds the minimum acceleration of 0.1 g required by the EU (=1.0 m/s^2). The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the load case of a beyond design basis earthquake. A collapse of the storage building is not to be postulated.

The main vital function of the ZL KKE is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The site is located at an altitude of about 31 m above sea level and is mainly flat. The ZL KKE is about 550 m from the eastern bank of the river Ems. The water level is maintained at 21.57 m above sea level by damming of the Hanekenfähr weir. On 01.03.1987, the highest flood observed so far at the site led to a water level of 22.10 m above sea level. For a 10,000-year flood, this leads to a water level of about 25.0 m above sea level as a maximum. Due to the topographical situation, the site is not prone to flooding.

Precautionary measures
Since the site is not prone to flooding due to the topographical situation and thus is to be regarded as flood-free, this issue is not relevant for the ZL KKE.

Behaviour at the stress level
Since the site is not prone to flooding due to the topographical situation and thus is to be regarded as flood-free, this issue is not relevant for the ZL KKE.

Accident management measures
Since the site is not prone to flooding due to the topographical situation and thus is to be regarded as flood-free, this issue is not relevant for the ZL KKE.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed.

Cliff edge effects are not to be expected. Danger from flooding is to be excluded site-specifically and stress level 3 is complied with.

C Heavy rain

Design
To protect the casks against corrosion and with regard to the durability of the building, the on-site storage facility was also protected against ingress of water from outside.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
Also in case of heavy rain, no damage to the building is to be expected due to the design of the ZL KKE. In addition, the casks themselves provide effective protection so that no damage mechanisms occur.

Accident management measures
For compliance with the protection goals, no accident management measures are required even in case of beyond design basis events.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. In addition, the design against earthquakes ensures a large margin against increased loads. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the ZL KKE, load assumptions according to DIN 1055 applicable at that time were considered in the design. For the design of the storage facility, special loads, such as earthquake, blast wave or aircraft crash, were taken into account. These load cases result in higher loads than those specified in DIN 1055 so that the loads from weather-related events are not only covered but that there is even a considerable degree of robustness.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
Also in case of other weather-related events, no major damage mechanisms are to be expected due to the design of the ZL KKE.

Accident management measures
For compliance with the protection goals, no accident management measures are required even in case of beyond design basis events.

Summary assessment on other weather-related events
The KKE storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is excluded due to the robust construction of the storage hall. A failure of the storage building postulated nonetheless will not compromise compliance with the protection goals.

Protection against mechanical loading is represented by the TLBs, heat removal from the casks will also be ensured if the casks are buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
For compliance with the protection goals, no safety systems are required that depend on power supply.

Other safety-relevant systems and components are, according to the operating manual,

- pressure switch,
- cask monitoring system,
- fire alarm system,
- emergency power system,
- crane control, and
- storage building ventilation system.

Compliance with the protection goals will also be ensured in case of failure of these systems.

Design of the power supply
For compliance with the protection goals, no safety systems are required that depend on power supply. This also applies to the systems listed above as other safety-relevant systems.

Design of the emergency and backup power supply
For compliance with the protection goals, no safety systems are required that depend on power supply. This also applies to the systems listed above as other safety-relevant systems.

Behaviour in case of longer-term total loss of power supply
A total loss of power supply and the emergency/backup power supply for a longer period of time has no safety significance since compliance with the protection goals is also ensured without electrical energy.

Accident management measures
For compliance with the protection goals, no accident management measures are required since loss of power supply has no safety significance.

Summary assessment on the loss of electrical power
A loss of power supply has no safety-relevant impacts on the casks and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as storage cask monitoring system, fire alarm system and local dose rate monitoring, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
According to the licence, internal fires were classified as non-hazardous with regard to safety. For the ZL KKE, a fire protection concept was developed for personal protection, for preventing the development of a fire as far as possible and for preventing spread of fire, which was reviewed and approved within the licensing procedure. The concept ensures fast and effective fire fighting. The fires considered in the design will have no consequences for the emplaced casks. Further measures are not required and thus not provided.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
The fire loads in the ZL KKE are not sufficient to jeopardise the integrity of the casks in case of stress level 1. An independent accident analysis was performed within the nuclear licensing procedure and the mechanical and thermal loads for the casks resulting from potential design basis accidents were analysed. The fire loads in the ZL KKE are low due to the structural design of the ZL KKE and the amounts of combustible material stored there. Due to the small fire inventory, only localised fires may occur.

Accident management measures
For compliance with the protection goals, no accident management measures are required.

Summary assessment on internal fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the properties of the TLBs, compliance with the protection goals is ensured. In addition, effective preventive fire protection in the storage area of the ZL KKE is realised by only admitting negligible fire loads

within the storage areas. Compliance with this preventive fire protection is ensured by administrative regulations.

In the loading hall, temporarily stay of a transport vehicle is possible. To minimise the risk of fire, the towing vehicle will be removed from the cask reception area immediately after cask transfer.

For the special case of fire in the truck lock it is important to note that this could only be relevant for the very short period of time during which the TLB on the transport vehicle and the towing vehicle stay in the truck lock at the same time. The thermal impact on the sealing area of the cask would, however, also then be definitely smaller than in the event of an aircraft crash with subsequent fire for which control was demonstrated.

Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
The ZL KKE does not border on woodland areas or on built-up areas with increased fire loads or on traffic routes on which larger fire loads are regularly transported.

Design
For the ZL KKE, hazards from external fires were also considered. There will be no consequences for the facility. Impacts of an external fire on the ZL KKE are not given, i.a. due to the massive monolithic building structure, and thus are not to be considered.

Precautionary measures
For compliance with the protection goals, no precautionary measures are required.

Behaviour at the stress level
Fires in the area adjacent to the facility lasting one hour longer than the design basis fires are not to be feared due to the absence of fire loads so that damage mechanisms will not occur.

Accident management measures
Since impacts on the ZL KKE caused by external fires are not given, accident management measures to limit the consequences are not required.

Summary assessment on external fires

The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts

The impacts of a postulated crash of a high-speed military aircraft were considered for the ZL KKE. Both the storage building and the TLBs are designed to withstand aircraft crashes.

In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path

The ZL KKE is not located in the approach path of an airport.

Summary assessment on aircraft crashes

The impacts of an aircraft crash were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure for the PKA. The scenario of an aircraft crash was appropriately considered in the design of the storage facility. The examinations comprised the mechanical and thermal impacts. These may lead to a collapse of walls and roofing as well as to the penetration of aircraft wreckage and kerosene, where the kerosene partly runs off through drains in the floor. The aircraft crash leads to both mechanical loads on the TLBs and to thermal loads by a subsequent kerosene fire. According to the examination performed by the Federal Office for Radiation Protection, the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV) are complied with. A release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached will neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire.

The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
The storage building and the TLBs are designed against the blast wave load case in accordance with the pressure wave guideline of the Federal Ministry of the Interior (BMI).

Impacts of stronger blast waves
The possible points of origin of pressure waves have sufficient safety distance to the ZL KKE so that pressure waves beyond the design basis can, in principle, not occur. In addition, there are substantial margins due to the design of the ZL KKE against aircraft crash and the TLBs themselves.

Site-specific amounts of explosive gases
Possible points of origin of blast waves are beyond the defined safety margins. This issue is covered by having considered the damage to a liquid gas tanker (1,800 m^3) on the Ems.

Potential damage in case of facilities with no special design
The ZL KKE and the TLBs are designed against the blast wave load case.

Summary assessment on blast waves
Due to the solid construction of the ZL KKE built according to the STEAG concept, a collapse of the storage building is not to be postulated. Moreover, the TLBs are designed against the blast wave load case.
Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.9 Unterweser on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Lower Saxony Ministry for the Environment, Energy and Climate Protection dated 10.09.2012 [6] with comments and notes [6, Annex 1] and the response from the operator of 31.07.2012 [6, Annex 5]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test were taken into account.

A Earthquake

Design

The site of the Unterweser storage facility (ZL KKU) is not to be assigned to an earthquake zone according to DIN 4149 or DIN-EN-1998.The storage building and the TLBs are designed against the earthquake load case. Within the licensing procedure, the structural design of the ZL KKU was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability < $1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of 0.5 m/s^2, were considered in the structural design of the storage building.

Precautionary measures

Precautionary measures do not have to be considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes

The storage building is designed against the earthquake load case. According to the operator, margins are available that cover at least one intensity level more. Further margins are available due to the structural design of the storage building against aircraft crash and blast wave. In addition, the protective functions of the TLBs will also be ensured in case of an earthquake with an intensity increased by a factor of 1 compared to the design basis earthquake. In particular, confinement of the radioactive material and residual heat removal from the TLBs in case of being buried (debris load) and stability of the TLBs will be ensured.

Applicability of damage mechanisms

Damage mechanisms are not to be expected. The relevant basis for the design of the storage facility components are the load cases aircraft crash and blast wave.

Combinations with other load cases

Consequential impacts from interdependent combinations with other load cases are not to be postulated; the impacts are covered by those of an aircraft crash.

Accident management measures

There are no accident management measures provided. An on-site emergency preparedness plan is not required due to the impacts to be expected in case of incidents, and it was demonstrated within the licensing procedure that no major accident management measures will be required in case of beyond design basis events.

Soil liquefaction

The danger of soil liquefaction at the site can be excluded.

Summary assessment on earthquakes
The building structure of the ZL KKU is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 0.5 m/s^2 is below the minimum acceleration of 0.1 g required by the EU (= 1 m/s^2). The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the load case of a beyond design basis earthquake. A collapse of the storage building is not to be postulated.

The main vital function of the ZL KKU is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The ZL KKU is designed against a flood with an exceedance probability of less than 1.10-4/a. The building is designed against uplift and also sealed against the ingress of water. The doors and the transport gate are designed “waterproof” (leak rate 5 l/h) up to a water column of 2.80 m. In addition, the windows can be closed with stop logs. The stop logs cover the windows completely.

The site is protected against flooding by dykes (dyke top height of +7.10 m above sea level). With +6.00 m above sea level, the design basis flood (10,000-year flood) is about 1 m below the dyke top. In the event of a dyke failure at the ZL KKU, a water level is to be postulated in the area of the storage facility – depending on the expected storm surge – of up to +4.00 m above sea level. Since the floor top level of ZL KKU has a height of +1.85 m above sea level, the storage facility would then be flooded up to a height of 2.15 m. For this case, the E.ON Kernkraft GmbH provided temporary flood protection measures that are appropriate to prevent flooding of the cask reception and storage area. Irrespective of this, stability of the storage building and compliance with the protection goals are also ensured in case of flooding.

Precautionary measures
It is provided to prevent the ingress of water into the building by temporary measures. These precautions serve to protect personnel and property. A failure of the precautions taken against flood does not lead to safety-relevant impacts since the TLBs fulfil the protection goals.

Behaviour at the stress level
Due to its own weight, the building is uplift-resistant and stable up to a high-water mark of about +8.95 m building height. When reaching a flood level of about 5.20 m building height, the storage hall will be flooded through the window of the social wing. Flooding of the TLBs will not compromise compliance with the protection goals.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. The measures taken are usual precautions to protect personnel and property against ingress of water. They are irrelevant for the safe storage of the TLBs since the casks themselves are waterproof and corrosion-protected and cannot start floating due to postulated flooding of the contamination-free storage area. The protection goals will also be complied with in case of water ingress into the storage area. Foundation and stability of the storage building will not be impaired by flooding either.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels depends on the presentation of additional verifications and their confirmation. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
According to the operator, rain impacts were considered in the design of the ZL KKU in accordance with DIN 1045 and DIN 1055-1. It was demonstrated in the framework of the licensing procedure that weather-related influences were adequately taken into account in the building design.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
According to the operator, the safety of the ZL KKU will not be impaired also in case of heavy rain with a rainfall intensity of $r_{5,100}$ in accordance with DIN 1986-100.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. The DIN standards referred to by the operator do not apply to heavy rain. However, the ESK holds the view that it can be assumed that the impacts and influences on the storage facility from other natural hazards also cover the heavy rain event. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the ZL KKU, load assumptions according to DIN 1055 applicable at that time were considered in the design. For the design of the storage facility, special loads, such as earthquake, blast wave or aircraft crash, were taken into account. These load cases result in higher loads than those specified in DIN 1055 so that the loads from weather-related events are not only covered but that there is even a considerable degree of robustness.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
The loads from both natural hazards (earthquake, flooding) and man-made hazards (blast wave, aircraft crash) are higher than those from load cases beyond the structural design with regard to other weather-related events so that these are covered by them. Also in case of other weather-related events beyond the design basis according to DIN 1055, the facility behaves as designed due to the available margins in the structural design.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The structural design of the ZL KKU against other weather-related events complies with the applicable regulations and standards so that resistance is ensured according to the basic level. Other weather-related events, such as storm (also including hurricane), hail, snow loads, freezing rain and lightning, are generally no design-relevant load cases for the ZL KKU. Due to weather-related events, load cases such as flood, loss of electrical power and fire may occur which, just as a postulated failure of the storage building, will not compromise compliance with the protection goals. Potential weather-related events beyond the design basis are covered by the verifications performed within the licensing procedure for the load cases earthquake, aircraft crash, blast wave and fire.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
To ensure the protective functions of the TLBs, no electrically powered systems are required. As a passive system, the TLB with pressure switch as part of the sealing barriers does not require any electrical power supply. Power supply for the electrical installations of the on-site storage facility is adequately ensured by normal power supply, backup power supply and uninterruptible power supply (UPS) for all load cases to be postulated. A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel.

Design of the power supply
The normal grid switchgears of the ZL KKU are supplied with energy via a normal grid switchgear of the KKU with availability of two alternative supplies from the regional 20 kV grid. In case of loss power supply for the ZL KKU from the normal grid, supply by the normal grid switchgears is automatically disconnected from the normal grid. Furthermore, the tie breakers between the normal grid switchgears and backup power switchgears are automatically switched off, the backup power diesel generator started and the circuit breakers of the diesel generator activated. In case of unavailability of the normal grid and the backup power switchgears, the following systems are supplied from a central UPS:

- higher-level I&C,
- radiation monitoring systems and equipment, and
- communications technology.

The following systems are provided with an autonomous, internal UPS:

- cask monitoring system,
- fire alarm system,
- smoke extraction system, and
- emergency lighting.

Design of the emergency and backup power supply
Without refuelling, the backup diesel generator is designed for 17 hours of operation. Personnel actions to start the diesel generator are not required.

Behaviour in case of longer-term total loss of power supply
The protective functions of the TLBs will not be affected by it. Other important systems that depend on power supply will no longer be available, but their function is not required to maintain the protective functions of the

TLBs. A failure of the systems can be compensated by administrative measures, such as inspections or measurements with mobile devices.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of power supply has no safety-relevant impacts on the casks and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Other important systems that depend on power supply do not serve to maintain the protection goals. They fulfil monitoring tasks in the framework of cask storage (e.g. monitoring of cask leak tightness, fire detection, radiation protection). A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
For the design, fires in the storage hall and in the loading area were examined. The other areas of the building were protected according to their use and the fire loads in them and separated from the loading and storage area in accordance with the fire protection regulations. The structural design of the storage building includes the use of mainly non-combustible or flame-resistant materials as a preventive fire protection measure. Furthermore, the building was divided into fire compartments. The entire storage area is monitored by an automatic fire alarm system. For fire fighting, portable fire extinguishers as well as supply of water are available via external hydrants.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
A fire in the storage hall for a period of more than one hour is only conceivable as a smouldering fire with a low pyrolysis rate. Such a low pyrolysis rate cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Operating personnel will permanently be present as long as the transport vehicle stays in the loading area so that a fire can be immediately detected and fought with the available extinguishing agents and equipment. Should, however, a postulated vehicle fire last longer than one hour, so this will only be possible with a reduced pyrolysis rate which cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Accident management measures
Accident management measures are not required.

Summary assessment on internal fires
In the storage area, there are only small fire loads since there are mainly non-combustible or flame-resistant materials and the use of combustible construction elements and working materials was reduced to a minimum. A postulated fire in the cask reception area during handling of a TLB will immediately be detected by the staff on site and effectively fought. Thus, only localised fires may occur within the storage building whose duration and intensity will be well below the approved design of the TLBs against the impacts of fire.

For the special case of fire in the truck lock it is important to note that this could only be relevant for the very short period of time during which the TLB on the transport vehicle and the towing vehicle stay in the truck lock at the same time. The thermal impact on the sealing area of the cask would, however, also then be definitely smaller than in the event of an aircraft crash with subsequent fire for which control was demonstrated.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
Small stands of trees only exist outside the premises of the ZL KKU.

Design
A fire occurring in stands of trees outside the premises of the ZL KKU can be fought effectively with the available fire extinguishing equipment so that spread of a forest fire to the ZL KKU is prevented. Thus, impacts of external fires on the ZL KKU are not to be postulated so that this does not result in special design features for the facility.

Precautionary measures
Protection of the facility against the consequences of external fires does not require any precautionary measures.

Behaviour at the stress level
The duration of fires outside the facility has no influence on the design of the facility. Therefore, a fire duration of one hour more does not influence the impacts on the facility either.

Accident management measures
Accident management measures are not required.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were taken into account. These considerations covered both military aircrafts and large commercial airliners. The mechanical and thermal impacts on the TLBs resulting from a crash of a high-speed military aircraft do not lead to such loads on the casks that, in particular, the confinement of the radioactive inventory would not be appropriately ensured. Due to the design of the storage building of the ZL KKU against aircraft crash, additional protection is achieved. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The ZL KKU is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Blast wave was considered as beyond design basis event in the licensing procedure. The stability of the storage building and the integrity of the TLBs are not endangered by blast waves. The storage building and the TLBs are designed against the blast wave load case in accordance with the pressure wave guideline of the Federal Ministry of the Interior (BMI). The TLBs fulfil the protective function against the impacts of blast waves.

Impacts of stronger blast waves
The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the blast wave load case. A collapse of the storage building is not to be postulated.

Also in case of a much stronger pressure wave than designed it can be assumed that the protective functions of the TLBs will be ensured. In particular, the confinement of radioactive material and residual heat removal from the TLBs in case of being buried (debris load) will be ensured.

Site-specific amounts of explosive gases
The safety distances to industrial facilities, gas pipelines and transport routes are sufficiently large so that undue loads on the TLBs cannot occur.

Potential damage in case of facilities with no special design
The ZL KKU and the TLBs are designed against the blast wave load case.

Summary assessment on blast waves
Due to the solid construction of the ZL KKU built according to the STEAG concept, a collapse of the storage building is not to be postulated. Moreover, the TLBs are designed against the blast wave load case.

Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.10 Brokdorf on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Ministry of Energy Transition, Agriculture, the Environment and Rural Areas Schleswig-Holstein dated 16.10.2013 [17] and the response from the operator E.ON Kernkraft GmbH of 07.08.2012 [17, Annex 1].

A Earthquake

Design
The site of the Brokdorf storage facility (ZL KBR) is not to be assigned to an earthquake zone according to DIN 4149 or DIN-EN-1998. The storage building and the TLBs are designed against the earthquake load case. Within the licensing procedure, the structural design of the ZL KBR was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of 0.5 m/s^2, were considered in the structural design of the storage building.

Precautionary measures
Precautionary measures do not have to be considered in the design of the building against the design basis earthquake.

Behaviour in the event of beyond design basis earthquakes
The storage building is designed against the earthquake load case. According to the operator, margins are available that cover at least one intensity level more. Further margins are available due to the structural design of the storage building against aircraft crash and blast wave. In addition, the protective functions of the TLBs will also be ensured in case of an earthquake with an intensity increased by a factor of 1 compared to the design basis earthquake. In particular, confinement of the radioactive material and residual heat removal from the TLBs in case of being buried (debris load) and stability of the TLBs will be ensured.

Applicability of damage mechanisms
Damage mechanisms are not to be expected. The relevant basis for the design of the storage facility components are the load cases aircraft crash and blast wave.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated; the impacts are covered by those of an aircraft crash.

Accident management measures
There are no accident management measures provided. It was demonstrated within the licensing procedure that no major accident management measures will be required in case of beyond design basis events.

Soil liquefaction
The danger of soil liquefaction at the site can be excluded.

Summary assessment on earthquakes
The building structure of the ZL KBR is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 0.5 m/s^2 is below the minimum acceleration of 0.1 g required by the EU (= 1 m/s^2). The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the load case of a beyond design basis earthquake. A collapse of the storage building is not to be postulated.

The main vital function of the ZL KBR is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The ZL KBR is designed against a flood with an exceedance probability of less than 1.10-4/a. The building is designed against uplift and also sealed against the ingress of water. The site is protected against flooding from storm surges by the land protection dyke of the Elbe. The site is protected against flooding by dykes (dyke top height of 8.40 m above sea level).

In the event of a dyke failure at the ZL KBR, a water level is to be postulated in the area of the storage facility of up to 4.30 m above sea level. Since the floor top level of the ZL KBR has a height of 1.55 m above sea level, the storage facility would then be flooded up to a height of 2.75 m. Also for this case, stability of the storage building and compliance with the protection goals are ensured. For the case of a dyke failure, the operators provided temporary flood protection measures that are appropriate to prevent flooding of the storage building.

Precautionary measures
To protect personnel and property, appropriate precautions are taken by temporary flood protection measures in accordance with the alarm regulation. In case of failure of these temporary flood protection measures, the staff facilities and the cask reception area of the ZL KBR will be flooded. Since no further protective measures

are provided between the cask reception and storage area, the storage area will be flooded subsequently. After a while, in the building, the same water level will be reached as outside.

A failure of the precautions taken against flood does not lead to safety-relevant impacts since the TLBs fulfil the protection goals.

Behaviour at the stress level
For a postulated dyke failure, a water level of 4.30 m above sea level would be reached, i.e. the ZL KBR would be flooded up to a height of 2.75 m. Also in this case, stability of the storage building and compliance with the protection goals will be ensured. Flooding of the TLBs will not compromise compliance with the protection goals.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. The measures taken are usual precautions to protect personnel and property against ingress of water. They are irrelevant for the safe storage of the TLBs since the casks themselves are waterproof and corrosion-protected and cannot start floating due to postulated flooding of the contamination-free storage area. The protection goals will also be complied with in case of water ingress into the storage area. Foundation and stability of the storage building was considered in the design.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels depends on the presentation of additional verifications and their confirmation.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
According to the operator, rain impacts were considered in the design of the ZL KBR in accordance with DIN 1045 and DIN 1055-1. It was demonstrated in the framework of the licensing procedure that weather-related influences were adequately taken into account in the building design.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
According to the operator, the safety of the ZL KBR will not be impaired also in case of heavy rain with a rainfall intensity of $r_{5,100}$ in accordance with DIN 1986-100.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. The DIN standards referred to by the operator do not apply to heavy rain. However, the ESK holds the view that it can be assumed that the impacts and influences on the storage facility from other natural hazards also cover the heavy rain event. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the ZL KBR, load assumptions according to DIN 1055 applicable at that time were considered in the design. For the design of the storage facility, special loads, such as earthquake, blast wave or aircraft crash, were taken into account. These load cases result in higher loads than those specified in DIN 1055 so that the loads from weather-related events are not only covered but that there is even a considerable degree of robustness.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
The loads from both natural hazards (earthquake, flooding) and man-made hazards (blast wave, aircraft crash) are higher than those from load cases beyond the structural design with regard to other weather-related events so that these are covered by them. Also in case of other weather-related events beyond the design basis according to DIN 1055, the facility behaves as designed due to the available margins in the structural design.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events

The structural design of the ZL KBR against other weather-related events complies with the applicable regulations and standards so that resistance is ensured according to the basic level. Other weather-related events, such as storm (also including hurricane), hail, snow loads, freezing rain and lightning, are generally no design-relevant load cases for the ZL KBR. Due to weather-related events, load cases such as flood, loss of electrical power and fire may occur which, just as a postulated failure of the storage building, will not compromise compliance with the protection goals. Potential weather-related events beyond the design basis are covered by the verifications performed within the licensing procedure for the load cases earthquake, aircraft crash, blast wave and fire.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply

To ensure the protective functions of the TLBs, no electrically powered systems are required. As a passive system, the TLB with pressure switch as part of the sealing barriers does not require any electrical power supply.

Power supply for the electrical installations of the on-site storage facility is adequately ensured by normal power supply, backup power supply and uninterruptible power supply (UPS) for all load cases to be postulated. A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel.

Design of the power supply

The normal grid switchgears of the ZL KBR are supplied with energy via a normal grid switchgear of the KBR. In case of loss power supply for the ZL KBR from the normal grid, supply by the normal grid switchgears is automatically disconnected from the normal grid. Furthermore, the tie breakers between the normal grid switchgears and backup power switchgears are automatically switched off, the backup power diesel generator started and the circuit breakers of the diesel generator activated.

In case of unavailability of the normal grid and the backup power switchgears, the following systems are supplied from a central UPS:

- higher-level I&C,
- radiation monitoring systems and equipment, and
- communications technology.

The following systems are provided with an autonomous, internal UPS:

- cask monitoring system,
- fire alarm system, and
- emergency lighting.

Design of the emergency and backup power supply
Without refuelling, the backup diesel generator is designed for 17 hours of operation. Personnel actions to start the diesel generator are not required.

Behaviour in case of longer-term total loss of power supply
The protective functions of the TLBs will not be affected by it. Other important systems that depend on power supply will no longer be available, but their function is not required to maintain the protective functions of the TLBs. A failure of the systems can be compensated by administrative measures, such as inspections or measurements with mobile devices.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Other important systems that depend on power supply do not serve to maintain the protection goals. They fulfil monitoring tasks in the framework of cask storage (e.g. monitoring of cask leak tightness, fire detection, radiation protection). A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
For the design, fires in the storage hall and in the loading area were examined. The other areas of the building were protected according to their use and the fire loads in them and separated from the loading and storage area in accordance with the fire protection regulations.

The structural design of the storage building includes the use of mainly non-combustible or flame-resistant materials as a preventive fire protection measure. The entire storage area is monitored by an automatic fire alarm system. For fire fighting, portable fire extinguishers as well as supply of water are available via external hydrants.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
A fire in the storage hall for a period of more than one hour is only conceivable as a smouldering fire with a low pyrolysis rate. Such a low pyrolysis rate cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Operating personnel will permanently be present as long as the transport vehicle stays in the loading area so that a fire can be immediately detected and fought with the available extinguishing agents and equipment. Should, however, a postulated vehicle fire last longer than one hour, so this will only be possible with a reduced pyrolysis rate which cannot result in fire-induced external temperatures at the TLBs beyond the cask design.

Accident management measures
Accident management measures are not required.

Summary assessment on internal fires
In the storage area, there are only small fire loads since there are mainly non-combustible or flame-resistant materials and the use of combustible construction elements and working materials was reduced to a minimum. A postulated fire in the cask reception area during handling of a TLB will immediately be detected by the staff on site and effectively fought.

Thus, only localised fires may occur within the storage building whose duration and intensity will be well below the approved design of the TLBs against the impacts of fire.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
Stands of trees only exist outside the premises of the ZL KBR.

Design
A fire occurring in stands of trees outside the premises of the ZL KBR can be fought effectively with the available fire extinguishing equipment so that spread of a forest fire to the ZL KBR is prevented. Thus,

impacts of external fires on the ZL KBR are not to be postulated so that this does not result in special design features for the facility.

Precautionary measures
Protection of the facility against the consequences of external fires does not require any precautionary measures.

Behaviour at the stress level
The duration of fires outside the facility has no influence on the design of the facility. Therefore, a fire duration of one hour more does not influence the impacts on the facility either.

Accident management measures
Accident management measures are not required.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Spread of external fires to the storage facility is excluded due to appropriate zones with low fire loads in the vicinity of the storage facility. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is to be excluded. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were considered. These considerations covered both military aircrafts and large commercial airliners. The mechanical and thermal impacts on the TLBs resulting from a crash of a high-speed military aircraft do not lead to such loads on the casks that, in particular, the confinement of the radioactive inventory would not be appropriately ensured. Due to the design of the storage building of the ZL KBR against aircraft crash, additional protection is achieved. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The ZL KBR is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash

of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Blast wave was considered as beyond design basis event in the licensing procedure. The stability of the storage building and the integrity of the TLBs are not endangered by blast waves. The storage building and the TLBs are designed against the blast wave load case in accordance with the pressure wave guideline of the Federal Ministry of the Interior (BMI). The TLBs fulfil the protective function against the impacts of blast waves.

Impacts of stronger blast waves
The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the blast wave load case. A collapse of the storage building is not to be postulated.

Also in case of a much stronger pressure wave than designed it can be assumed that the protective functions of the TLBs will be ensured. In particular, the confinement of radioactive material and residual heat removal from the TLBs in case of being buried (debris load) will be ensured.

Site-specific amounts of explosive gases
The safety distances to industrial facilities, gas pipelines and transport routes are sufficiently large so that undue loads on the TLBs cannot occur.

Potential damage in case of facilities with no special design
The ZL KBR and the TLBs are designed against the blast wave load case.

Summary assessment on blast waves
Due to the solid construction of the ZL KBR built according to the STEAG concept, a collapse of the storage building is not to be postulated. Moreover, the TLBs are designed against the blast wave load case.

Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.11 Brunsbüttel on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Ministry of Energy Transition, Agriculture, the Environment and Rural Areas Schleswig-Holstein dated 16.10.2013 [17] and the response from the operator of 30.07.2012 [17, Annex 2].

A Earthquake

Design
The site of the Brunsbüttel storage facility (ZL KKB) is not to be assigned to an earthquake zone according to DIN 4149 or DIN-EN-1998. The storage building and the TLBs are designed against the earthquake load case. Within the licensing procedure, the structural design of the ZL KKB was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of 0.5 m/s^2, were considered in the structural design of the storage building.

Precautionary measures
The design of the ZL KKB is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
The storage building of the ZL KKB is not only designed against the impacts of earthquakes but also against the impacts caused by an aircraft crash. The impacts due to aircraft crash are much greater than the impacts due to the design basis earthquake so that the design of the storage building against aircraft crash also covers the beyond design basis earthquake.

Applicability of damage mechanisms
Safety-relevant damage mechanisms are not to be expected.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated.

Accident management measures
Accident management measures according to the Radiation Protection Ordinance (StrlSchV) that serve to stay below the dose limits as specified in § 49 of the Radiation Protection Ordinance are not required.

Soil liquefaction
The danger of soil liquefaction at the site can be excluded.

Summary assessment on earthquakes
The building structure of the ZL KKB is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 0.5 m/s^2 is below the minimum acceleration of 0.1 g required by the EU (= 1 m/s^2). The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the load case of a beyond design basis earthquake. A collapse of the storage building is not to be postulated.

The main vital function of the ZL KKB is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The ZL KKB is located on the premises of the Brunsbüttel GmbH & Co. oHG nuclear power plant with a ground elevation of approximately +3.00 m above sea level where the ZL KKB is in an area at an altitude of +2.50 m above sea level and adjacent to the tidal area of the river Elbe. The relevant peak storm surge level with an exceedance probability of $1 \cdot 10^{-4}$/a according to nuclear safety standard KTA 2207 was specified for the KKB within a conservative assessment on +7.50 m above sea level. The dyke height is +8.45 m above sea level. For the case of a dyke failure, the operators provided temporary flood protection measures that are appropriate to prevent flooding of the storage building.

Precautionary measures
The ZL KKB is already adequately protected by the existing dyke. Nevertheless, flood barriers will be mounted in case of a flood level > +5.00 m above sea level for shielding to prevent, together with the pressurised water doors, ingress of water into the storage area. Only in case of failure of the dyke and the temporary flood barriers there would be ingress of water into the storage area and rise of the water level in the storage area to < +3.39 m above sea level or a water level of 0.89 m in the storage area. A failure of the precautions taken against flood does not lead to safety-relevant impacts since the TLBs fulfil the protection goals.

Behaviour at the stress level
When postulating a dyke failure in the immediate vicinity of the facility, the water level at the site results from an equilibrium analysis of the inflow caused by the postulated dyke breach near the facility and runoff into the Elbe marsh Wilstermarsch which represents a virtually unlimited sink with a flooding area of about 19,000 ha. According to the operators, a further rise in the flood level is not possible also in this case due to the topology

of the lower Elbe region and the dyke heights there so that there are no plausible reasons for an increase in the 10,000-year storm surge level by 1 or 2 m.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. The measures taken are usual precautions to protect personnel and property against ingress of water. They are irrelevant for the safe storage of the TLBs since the casks themselves are waterproof and corrosion-protected and cannot start floating due to postulated flooding of the contamination-free storage area. The protection goals will also be complied with in case of water ingress into the storage area. Foundation and stability of the storage building will not be impaired by flooding either.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels depends on the presentation of additional verifications and their confirmation.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
The drainage system was designed in accordance with DIN 1986-2: 1995-03 applicable then. It was demonstrated within the licensing procedure performed at the Federal Office for Radiation Protection (BfS) that the facility also fulfils the requirements of the current rules and regulations according to DIN 1986-100: 2008-04 with a rainfall of $r_{5,5}$.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
According to the operators, the existing rainwater drainage of the storage building is adequately dimensioned for a heavy rain event of $r_{5,100}$ = 552,5 l/(s·ha) at the Brunsbüttel site, and the rainfall to be postulated can be discharged via the installed drainage system. When postulating a failure of all drain outlets, the water accumulates on the storage building and runs off via the attic.

Accident management measures
The safety of the ZL KKB will not be impaired by heavy rain.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. However, the ESK holds the view that it can be assumed that the impacts and influences on the storage facility from other natural hazards also cover the heavy rain event. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the ZL KKB, load assumptions according to DIN 1055 applicable at that time were considered in the design. The relevant basis for assessing the stability of the storage hall is the aircraft crash load case. Building failure caused by weather-related events is excluded due to the robust construction of the storage hall.

Site-specific weather-related events
In addition to the above events, the impacts of flood events were analysed.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
The relevant basis for assessing the stability of the storage hall is the aircraft crash load case.

Building failure caused by weather-related events is excluded due to the robust construction of the storage hall. This also applies to weather-related events beyond the design basis.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The structural design of the ZL KKB against other weather-related events complies with the applicable regulations and standards so that resistance is ensured according to the basic level.

Other weather-related events, such as storm (also including hurricane), hail, snow loads, freezing rain and lightning, are generally no design-relevant load cases for the ZL KKB. Due to weather-related events, load

cases such as flood, loss of electrical power and fire may occur which, just as a postulated failure of the storage building, will not compromise compliance with the protection goals. Potential weather-related events beyond the design basis are covered by the verifications performed within the licensing procedure for the aircraft crash load case.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The safety-relevant systems and installations comprise components of the TLBs and other safety-relevant systems. The safety-relevant components of the TLBs serve the leak-tight confinement of the spent nuclear fuel. The safety-relevant components are not dependent on power supply.

The other safety-relevant systems or installations comprise the following systems or installations connected to the power supply:

- cask monitoring system,
- fire protection systems and equipment including fire alarm system, and
- components of the storage hall crane.

Design of the power supply
Power supply for the ZL KKB comprises

- normal power supply,
- backup power supply, and
- uninterruptible power supply (UPS).

Design of the emergency and backup power supply
Without refuelling, the emergency diesel generator is designed for 72 hours of operation. The two UPSs have an operating time of > 1 hour. Start and maintenance of standby power operation, the uninterruptible and the internal, autonomous power supply do not require staff activities.

Behaviour in case of longer-term total loss of power supply
The protective functions of the TLBs will not be affected by it. Other important systems that depend on power supply will no longer be available, but their function is not required to maintain the protective functions of the TLBs. A failure of the systems can be compensated by administrative measures, such as inspections or measurements with mobile devices.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Other important systems that depend on power supply do not serve to maintain the protection goals. They fulfil monitoring tasks in the framework of cask storage (e.g. monitoring of cask leak tightness, fire detection, radiation protection). A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
For the design, fires in the storage hall and in the loading area were examined. The other areas of the building were protected according to their use and the fire loads in them and separated from the loading and storage area in accordance with the fire protection regulations. The structural design of the storage building includes the use of mainly non-combustible or flame-resistant materials as a preventive fire protection measure. The entire storage area is monitored by an automatic fire alarm system. For fire fighting, portable fire extinguishers as well as supply of water are available via external hydrants.

Precautionary measures
The design against internal fires is not based on precautionary measures.

Behaviour at the stress level
Due to the limited fire loads, fire durations beyond the design basis are, in principle, not possible.

Accident management measures
Accident management measures are not required.

Summary assessment on internal fires
In the storage area, there are only small fire loads since there are mainly non-combustible or flame-resistant materials and the use of combustible construction elements and working materials was reduced to a minimum. A postulated fire in the cask reception area during handling of a TLB will immediately be detected by the staff on site and effectively fought. Thus, only localised fires may occur within the storage building whose duration and intensity will be well below the approved design of the TLBs against the impacts of fire.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
Stands of trees only exist outside the security fence at a distance of more than 100 m from the ZL KKB towards the north. The nearest public road (K76) and the middle of the Elbe fairway are about 1 km away. Thus, the ZL KKB does not directly border on traffic routes on which increased or larger fire loads are transported.

Design
Due to the distances as well as due to the low fire loads and the available fire extinguishing systems and equipment, spread of an external fire to the ZL KKB can be excluded so that this does not result in special design features for the facility.

Precautionary measures
Protection of the facility against the consequences of external fires does not require any precautionary measures.

Behaviour at the stress level
Due to the limited fire loads in the area adjacent to the facility, fires, i.e. fire durations beyond the design, are principally not possible.

Accident management measures
Accident management measures are not required.

Summary assessment on external fires
The ZL KKB is designed against impacts resulting from external fires. Due to the low fire load in the surrounding area, external fires beyond the design basis are, in principle, not possible. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is not possible. Further, there is additional inherent protection of the stored fuel against fire since compliance with the protection goals is already ensured due to the properties of the TLBs. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were taken into account. These considerations covered both military aircrafts and large commercial airliners. The mechanical and thermal impacts on the TLBs resulting from a crash of a high-speed military aircraft do not lead to such loads on the casks that, in particular, the confinement of the radioactive inventory would not be appropriately ensured. Due to the design of the storage building of the ZL KKB against aircraft crash, additional protection is achieved. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The ZL KKB is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Blast wave was considered as beyond design basis event in the licensing procedure. The stability of the storage building and the integrity of the TLBs are not endangered by blast waves. The storage building and the TLBs are designed against the blast wave load case in accordance with the pressure wave guideline of the Federal Ministry of the Interior (BMI).

Impacts of stronger blast waves
The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the blast wave load case. A collapse of the storage building is not to be postulated.

Also in case of a much stronger pressure wave than designed it can be assumed that the protective functions of the TLBs will be ensured. In particular, the confinement of radioactive material and residual heat removal from the TLBs in case of being buried (debris load) will be ensured.

Site-specific amounts of explosive gases
Transport of explosive gases on the Elbe is possible. Here, with 1,200 m, the distances are far above the safety margins required according to the pressure wave guideline of the Federal Ministry of the Interior (BMI). There are no undertakings in the immediate vicinity dealing with explosive substances and there are no hazards from the transport of dangerous goods by road and rail either.

Potential damage in case of facilities with no special design
The ZL KKB and the TLBs are designed against the blast wave load case.

Summary assessment on blast waves
Due to the solid construction of the ZL KKB built according to the STEAG concept, a collapse of the storage building is not to be postulated. Moreover, the TLBs are designed against the blast wave load case.
Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.2.12 Krümmel on-site storage facility

Basis of assessment
The assessment was primarily based on the letter from the Ministry of Energy Transition, Agriculture, the Environment and Rural Areas Schleswig-Holstein dated 16.10.2013 [17] and the response from the operator of 17.07.2012 [17, Annex 3].

A Earthquake

Design
Within the licensing procedure, the structural design of the Krümmel storage facility (ZL KKK) was based on the design basis earthquake for the site, and the site intensity was determined for an exceedance probability $< 1 \cdot 10^{-5}$/a. A ground response spectrum was assigned to the design intensity. This approach complies with nuclear safety standard KTA 2201.1 and was deemed to be positive by the seismological experts consulted by the Federal Office for Radiation Protection (BfS). The corresponding seismic load assumptions, such as a horizontal acceleration of 0.73 m/s^2, were considered in the structural design of the storage building.

Precautionary measures
The design of the ZL KKK is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
The storage building of the ZL KKK is not only designed against the impacts of earthquakes but also against the impacts caused by an aircraft crash. The impacts due to aircraft crash are much greater than the impacts due to the design basis earthquake so that the design of the storage building against aircraft crash also covers the beyond design basis earthquake.

Applicability of damage mechanisms
Safety-relevant damage mechanisms are not to be expected.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated.

Accident management measures
Accident management measures according to the Radiation Protection Ordinance (StrlSchV) that serve to stay below the dose limits as specified in § 49 of the Radiation Protection Ordinance are not required.

Soil liquefaction
The danger of soil liquefaction at the site in the event of an earthquake was examined and can be excluded.

Summary assessment on earthquakes
The building structure of the ZL KKK is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 0.73 m/s^2 is below the minimum acceleration of 0.1 g required by the EU (= 1 m/s^2). The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the load case of a beyond design basis earthquake. A collapse of the storage building is not to be postulated.

The main vital function of the ZL KKK is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for the scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not to be expected. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The ZL KKK is located on the premises of the KKK GmbH & Co. oHG with a ground elevation of approximately +8.50 m above sea level, for which a design basis flood of +8.20 m above sea level with an occurrence probability of $1 \cdot 10^{-4}$/a was determined in accordance with nuclear safety standard KTA 2207. The

maximum flood occurring due to the rare event of ice jam formation in the lower Elbe is stated with +8.50 m above sea level.

The temporary flood protection measures installed on site have a height of 9.70 m above sea level and are thus higher than the dykes on the south bank of the Elbe. The measures for the use of the flood protection system are adequately regulated in the operating manual. Flooding of the Krümmel on-site storage facility is thus to be excluded.

Precautionary measures
When reaching a water level of +7.80 m above sea level, temporary flood protection measures (site protection) will be installed at the main gate and at the track entrance which will become effective when reaching a water level of +8.50 m above sea level. In case of failure of the temporary flood protection and a maximum water level of the Elbe of +9.63 m above sea level, the site would be flooded up to about 1.13 m as a maximum. In this case, water enters the storage area.

A failure of the precautions taken against flood does not lead to safety-relevant impacts since the TLBs fulfil the protection goals.

Behaviour at the stress level
In case of failure of the temporary flood protection and a maximum water level of the Elbe of +9.63 m above sea level, the site would be flooded up to about 1.13 m as a maximum. A higher water level is not possible due to the topographical conditions of the site on the north bank of the Elbe since the lower area adjacent to the south bank of the Elbe is protected by a dyke with a height of +9.56 m above sea level.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. The measures taken are usual precautions to protect personnel and property against ingress of water. They are irrelevant for the safe storage of the TLBs since the casks themselves are waterproof and corrosion-protected and cannot start floating due to postulated flooding of the contamination-free storage area. The protection goals will also be complied with in case of water ingress into the storage area. Foundation and stability of the storage building will not be impaired by flooding either.

The ESK holds the view that the fuel assembly casks will not suffer any damage caused by flooding that would have to be considered in the stress test. However, site-specific compliance with stress level 3 cannot be confirmed since a hazard is not excluded site-specifically but due to the storage concept. Compliance with the site-specific stress levels depends on the presentation of additional verifications and their confirmation. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

C Heavy rain

Design
The drainage system was designed in accordance with DIN 1986-2: 1995-03 applicable then. It was demonstrated within the licensing procedure performed at the Federal Office for Radiation Protection (BfS) that the facility also fulfils the requirements of the current rules and regulations according to DIN 1986-100: 2008-04 with a rainfall of $r_{5,5}$.

Precautionary measures
Precautionary measures are not required.

Behaviour at the stress level
According to the operator, the existing rainwater drainage of the storage building is adequately dimensioned for a heavy rain event of $r_{5,100}$ = 494 l/(s·ha) at the Krümmel site, and the rainfall to be postulated can be discharged via the installed drainage system. When postulating a failure of all drain outlets, the water accumulates on the storage building and runs off via the attic.

Accident management measures
The safety of the ZL KKK will not be impaired by heavy rain.

Summary assessment on heavy rain
The design of the storage facility against weather-related impacts roughly corresponds to the basic level. However, the ESK holds the view that it can be assumed that the impacts and influences on the storage facility from other natural hazards also cover the heavy rain event. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For the erection of the ZL KKK, load assumptions according to DIN 1055 applicable at that time were considered in the design. The relevant basis for assessing the stability of the storage hall is the aircraft crash load case. Building failure caused by weather-related events is excluded due to the robust construction of the storage hall.

Site-specific weather-related events
In addition to the above events, the impacts of flood events were analysed.

Precautionary measures
The design against other weather-related events is not based on precautionary measures.

Behaviour at the stress level
The relevant basis for assessing the stability of the storage hall is the aircraft crash load case. Building failure caused by weather-related events is excluded due to the robust construction of the storage hall. This also applies to weather-related events beyond the design basis.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The structural design of the ZL KKK against other weather-related events complies with the applicable regulations and standards so that resistance is ensured according to the basic level. Other weather-related events, such as storm (also including hurricane), hail, snow loads, freezing rain and lightning, are generally no design-relevant load cases for the ZL KKK. Due to weather-related events, load cases such as flood, loss of electrical power and fire may occur which, just as a postulated failure of the storage building, will not compromise compliance with the protection goals. Potential weather-related events beyond the design basis are covered by the verifications performed within the licensing procedure for the aircraft crash load case.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The safety-relevant systems and installations comprise components of the TLBs and other safety-relevant systems. The safety-relevant components of the TLBs serve the leak-tight confinement of the spent nuclear fuel. The safety-relevant components are not dependent on power supply.

The other safety-relevant systems or installations comprise the following systems or installations connected to the power supply:

- cask monitoring system,
- fire protection systems and equipment including fire alarm system, and
- components of the storage hall crane.

Design of the power supply
Power supply for the ZL KKK comprises

- normal power supply,
- backup power supply, and
- uninterruptible power supply (UPS).

Design of the emergency and backup power supply
Without refuelling, the emergency diesel generator is designed for 72 hours of operation. The two UPSs have an operating time of > 1 hour. Start and maintenance of standby power operation, the uninterruptible and the internal, autonomous power supply do not require staff activities.

Behaviour in case of longer-term total loss of power supply
The protective functions of the TLBs will not be affected by it. Other important systems that depend on power supply will no longer be available, but their function is not required to maintain the protective functions of the TLBs. A failure of the systems can be compensated by administrative measures, such as inspections or measurements with mobile devices.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of normal power supply does not have any safety-relevant impacts on the storage of the spent fuel. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

Other important systems that depend on power supply do not serve to maintain the protection goals. They fulfil monitoring tasks in the framework of cask storage (e.g. monitoring of cask leak tightness, fire detection, radiation protection). A failure of the systems can be compensated by administrative measures, such as additional inspections or the use of mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
For the design, fires in the storage hall and in the loading area were examined. The other areas of the building were protected according to their use and the fire loads in them and separated from the loading and storage area in accordance with the fire protection regulations. The structural design of the storage building includes the use of mainly non-combustible or flame-resistant materials as a preventive fire protection measure. The entire storage area is monitored by an automatic fire alarm system. For fire fighting, portable fire extinguishers as well as supply of water are available via external hydrants.

Precautionary measures
The design against internal fires is not based on precautionary measures.

Behaviour at the stress level
Due to the limited fire loads, fire durations beyond the design basis are, in principle, not possible.

Accident management measures
Accident management measures are not required.

Summary assessment on internal fires
In the storage area, there are only small fire loads since there are mainly non-combustible or flame-resistant materials and the use of combustible construction elements and working materials was reduced to a minimum. A postulated fire in the cask reception area during handling of a TLB will immediately be detected by the staff on site and effectively fought. Thus, only localised fires may occur within the storage building whose duration and intensity will be well below the approved design of the TLBs against the impacts of fire.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
Stands of trees only exist outside the security fence at a distance of more than 100 m from the ZL KKK. The minimum distance between the storage facility and district road 63 is about 50 m. Larger fire loads are not regularly transported on district road 63. The distance to the nearest rural road is about 750 m and the distance to the nearest federal highway is about 1.5 km. The federal waterway Elbe (middle of the fairway) is 300 m away. Thus, the ZL KKK does not directly border on traffic routes on which increased or larger fire loads are transported.

Design
Due to the distances as well as due to the low fire loads and the available fire extinguishing systems and equipment, spread of an external fire to the ZL KKK can be excluded so that this does not result in special design features for the facility.

Precautionary measures
Protection of the facility against the consequences of external fires does not require any precautionary measures.

Behaviour at the stress level
Due to the limited fire loads in the area adjacent to the facility, fires, i.e. fire durations beyond the design, are principally not possible.

Accident management measures
Accident management measures are not required.

Summary assessment on external fires
The ZL KKK is designed against impacts resulting from external fires. Due to the low fire load in the surrounding area, external fires beyond the design basis are, in principle, not possible. Moreover, the storage facility consists of non-combustible materials, in particular in the outdoor areas, so that development of a fire at the building is not possible. Further, there is additional inherent protection of the stored fuel against fire since compliance with the protection goals is already ensured due to the properties of the TLBs. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were taken into account. These considerations covered both military aircrafts and large commercial airliners. The mechanical and thermal impacts on the TLBs resulting from a crash of a high-speed military aircraft do not lead to such loads on the casks that, in particular, the confinement of the radioactive inventory would not be appropriately ensured. Due to the design of the storage building of the ZL KKK against aircraft crash, additional protection is achieved. In addition, impacts of a postulated crash of a large commercial airliner were considered by the Federal Office for Radiation Protection (BfS) within the licensing procedure.

Location in an airport approach path
The ZL KKK is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. Thus, the scenario of an aircraft crash was appropriately considered in the design. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft would be well below the accident planning values according to § 49 of the Radiation Protection Ordinance (StrlSchV). The structural design of the storage facility provides additional protection against aircraft crash. Moreover, the potential impacts of a crash

of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. In this context, the possible mechanical and thermal impacts were also examined. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Blast wave was considered as beyond design basis event in the licensing procedure. The stability of the storage building and the integrity of the TLBs are not endangered by blast waves. case in accordance with the pressure wave guideline of the Federal Ministry of the Interior (BMI).

Impacts of stronger blast waves
The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the blast wave load case. A collapse of the storage building is not to be postulated. Also in case of a much stronger pressure wave than designed it can be assumed that the protective functions of the TLBs will be ensured. In particular, the confinement of radioactive material and residual heat removal from the TLBs in case of being buried (debris load) will be ensured.

Site-specific amounts of explosive gases
Transport of explosive gases on the Elbe is possible. With 300 m, the distance to the fairway is far above the safety margins required according to the pressure wave guideline of the Federal Ministry of the Interior (BMI). There are no undertakings in the immediate vicinity dealing with explosive substances and there are no hazards from the transport of dangerous goods by road and rail either. There are gas pipelines at a greater distance (1.8 and 5.5 km) to the site so that also here no hazards can be derived.

Potential damage in case of facilities with no special design
The ZL KKK and the TLBs are designed against the blast wave load case.

Summary assessment on blast waves
Due to the solid construction of the ZL KKK built according to the STEAG concept, a collapse of the storage building is not to be postulated. Moreover, the TLBs are designed against the blast wave load case.
Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

7.3 Gorleben transport cask storage facility

Basis of assessment
The assessment was primarily based on the letter from the Lower Saxony Ministry for the Environment, Energy and Climate Protection dated 10.09.2012 [6] with notes on the Gorleben transport cask storage facility [6, Annex 1], a letter on the overflight restrictions [6, Annex 2] and the response from the operator GNS of 06.08.2012 [6, Annex 4]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test were taken into account.

A Earthquake

Design
The design against earthquakes was considered within the licensing procedure which was demonstrated under the boundary conditions of the draft nuclear safety standard KTA 2201.3. Based on the regulations of Section 2.2.4.7 of nuclear safety standard KTA 2201.3, the facility was classified as structure of Class II*. An intensity of VII (MSK scale) was defined. The stability of the storage building was demonstrated for a horizontal acceleration of 0.6 m/s^2.

Precautionary measures
The design against earthquakes is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
When increasing the stress level beyond the acceleration values of the design basis earthquake, various components may be damaged by overloading. A partial collapse of the storage hall cannot be excluded. Here, dropping of larger parts of the roof (e.g. roof truss) is postulated. In case that the roof truss falls onto the middle of the double-lid closure system of a TLB, its integrity will be maintained.

Furthermore, heat removal from individual TLBs may be impaired due to coverage with debris. Sufficient heat removal will also be given if some of the TLBs are buried by debris so that there will be a margin of several days for clean-up work.

For the damage events considered it was demonstrated that the resulting potential radiation exposure is below the limit of 50 mSv in accordance with § 50 of the Radiation Protection Ordinance (StrlSchV) in conjunction with § 117 (16) of the Radiation Protection Ordinance (StrlSchV).

Applicability of damage mechanisms
For potential damage mechanisms, the load case aircraft crash is defined as the most unfavourable event and its consequences are considered. For this event, collapse of the storage hall in combination with a kerosene fire is postulated. The integrity of the TLBs was demonstrated for this case within the licensing procedure.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated since due to the low fire loads, fires in the storage area will have no significant impacts. Explosions of systems with high energy potential (pressure, temperature) are not to be postulated.

Accident management measures
There are no accident management measures provided. A release of radioactivity will not occur also at the stress level for an earthquake event. Moreover, there will be no safety-relevant impairment of heat removal for a longer period of time. Measures to remove the coverage with debris can be carried out in compliance with the rules of radiation protection and occupational safety since tightness and integrity of the casks are still maintained.

Soil liquefaction
As part of the planning for the Gorleben pilot conditioning plant (PKA), the boundary conditions for the Gorleben site with regard to subsoil, soil mechanics including seismology, and hydrological conditions were confirmed by a geotechnical report. The statements can also be applied to the Gorleben transport cask storage facility since the facilities are located close to each other. According to the report, soil liquefaction is excluded for the site due to the bulk density of the foundation soil with medium dense compaction that exists here.

Summary assessment on earthquakes
The design of the storage hall against earthquakes was considered and demonstrated within the licensing procedure. Due to the structural design of the storage facility, a failure is not to be postulated. The underlying design basis earthquake with a maximum horizontal acceleration of $0.6\ m/s^2$ is below the minimum acceleration of 0.1 g required by the EU. The ESK considers the margins that may exist due to the design not to be sufficiently quantified to confirm compliance with the stress level for the building.

The verifications performed within the licensing procedure show that stability of the TLBs is ensured for the design intensity. Further investigations also show that stability is not endangered even in case of higher accelerations. Moreover, the TLBs ensure compliance with the protection goals also in case of a postulated collapse of the storage building. The main vital function of the Gorleben transport cask storage facility is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for all scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not foreseeable.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional

condition of the TLBs by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
The Elbe water levels only have indirect impacts on the groundwater levels. The site terrain with an average natural ground elevation of 21.25 m above sea level is located about 1 m higher than the nearby Elbe dams and dykes with a height of up to 20 m above sea level. The dams are higher than the highest flood levels measured over many years. Flooding of the site area is not to be postulated in case of dyke overtopping or failure due to the large Elbe-Jeetzel lowland which is located at a significantly lower level.

Within the framework of the planning for the PKA, the design water level was based on the maximum groundwater level of +20.00 m above sea level. At its 64th/65th meeting in 1983, the German-German Border Waters Commission specified the design basis flood level of 18.90 m above sea level for the altitude of Gorleben. The traffic areas at the site are at least at +21.50 m above sea level. Impairment by flood is not given.

Precautionary measures
Due to the exclusion of a danger from flooding, further precautionary measures are not required.

Behaviour at the stress level
Due to the topographical situation of the Gorleben transport cask storage facility, flooding during high water can be excluded.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
The potential impacts of a flood were considered in the design of the storage facility. For compliance with the protection goals, no flood-specific precautionary measures are needed since flooding during high water can be excluded due to the topographical situation. Cliff edge effects are not foreseeable. The ESK holds the view that a hazard is to be excluded site-specifically and thus stress level 3 is complied with.

C Heavy rain

Design

The rainwater at the site of the Gorleben transport cask storage facility is discharged into the ground via a drainage basin. The design was based on a rainfall intensity of $r_{5,5}$ = 306 l/(s·ha). For a sealed area (roads, roofs) of 3.8 ha this leads to a rainwater volume of 342 m^3 in 15 minutes. The existing sewer system with separator has a volume of 370 m^3 and is thus appropriate for the rainfall event. For this 15-minute rain, verification was performed for the entire retention in the drainage system.

Precautionary measures

The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level

With regard to heavy rain, the following values are applied today for sealed areas (nearest town: Wittenberg) in accordance with DIN 1986-100, Table A.1:

- 5-minute rain every five years $r_{5,5}$ = 260 l/(s·ha)
- 5-minute rain every 100 years $r_{5,100}$ = 459 l/(s·ha)

Thus, DIN value $r_{5,5}$ = 260 l/(s·ha) is complied with. DIN value $r_{5,100}$ = 459 l/(s·ha) corresponds to a volume of 523 m^3 in five minutes for an area of 308 ha. A part of the volume, i.e. 370 m^3, flows into the drainage system. The remaining 153 m^3 of rainwater flows into the adjacent drainage basin.

Accident management measures

There are no accident management measures provided.

Summary assessment on heavy rain

The storage facility is designed against weather-related impacts in accordance with the rules and regulations applicable then. Should, however, water enter the storage facility due to heavy rainfall, the TLBs ensure compliance with the protection goals. This applies to all rainfall intensities.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with.

D Other weather-related events

Design

For design and operation of the facility, all conceivable other natural hazards at the site, such as extreme weather conditions (storms, lightning, heavy rain, hail, black ice, etc.) and their causally related combinations, were taken into account.

Site-specific weather-related events
Due to the geographical situation, additional weather-related events are not to be considered.

Precautionary measures
The design is not based on precautionary measures.

Behaviour at the stress level
In transverse direction, the bracing of the transport cask storage hall consists of frame structures. The frames are formed by the outer hall supports and the roof trusses that are elastically placed on the hall supports. More detailed studies on much larger horizontal loads from wind are not available.

For the Gorleben transport cask storage facility, the roof trusses are to be mentioned as main load-bearing elements for snow loads. The roof trusses carry the massive roof plate structures (d = 20 cm) including the massive hall ventilation structures placed on them, the loads of the roofing and waterproofing and the loads from snow. Permanent excess of the snow loads to a significant degree will lead to the formation of fine cracks at the roof truss undersides which may cause corrosion damage. Also a permanent excess of the snow loads to a significant degree cannot result in a spontaneous collapse of the hall.

Summary assessment on other weather-related events
The Gorleben storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is excluded due to the robust construction of the storage hall. A failure of the storage building postulated nonetheless will not compromise compliance with the protection goals. Protection against mechanical loading is represented by the TLBs, heat removal from the TLBs will also be ensured if the casks are buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The following systems, which belong to the category of other important functions and systems, are dependent on power supply:

- the storage cask monitoring system,
- the fire alarm systems, and
- the local dose rate measuring systems.

Design of the power supply
The power supply is located in the service building. It is divided into three areas and mainly comprises the

- normal power supply (with supply from the power utility),
- backup power supply with interruption, and
- backup power supply without interruption, including battery system.

Design of the emergency and backup power supply
The backup power supply with interruption is equipped with a 10,000 l fuel storage tank (diesel) and with a 500 l day tank. In case of demand, an operating time of backup power supply of more than eight days would have to be assumed. Backup power supply without interruption is designed for a period of autonomy of five hours. The controls of backup power supplies with and without interruption are fully automatic.

Behaviour in case of longer-term total loss of power supply
The connected consumers will no longer be supplied with electrical energy so that the systems fail. Also in case of longer-term loss of power supply or I&C failure in the Gorleben transport cask storage facility, the protection goals will not be compromised.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of power supply has no safety-relevant impacts on the TLBs and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as storage cask monitoring system, fire alarm system and local dose rate monitoring, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
The fire loads in the cask reception area and in the storage facility are low due to the structural design of the storage facility and the amounts of combustible material stored there. Due to the small fire inventory, only localised fires may occur that can be fought sufficiently fast due the fire detection and fire fighting measures provided.

Precautionary measures
The design against internal fires is not based on precautionary measures.

Behaviour at the stress level
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

Accident management measures
Local fires can be fought quickly by the on-site fire brigade.

Summary assessment on internal fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the properties of the TLBs, compliance with the protection goals is ensured. In addition, effective preventive fire protection in the storage areas of the Gorleben transport cask storage facility is realised by only admitting negligible fire loads within the storage areas. Compliance with this preventive fire protection is ensured by administrative regulations. Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
The site area is surrounded by pine forest. To the east, there is the K2 district road. There are no regular transports with increased fire loads.

Design
Due to the distance of the storage hall to the fencing (> 35 m) and the fire protection measures, spread of fires from outside the facility will be prevented.

Precautionary measures
The design against external fires is not based on precautionary measures.

Behaviour at the stress level
Due to the distance of the storage hall to the fencing, spread of fires from outside the facility will be prevented.

A large forest fire may lead to a failure of heat removal from the cask storage facility. This event is covered by the verification in the context of impaired heat removal due to coverage of the TLBs with debris.

Accident management measures
A camera-based forest fire monitoring system is installed in the area of the Lüneburg police headquarters for early detection of incipient forest fires so that volunteer fire departments can be alerted for fire fighting in time. Should there be a major forest fire, the regional fire brigade task force may be called for assistance. Task forces from neighbouring districts may also be alerted. Together with the volunteer fire departments and the on-site fire brigade, a fire barrier zone around the facility can be established. These measures can also still be performed in case of a fire of stress level 1.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. In addition, danger from external fires is excluded due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported. Spread of external fires to the Gorleben transport cask storage facility is excluded due to appropriate zones with low fire loads in the surrounding area (grassland/wasteland). Moreover, in particular in the outdoor areas, the Gorleben transport cask storage facility consists of non-combustible materials (mainly steel and concrete) so that development of a fire at the building is not possible. Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were the subject of in-depth examinations performed within the licensing procedure for the Gorleben transport cask storage facility. An aircraft crash may lead to a collapse of walls and roofing as well as to the penetration of aircraft wreckage and kerosene into the Gorleben transport cask storage facility. The aircraft crash leads to both mechanical loads on the TLBs and to thermal loads by a subsequent kerosene fire.

Location in an airport approach path
The Gorleben transport cask storage facility is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The design of the TLBs ensures that for a postulated crash of a high-speed military aircraft, the accident planning values according to § 50 of the Radiation Protection Ordinance (StrlSchV) in conjunction with § 117 (16) of the Radiation Protection Ordinance (StrlSchV) are complied with.

Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire.

The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Due to their low probability of occurrence, the Gorleben transport cask storage facility is not designed to withstand blast waves from chemical explosions. The TLBs themselves withstand external pressures from chemical explosions due to their large wall thickness. The tightness of the TLBs will not be impaired by such events.

Impacts of stronger blast waves
The Gorleben transport cask storage facility is not designed to withstand blast waves.

Site-specific amounts of explosive gases
In the surrounding area of the Gorleben transport cask storage facility, there is no handling of explosive substances and no industry with a high hazard potential. The only possible scenario that may lead to a significant pressure wave with potential impairment of the stability of the Gorleben transport cask storage facility is the explosion of a tanker with liquefied gas or the like on the road Lüchower Straße near the premises of the Gorleben transport cask storage facility.

Potential damage in case of facilities with no special design
Since the storage facility is not designed to withstand blast waves, the collapse of the cask reception area and partial collapse of the storage hall on a length of 20 m was postulated in the licensing procedure. Here, several roof trusses (i.e. 3 roof trusses) would be affected which would fall down.

Summary assessment on blast waves
The ESK notes that due to the site-specific conditions, no massive blast wave can occur so that degree of protection 3 can be confirmed. Cliff edge effects are not to be expected.

7.4 Ahaus transport cask storage facility

Basis of assessment
The assessment was primarily based on the letter from the Ministry for Economic Affairs, Energy, Industry, SMEs and the Trades of North Rhine-Westphalia dated 15.08.2012 [4] with comments [4, Annex 3] and the

response from the operator GNS of 31.07.2012 [4, Annex 4]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test were taken into account.

A Earthquake

Design
The design against earthquakes was considered within the licensing procedure which was demonstrated under the boundary conditions of the draft nuclear safety standard KTA 2201.3. Based on the regulations of Section 2.2.4.7 of nuclear safety standard KTA 2201.3, the facility was classified as structure of Class II*. An intensity of VII (MSK scale) was defined.

The Geological Survey of North Rhine-Westphalia (*Geologischer Dienst Nordrhein-Westfalen - GD NRW*) re-assessed the design basis earthquake for the site of the Ahaus transport cask storage facility in 2011 based on KTA 2201.1, issue of *11/2010* (draft safety standard). A site intensity of VI - VII (6.5) was determined. Thus, intensity VII considered in the design is covered by site intensity 6.5 (basic level to be considered) determined by the Geological Survey of North Rhine-Westphalia.

The stability of the storage building was demonstrated for a horizontal acceleration of 0.6 m/s^2.

Precautionary measures
The design against earthquakes is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
When increasing the stress level of 1 beyond the basic level of 6.5, various components may be damaged by overloading, but the operator does not expect a loss of stability of the storage hall. Even in case that larger parts of the roof, e.g. roof truss, fall onto the middle of the double-lid closure system of a TLB, its integrity will be maintained. Furthermore, heat removal from individual TLBs may be impaired due to coverage with debris. Sufficient heat removal will also be given if some of the TLBs should then be buried by debris so that there will be a margin of several days for clean-up work.

Applicability of damage mechanisms
For potential damage mechanisms, the load case aircraft crash is defined as the most unfavourable event and its consequences are considered. For this event, collapse of the storage hall in combination with a kerosene fire is postulated. The integrity of the TLBs was demonstrated for this case.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated since due to the low fire loads, fires in the cask storage area will have no significant impacts. Explosions of systems with high energy potential (pressure, temperature) are not to be postulated.

Accident management measures
There are no accident management measures provided. A release of radioactivity will not occur also at the stress level for an earthquake event. Moreover, there will be no safety-relevant impairment of heat removal for a longer period of time. Measures to remove the coverage with debris can be carried out in compliance with

the rules of radiation protection and occupational safety since tightness and integrity of the casks are still maintained.

Soil liquefaction
In the framework of the expert report prepared by the consulting engineers Erdbaulaboratorium Essen it was examined whether the subsoil at the Ahaus site tends to soil liquefaction under seismic loading. According to this expert report, soil liquefaction can be excluded for the exhibited marl layers.

Summary assessment on earthquakes
The seismic design of the storage hall was considered and demonstrated within the licensing procedure. Due to the structural design of the storage facility, a failure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 1 m/s^2 corresponds to the minimum acceleration of 0.1 g required by the EU. The ESK considers the margins that may exist due to the design not to be sufficiently quantified to confirm compliance with the stress level for the building.

The verifications performed within the licensing procedure show that stability of the TLBs is ensured for the design intensity. Further investigations also show that stability is not endangered even in case of higher accelerations. Moreover, the TLBs ensure compliance with the protection goals also in case of a postulated collapse of the storage building.

The main vital function of the Ahaus transport cask storage facility is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for all scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not foreseeable. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
There is no danger from flooding at the site of the Ahaus transport cask storage facility. Until now, no flood levels have been observed in the area of the site at the Moorbach brook and the Ahauser Aa river. The technical inspection agency TÜV Hannover /Sachsen-Anhalt also confirmed in its expert assessment of September 1997 that impacts due to flooding do not have to be considered since the site is not prone to flooding.

Precautionary measures
Due to the exclusion of a danger from flooding, further precautionary measures are not required.

Behaviour at the stress level
Due to the topographical situation of the Ahaus transport cask storage facility, flooding during high water can be excluded.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
The design of the storage facility considers the potential impacts of flooding. For compliance with the protection goals, no flood-specific precautionary measures are needed since flooding during high water can be excluded due to the topographical situation. Cliff edge effects are not foreseeable. The ESK holds the view that a hazard is to be excluded site-specifically and thus stress level 3 is complied with.

C Heavy rain

Design
For the collection and drainage of rainwater, there is a rainwater retention basin at the site of the Ahaus transport cask storage facility. This rainwater retention basin collects the water from heavy rain and discharges it into the nearby Moorbach brook in regulated quantities.

The design was based on a rainfall intensity of $r_{15,\ n=0,2}$ = 345 l/(s·ha). For this rainfall, a storage volume of 888 m^3 is required for the entire site. The actual capacity of the rainwater retention basin, including pipe and ditch systems, is 1.380 m^3 so that the system has a capacity for a rainfall intensity of significantly more than 345 l/(s·ha).

There are no measures provided for the impacts of heavy rain events.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
Should a heavy rain event exceed the capacity of the rainwater retention basin, water accumulates at the site of the Ahaus transport cask storage facility. This accumulation of water has no safety significance for the storage of the fuel assembly casks. Damage mechanisms in this connection are being excluded. Even the ingress of backed up water into the storage hall or into the service building may lead to a loss of power supply but not to a loss of function of the casks.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The Ahaus transport cask storage facility is designed against weather-related impacts in accordance with the rules and regulations applicable then. The design against heavy rain roughly corresponds to the basic level. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For design and operation of the facility, all conceivable other natural hazards at the site, such as extreme weather conditions (storms, lightning, heavy rain, hail, black ice, etc.) and their causally related combinations, were taken into account.

Site-specific weather-related events
Due to the geographical situation, additional weather-related events are not to be considered.

Precautionary measures
The design is not based on precautionary measures.

Behaviour at the stress level
In transverse direction, the bracing of the transport cask storage hall consists of frame structures. The frames are formed by the outer hall supports and the roof trusses that are elastically placed on the hall supports. More detailed studies on much larger horizontal loads from wind are not available.

For the Ahaus transport cask storage facility, the roof trusses are to be mentioned as main load-bearing elements for snow loads. The roof trusses carry the massive roof plate structures (d = 20 cm) including the massive hall ventilation structures placed on them, the loads of the roofing and waterproofing and the loads from snow. Permanent excess of the snow loads to a significant degree will lead to the formation of fine cracks at the roof truss undersides which may cause corrosion damage. Also a permanent excess of the snow loads to a significant degree cannot result in a spontaneous collapse of the hall.

Accident management measures
There are no accident management measures provided.

Summary assessment on other weather-related events
The Ahaus transport cask storage facility is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is excluded due to the robust construction of the storage hall. A failure of the storage building postulated nonetheless will not compromise compliance with the protection goals. Protection against mechanical loading is ensured by the TLBs, heat removal from the TLBs will also be ensured if the casks are buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The following systems, which belong to the category of other important functions and systems, are dependent on power supply:

- the storage cask monitoring system,
- the fire alarm systems, and
- the local dose rate measuring systems.

Design of the power supply
The power supply is located in the service building. It is divided into three areas and mainly comprises the

- normal power supply (with supply from the power utility),
- backup power supply with interruption, and
- backup power supply without interruption, including battery system.

Design of the emergency and backup power supply
The backup power supply with interruption is equipped with an 8,000 l fuel storage tank (diesel) and with a 500 l day tank. In case of demand, an operating time of backup power supply of more than eight days would have to be assumed. Backup power supply without interruption is designed for a period of autonomy of four hours. The controls of backup power supplies with and without interruption are fully automatic.

Behaviour in case of longer-term total loss of power supply
The connected consumers will no longer be supplied with electrical energy so that the systems fail. Also in case of longer-term loss of power supply or I&C failure in the Ahaus transport cask storage facility, the protection goals will not be compromised.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
A loss of power supply has no safety-relevant impacts on the TLBs and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as storage cask monitoring system, fire alarm system and local dose rate monitoring, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
The fire loads in the cask reception area and in the storage facility are low due to the structural design of the storage facility and the amounts of combustible material stored there. Due to the small fire inventory, only localised fires may occur that can be fought sufficiently fast due the fire detection and fire fighting measures provided.

Precautionary measures
For the handling of casks, a tractor with diesel tank and transport trailer is temporarily driven into the cask reception area of the storage hall. In this case, the fire load in the storage hall is increased. There is personnel close to the tractor at any time so that a fire will already be detected in the development phase and fought with the available extinguishing agents and equipment. Even without the presence of personnel, the fire will cause no damages beyond those in case of a fire due to an aircraft crash.

Behaviour at the stress level
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

Accident management measures
Until arrival of the fire brigade, all measures will be co-ordinated by the competent fire protection officer. How to instruct the fire brigade in an emergency is regulated by the operator of the facility. The fire brigade is familiar with the facility specifics due to regular exercises.

Summary assessment on internal fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. In addition, effective preventive fire protection in the storage areas of the Ahaus transport cask storage facility is realised by only admitting negligible fire loads within the storage areas. Compliance with this preventive fire protection is ensured by administrative regulations. Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
There are only a few trees in the vicinity of the facility as fire load, apart from this there are pastures and arable land. On rural road L570 at a distance of > 100 m to the storage hall, there are no regular transports of flammable or explosive substances. At the eastern side of the facility, there is a public service road running along the fence. This road is, in general, only used by agricultural vehicles or cars.

The railroad track leading into the facility is the private siding of the transport cask storage facility. It is protected against unauthorised use in several ways and only used on behalf of or with the permission of the operator. Fire loads beyond the fuel supply of the tractor are not transported here. Oil and gas pipelines run along the storage facility at a distance of more than 1 kilometre.

Design
A theoretical wildfire was considered. This event is covered by the events "internal fire" and "aircraft crash with kerosene fire".

Precautionary measures
The design against external fires is not based on precautionary measures.

Behaviour at the stress level
Due to the distance of the storage hall to the fencing, spread of a fire from outside the facility will be prevented. A large forest fire cannot develop due to the absence of fire loads.

Accident management measures
There are no predefined accident management measures to limit the consequences of fires outside the facility. Measures are, in principle, also feasible at stress level 1 since it is not assumed that the fire spreads to the facility.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. In addition, direct danger from external fires is excluded due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported. Spread of external fires to the Ahaus transport cask storage facility is excluded due to appropriate zones with low fire loads in the surrounding area (grassland/wasteland). Moreover, in particular in the outdoor areas, the storage facility consists of non-combustible materials (mainly steel and concrete) so that development of a fire at the building is not possible.

Due to the limited fire loads in the area adjacent to the facility, fires beyond the design basis are not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were the subject of in-depth examinations performed within the licensing procedure for the Ahaus transport cask storage facility. An aircraft crash may lead to a collapse of walls and roofing as well as to the penetration of aircraft wreckage and kerosene into the Ahaus transport cask storage facility. The aircraft crash leads to both mechanical loads on the TLBs and to thermal loads by a subsequent kerosene fire.

Location in an airport approach path
The Ahaus transport cask storage facility is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The design of the TLBs ensures that for a postulated crash of a high-speed military aircraft, the accident planning values according to § 50 of the Radiation Protection Ordinance (StrlSchV) in conjunction with § 117 (16) of the Radiation Protection Ordinance (StrlSchV) are complied with. Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire.

The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
Due to their low probability of occurrence, the Ahaus transport cask storage facility is not designed to withstand blast waves from chemical explosions. The TLBs themselves withstand external pressures from chemical explosions due to their large wall thickness. The tightness of the TLBs will not be impaired by such events.

Impacts of stronger blast waves
The Ahaus transport cask storage facility is not designed to withstand blast waves.

Site-specific amounts of explosive gases
In the surrounding area of the Ahaus transport cask storage facility, there is no handling of explosive substances and no industry with a high hazard potential. On rural road L570 at a distance of > 100 m to the storage hall, there are no regular transports of flammable or explosive substances. Oil and gas pipelines run along the storage facility at a distance of more than 1 kilometre.

Potential damage in case of facilities with no special design
Since the storage facility is not designed to withstand blast waves, partial collapse of the storage hall has to be postulated. In case of a collapse of building structures, large pieces of debris are to be expected. The impact of the blast wave is covered by the impact of an aircraft crash.

Blast waves with a release potential for radioactivity are practically excluded.

Summary assessment on blast waves
The ESK notes that due to the site-specific conditions, no massive blast wave can occur so that degree of protection 3 can be confirmed. Cliff edge effects are not to be expected.

7.5 Jülich AVR storage facility

Basis of assessment
The assessment was primarily based on the letter from the Ministry for Economic Affairs, Energy, Industry, SMEs and the Trades of North Rhine-Westphalia dated 15.08.2012 [4] and the response from the operator of 30.07.2012 [4, Annex 5]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test were taken into account.

A Earthquake

Design
The facility was designed against earthquakes. The southern Lower Rhine Basin is a seismotectonic area where earthquakes of intensity VIII according to the MSK scale may occur. The construction was designed in accordance with DIN 4149 (as of 1981).

The building of the facility and the cask stacks (two casks each, stacked vertically) are designed for an earthquake with a horizontal acceleration of 2 m/s^2. For the hall crane under load, a horizontal acceleration of 1 m/s^2 resulting from the earthquake was considered.

The acceleration values considered in the design were higher than the load assumptions of DIN 4149 (1981) for the intensity of the safe shutdown earthquake at the site and were within the range stated in nuclear safety standard KTA 2201 (1975).

Precautionary measures
The design against earthquakes is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
Specific studies on the behaviour of the facility in case of a beyond design basis earthquake have not been performed until now. Static calculations indicate that the high crane load was load-relevant for the design of the load-bearing structure and not the design against earthquakes. This means that there are margins in the load-bearing structure of the building available for a beyond design basis earthquake. Since, however, the building has no safety-related function for the confinement of radioactive material, safe confinement of radioactive material in the casks will also be ensured at the stress level.

Applicability of damage mechanisms
Damage mechanisms from other load cases at the stress level that may have to be applied have not been considered so far.

Combinations with other load cases
At the stress level, combinations not considered so far with other load cases (e.g. subsequent fire) are conceivable.

Accident management measures
Whether the described accident management measures (fire brigade, emergency response, etc.) are also feasible at the stress level has not been considered for the case of an earthquake yet. However, the casks ensure safe confinement of the radioactive material also at the stress level.

Soil liquefaction
The issue of soil liquefaction at the site was dealt with in two expert reports and classified as unlikely. The same applies to tectonic fault scarps, soil cracks, areal ground subsidence, ground uplift, and the collapse of underground cavities or landslides. According to the expert reports, the seismic influences from the neighbouring mines are covered by the design basis earthquake for the site on which the facility is located.

Summary assessment on earthquakes
The storage hall was designed against earthquakes in accordance with DIN 4149 (as of 1981) which was verified within the licensing procedure. Thus, the basic level is complied with for earthquakes.

There are no studies on the behaviour of the facility and the casks in case of a beyond design basis earthquake. Also for the AVR cask storage facility, the main vital function of the storage facility is the integrity of the TLBs themselves. On this issue, investigations are being carried out in the context of the current licensing procedure.

B Flooding

Design
The facility is neither located near rivers nor tidal waters and thus complies with stress level 3, i.e. danger from flooding is excluded.

Precautionary measures
Due to the exclusion of a danger from flooding, further precautionary measures are not required.

Behaviour at the stress level
Danger from flooding is excluded.

Accident management measures
Danger from flooding is excluded.

Summary assessment on flooding
Cliff edge effects are not foreseeable. Danger from flooding is to be excluded site-specifically and stress level 3 is complied with.

C Heavy rain

Design
Roof and emergency drainage are designed according to the design basis rainfall for the region. Minimum values: the Jülich site according to the German Meteorological Service (DWD) KOSTRA 2000 (drainage).

- $r_{5,5}$ = 278 l/(s·ha); five-minute rain in five years (basic level), and
- $r_{5,100}$ = 518 l/(s·ha); five-minute rain in 100 years (stress level).

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
A hydrodynamic calculation conducted with the required block rainfall of $r_{5,100}$ of the sewer system does not result in a sewer overflow in the direct vicinity of the facility. The safety of the facility will not be impaired by heavy rain with a rainfall of $r_{5,100.}$

Accident management measures
Accident management measures are not required due to the design of the drainage system at the stress level. If necessary, the on-site fire brigade will protect the facility by barriers with sandbags and pump rainwater into adjacent green space and woodland. The feasibility of these measures will not be impaired in case of heavy rain with stress level.

Summary assessment on heavy rain
The AVR storage facility is designed against weather-related impacts in accordance with the rules and regulations applicable then. The design against heavy rain roughly corresponds to the basic level. The ESK holds the view that the accident management measures described by the operator can only be referred to to a limited extent. Should, however, water enter the storage facility due to heavy rainfall, the TLBs ensure compliance with the protection goals. This applies to all rainfall intensities.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
For design and operation of the facility, all conceivable other natural hazards at the site, such as extreme weather conditions and their causally related combinations, were taken into account in accordance with the rules and regulations applicable then.

Site-specific weather-related events
Due to the geographical situation, additional weather-related events are not to be considered.

Precautionary measures
The design is not based on precautionary measures.

Behaviour at the stress level
There are no such studies. However, the safe confinement of the radioactive material in the casks will not directly be impaired by the condition of the building and of the site and its access road due to other weather-related influences.

Accident management measures
Accident management measures (reduction of the static load due to hail, snow and ice) are also carried out at the stress level. In addition, the casks also ensure safe confinement of the radioactive material at the stress level.

Summary assessment on other weather-related events
The storage facility is designed against weather-related impacts in accordance with the rules and regulations applicable then. Since safe confinement of the radioactive material in the casks will not be impaired by the condition of the building and of the site and its access road due to other weather-related influences, safe confinement will also be ensured at the stress level.

The ESK holds the view that a postulated failure of the storage building would not compromise compliance with the protection goals. Protection against mechanical loading could be ensured by the TLBs. However, this has not been demonstrated. After presentation of appropriate verifications, the stress level could be complied with for all weather-related events.

E Loss of electrical power

Safety functions dependent on power supply
The following systems, which belong to the category of other important functions and systems, are dependent on power supply:

- emergency lighting system,
- fire alarm system, and
- cask monitoring system.

Design of the power supply
Building 12.6, in which the facility is located, is supplied with electrical power via a transformer which is fed from the general medium-voltage grid of the research centre. In case of loss of this supply, parts of building 12.6 and thus parts of the facility with emergency power authorisation can be supplied with power by the emergency generator (diesel) installed in the building.

The safety systems listed with emergency power authorisation are supplied via separate sub-distributions. They are additionally buffered separately by one battery system each. Thus, uninterruptible power supply is ensured for the safety systems.

Design of the emergency and backup power supply
The emergency generator will start automatically in case of loss of normal power supply with interruption of power supply for 20 seconds (starting time of the emergency generator). Until power supply from the emergency generator, the battery systems will automatically secure uninterruptible power supply to the safety systems.

Behaviour in case of longer-term total loss of power supply
Safe confinement of the radioactive material in the casks will also be ensured in case of a total loss of the safety functions.

If the emergency generator fails to start or fails during operation, the battery systems will automatically take over power supply for the safety functions according to their design:

- emergency lighting system approx. five hours,
- fire alarm system approx. 34 hours, and
- cask monitoring system approx. 30 hours.

In this case, a mobile emergency generator available on site will be put into operation within two hours which takes over the function of power supply.

Stress level 1: Loss of normal power supply for three days.
During emergency power supply, the on-call staff of the electrical department controls the fuel supply of the emergency generator and initiates refuelling within an operating time of about 20 hours. For this purpose, there is a mobile tank trailer with a capacity of 2,500 litres of diesel on the premises of the research centre that

can be used for refuelling during operation of the generator. This allows maintaining power supply for at least three days.

Stress level 2: Loss of normal power supply for one week.
In case of emergency power operation up to one week, the mobile tank trailer will be filled from a storage tank with a capacity of 10,000 litres located on the premises of the research centre.

Stress level 3: In addition to stress level 2, loss of emergency power supply for one day.
If emergency power supply to the facility fails, the battery systems take over power supply until the mobile emergency generator is put into operation. This is done within about two hours. Also at this stress level, the safe confinement of radioactive material in the casks will be ensured.

Accident management measures
There are no accident management measures provided.

Summary assessment on the loss of electrical power
The ESK holds the view that safety of storage will also be ensured in case of a long-lasting, complete loss of electrical power supply since severe impacts due to the loss of electrical power are not to be expected. A failure of the systems does not lead to a failure mechanism of the casks and can be compensated by administrative measures, such as additional inspections or mobile devices. Stress level 3 is complied with.

F Internal fires

Design
Due to the limited fire loads of the facility, only small fires are possible, in principle, that do not affect the confinement of the radioactive material.

Precautionary measures
The design against internal fires is not based on precautionary measures.

Behaviour at the stress level
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

Accident management measures
In case of internal fires, measures provided (emergency response organisation and on-site fire brigade) will be performed. Their performance will not be affected by a fire at stress level 1.

Summary assessment on internal fires
Within the AVR cask storage facility and the lock for transports, only limited sources of fire are conceivable due to the low fire inventory that have no impact on the safe confinement of the AVR fuel assemblies in the CASTOR THTR/AVR casks.

The ESK considers it to be plausible that the fire loads in the AVR cask storage facility are not sufficient for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
The facility is surrounded by open spaces consisting of grass or concrete/plaster/bitumen with a width of at least 15 m. To the southwest and the southeast, these open spaces border on forest land in the form of sparse stands and directly to the south on grass/grass paver areas which are still located within the monitoring area fence. The nearest buildings on the premises of the research centre are about 40 m away. The nearest small villages and the former Federal Railway Repair Shop are located at a distance of 0.8 to 2 km so that no built-up areas border on the research centre. There are no transports of larger fire loads in the vicinity of the AVR cask storage facility.

Design
Fires outside the facility were not considered in the design since they have no direct influence on the safe confinement of the radioactive material.

Precautionary measures
The design against external fires is not based on precautionary measures.

Behaviour at the stress level
There are no studies on this issue.

Accident management measures
In case of external fires, measures provided (emergency response organisation and on-site fire brigade) will be performed. Their performance will not be affected by a fire at stress level 1.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Although there are no explicit studies available, the ESK considers it to be plausible that, due to the limited fire loads in the area adjacent to the facility, no fires are possible that would lead to such heating of the TLBs that compliance with the protection goals was no longer ensured. Cliff edge effects are not foreseeable and stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The design considers the crash of a high-speed military aircrafts. Mechanical loads were not considered in the design.

The assessment of the potential impacts of a fire is based on the assumption that the heat energy released from the burning of 6.25 m^3 fuel will be completely absorbed by 150 storage casks. Considering the properties of the type B(U) storage casks, impairment of the integrity of the casks regarding the safe confinement of radioactive material is not to be expected. With respect to the thermal loads, the facility can be classified under thermal degree of protection 1.

Due to the low probability of a military aircraft crash, no such design was realised for the AVR cask storage building. However, the casks will also withstand the loads resulting form an aircraft crash due to their small external dimensions and their structural design.

Location in an airport approach path
The AVR storage cask facility is not located in the approach path of an airport but in the defined restricted area ED-R111.

Summary assessment on aircraft crashes
The studies on an aircraft craft crash on the AVR cask storage facility no longer comply with the state of the art in science and technology. According to the available studies, the facility can be classified as thermal degree of protection 1 with regard to the thermal loads. On the behaviour of the facility and the casks in the event of an aircraft crash, investigations are being carried out in the context of the current licensing procedure.

I Blast wave

Design
Due to their low probability of occurrence, the AVR cask storage facility is not designed to withstand blast waves from chemical explosions. Nonetheless, the casks are safe from pressure waves and impacts from explosions due to their design/construction.

Impacts of stronger blast waves
The facility is not designed to withstand blast waves.

Site-specific amounts of explosive gases
The AVR cask storage facility is located within the fenced area of the research centre. On the premises of the research centre, no significant amounts of explosive gases are to be expected in the vicinity of the plant. The same applies to the area of the neighbouring premises of the Enrichment Technology Company Ltd. (ETC) where there is no storage tank for flammable gases or liquids. Therefore, regardless of the traffic restriction described, there is not necessity that tank vehicles with explosive gases use the road outside the premises of the research centre along the facility.

A risk for the facility from the transport of explosive substances contained on the track for rail traffic at a distance of about 750 m can be excluded since in this track section there are no shunting operations and no sidings. As particular risk sources, the railway crossing at a distance of about 1,000 m and the junction of the track leading to the research centre would have to be considered. There is sufficient safety distance to these points.

Potential damage in case of facilities with no special design
Since the AVR cask storage facility is not designed to withstand blast waves, partial collapse of the storage hall has to be postulated.

Summary assessment on blast waves
According to the operator, there are no sources of explosive gases with release potential. The ESK notes that due to the site-specific conditions, no massive blast wave can occur so that degree of protection 3 can be confirmed. Cliff edge effects are not to be expected.

7.6 Storage facility north (ZLN)

Basis of assessment
The assessment was primarily based on the letter from the Mecklenburg-Vorpommern Ministry of the Interior and Sports dated 07.09.2012 [9], the response from the operator EWN of 16.07.2012 [9, Annex 1], a letter from the TÜV NORD SysTec GmbH & Co. KG dated 20.08.2012 [9, Annex 2] and a statement of the TÜV Nord EnSys Hannover GmbH & Co. KG dated 05.09.2012 [9, Annex 3]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test were taken into account.

A Earthquake

Design
The design against earthquakes was considered within the licensing procedure. The design complies with nuclear safety standard KTA 2201.1. The intensity of the design basis earthquake was conservatively set at VI (MSK scale). The design of the ZLN was based on an intensity of I = VI to VII. The stability of the storage building was demonstrated for a horizontal acceleration of 0.6 m/s^2.

Precautionary measures
Due to the extremely low seismicity at the ZLN site, no precautionary measures are provided.

Behaviour in the event of beyond design basis earthquakes
Since only earthquakes with I < V are known in the region but the design basis earthquake was conservatively set at I = VI and the ZLN is designed with I = VI to VII, no damage is expected where a release of radioactive material is to be feared. Therefore, further investigations were not carried out.

Applicability of damage mechanisms
Potential damage mechanisms were not considered. The damage mechanism from an aircraft crash could be applicable where parts of the building may crash onto the TLBs.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated up to and including I = VII due to the design of the storage building.

Accident management measures
Due to the extremely low seismicity at the ZLN site, no accident management measures are provided.

Soil liquefaction
The danger of soil liquefaction at the site in the event of a design basis earthquake was assessed to be very little with regard to the ground acceleration to be expected at the site of less than 1 m/s^2. According to nuclear safety standard KTA 2201.2 Part 2; Subsoil (issue of 11/82), no verification with respect to soil liquefaction was required since the maximum ground acceleration for the design basis earthquake is below 1 m/s^2.

Summary assessment on earthquakes
The building structure is designed to withstand earthquakes so that a failure of the building structure is not to be postulated. The underlying design basis earthquake with a peak ground acceleration of 1 m/s^2 corresponds to the minimum acceleration of 0.1 g required by the EU. The ESK considers the margins that may exist due to the design not to be sufficiently quantified to confirm compliance with the stress level for the building.

The verifications performed within the licensing procedure show that stability of the TLBs is ensured for the design intensity. Further investigations also show that stability is not endangered even in case of higher accelerations.

The main vital function of the ZLN is the integrity of the TLBs themselves. The integrity of the thick-walled metal TLBs will be maintained for all scenarios considered in the context of earthquakes and ensures compliance with the protection goals. Cliff edge effects are not foreseeable.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible so that the ESK cannot see any impairment of the functional condition of the fuel assembly casks by earthquakes. The ESK considers the stress level for earthquakes to be complied with due to the design of the TLBs.

B Flooding

Design
If at all, it is to be considered that the ZLN is located near tidal waters.

Highest water level measured in the Spandowerhagener Wiek bay:	1.90 m above sea level
Design basis flood:	2.75 m above sea level
Top level of the hall floor of the ZLN:	7.62 m above sea level

There are no measures provided since the site is classified as not prone to flooding. Impairment at the site and impaired access are not to be feared since the premises and its access road are located at a similar level as the top edge of the hall floor.

Precautionary measures
The design against flooding is not based on precautionary measures.

Behaviour at the stress level
Even when assuming stress level 2 (2.75 m +2.00 m = 4.75 m above sea level), impairment of the ZLN is excluded since there will still be 2.87 m left until reaching the top level of the hall floor.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
For the design of the storage facility, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. For compliance with the protection goals, no flood-specific precautionary measures are needed. Protection against ingress of water into the storage area is provided by the cask. The analysis of the event represents the usual precautions to protect property against ingress of water. A failure of this precaution does not lead to beyond design basis event sequences. Cliff edge effects are not foreseeable.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. The ESK holds the view that danger from flooding is to be excluded site-specifically and thus stress level 3 is complied with.

C Heavy rain

Design
The design of the ZLN was based on a rainfall intensity of $r_{5.5}$ = 235 l/(s·ha) with a rain duration of five minutes, followed by a rainfall of r = 100 l/(s·ha). A rainfall of r = 100 l/(s·ha) following the 5-minute rain does not lead to an increase in the backwater volume since the buried sewers were designed for a rainfall intensity of 150 l/(s·ha) and thus drainage of the water can be ensured.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
The rainwater is collected in socketless cast iron pipes and discharged via external cast iron downpipes. The rainwater pipes are provided with trace heating and thermal insulation. The rainwater of the facility is drained into the retention and discharge basin via underground concrete pipes.

In case of rainwater backflow, the roof can bear the additional loads. Compared to normal roofs, the proportion of the dead load is very high. A slight increase of the roof load does not affect the stability of the roof.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The design of the ZLN against weather-related impacts roughly corresponds to the basic level. In addition, the design against earthquakes ensures a large margin against increased loads. In the event that water enters the storage facility due to heavy rainfall, the TLBs would ensure compliance with the protection goals. This applies to all rainfall intensities to be considered.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by heavy rain and considers the stress level to be complied with due to the design of the TLBs.

D Other weather-related events

Design
Due to the type of roofing, the ZLN is designed to withstand hail, snow and freezing rain. Verification of correct execution of the wind suction protection can currently not be provided (verification of full-surface bonding). The functionality and accessibility of the ZLN will be maintained in case of storms and hurricanes, hail, snow and freezing rain.

Site-specific weather-related events
Additional weather-related events do not have to be considered.

Precautionary measures
The design is not based on precautionary measures.

Behaviour at the stress level
The roofing may be damaged which may lead to the ingress of water into the facility. Further investigations were not carried out. Ingress of water into or leakage of water from the facility is harmless from a radiological point of view (no handling of unsealed radioactive substances). The radiological conditions comply with the dangerous goods legislation.

Summary assessment on other weather-related events
The ZLN is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the storage hall is the earthquake load case. Building failure caused by postulated weather-related events is excluded due to the robust construction of the storage hall. All site-specific measures implemented for the drainage of water and maintenance of accessibility to the building are to be understood as precaution for the protection of property. Precautionary and accident management measures are not required. A failure of the storage building postulated nonetheless will not compromise compliance with the protection goals/vital functions. Protection against mechanical loading is represented by the TLB. Heat removal from the casks will also be ensured if the casks are buried by debris.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the fuel assembly casks by weather-related events and considers the stress level to be complied with due to the design of the TLBs.

E Loss of electrical power

Safety functions dependent on power supply
The safety functions (protection goals) of the TLBs are not dependent on the power supply of the storage facility. Thus, all power consumers supplied from the backup grid relate to other important functions and systems. Compliance with the protection goals will also be ensured in case of failure of these systems.

Design of the power supply
In the storage facility, power supply is divided into a normal power supply and a backup power supply. In case of loss of supplies, the diesel generator of the backup power supply will start automatically and supplies all power consumers connected to the backup power supply. In addition, a UPS system supplies all other important systems that depend on power supply.

Design of the emergency and backup power supply
The backup power supply with interruption is equipped with a 7,200 l fuel storage tank (diesel) and with a 2,520 l day tank. In case of demand, an operating time of backup power supply of at least 55 hours would have to be assumed. Personnel actions to start the diesel generator are not required.

Behaviour in case of longer-term total loss of power supply
A loss of power supply for a longer period of time has no safety-relevant impacts on the facility and the TLBs and their radioactive inventories.

Accident management measures
Accident management measures are not required.

Summary assessment on the loss of electrical power
A loss of power supply has no safety-relevant impacts on the TLBs and their radioactive inventories since safety during storage is ensured by passive systems. Active systems are not required for fulfilment of the protection goals, also including heat removal and leak tightness.

The monitoring systems, such as cask monitoring system and fire alarm system, only have indirect safety functions, i.e. they serve to monitor safety functions. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices. Thus, safe storage will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected. Failure of the pressure switch monitoring does not lead to a failure mechanism of the casks. Stress level 3 is complied with.

F Internal fires

Design
The design of the ZLN is based on a fire of a transport vehicle. The postulated fire has no impact on the lid and sealing system of the TLBs. A vehicle fire will immediately be detected by the staff and controlled by fire fighting measures

Precautionary measures
The design against internal fires is not based on precautionary measures.

Behaviour at the stress level
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.

Accident management measures
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible. Thus, there is no need to provide accident management measures.

Summary assessment on internal fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. Due to the properties of the TLBs, compliance with the protection goals is ensured. In addition, effective preventive fire protection in the storage area of the ZLN is realised by only admitting negligible fire loads within the storage areas. Compliance with this preventive fire protection is ensured by administrative regulations. Due to the limited fire loads, fires beyond the design basis are, in principle, not possible.
The ESK holds the view that with an effective preventive fire protection in the storage facility, there would not be enough fire load for a fire of such a duration and such temperatures that a failure of the cask seals occurs. Thus, stress level 2 is complied with.

G External fires

Site-specifically adjacent fire loads
The area of the facility does not border on woodland areas, not on built-up areas with increased fire loads and not on traffic routes on which larger fire loads are regularly transported.

Design
The design considers a wildfire (wasteland) outside the facility. With a distance between storage building and security fence of at least 60 m, there will be no consequences for the facility. Fire extinguishing systems to fight such wildfires are in place.

Precautionary measures
The design against external fires is not based on precautionary measures.

Behaviour at the stress level
Due to the limited fire loads in the area adjacent to the facility, fire durations beyond the design basis are, in principle, not possible.

Accident management measures
Due to the limited fire loads, fires beyond the design basis are, in principle, not possible. Thus, there is no need to provide accident management measures.

Summary assessment on external fires
The primary protective barrier of the emplaced fuel assemblies against fire is given by the design of the TLBs. In addition, direct danger from external fires is excluded due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported. Spread of external fires to the ZLN is excluded due to appropriate zones with low fire loads in the surrounding area (grassland/wasteland). Moreover, in particular in the outdoor areas, the Gorleben transport cask storage facility consists of non-combustible materials (mainly steel and concrete) so that development of a fire at the building is not possible.

Due to the limited fire loads in the area adjacent to the facility, fires beyond the design basis are not possible. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The crash of a high-speed military aircraft was considered within the licensing procedure for the ZLN. The crash of a medium-sized and a large commercial airliner was investigated in the framework of the fourth and sixth and seventh modification licence to the storage licence for the ZLN. An aircraft crash may lead to a collapse of walls and roofing as well as to the penetration of aircraft wreckage and kerosene into the ZLN.

Location in an airport approach path
The ZLN is not located in the approach path of an airport.

Summary assessment on aircraft crashes
The impacts of a postulated aircraft crash were considered within the licensing procedure. . Thus, the scenario of an aircraft crash was appropriately considered in the design of the ZLN. The design of the TLBs ensures that the values reached for a postulated crash of a high-speed military aircraft are well below the accident planning values according to § 50 of the Radiation Protection Ordinance (StrlSchV).

Moreover, the potential impacts of a crash of a large commercial airliner were the subject of in-depth examinations performed by the Federal Office for Radiation Protection (BfS) within the licensing procedure. The examinations performed by the Federal Office for Radiation Protection showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur with the mechanical loads on the TLBs nor in case of a subsequent kerosene fire. The ESK holds the view that for the aspect “aircraft crash”, the requirements of the mechanical and thermal degree of protection 3 are fulfilled.

I Blast wave

Design
The ZLN was designed to withstand blast waves. As boundary conditions, additional impacts from an external blast wave in the area of halls 7 and 8 (axis 10 to 39) and in the area of axis 40 including the roof components with a pressure of 19 mbar and a dynamic load factor of 1.5 were considered in the design basis.

Impacts of stronger blast waves
It cannot be excluded that parts of the storage building may be damaged which may result in an impairment of heat removal or of the lid and sealing system by debris so that increased leak rates cannot be excluded.

Site-specific amounts of explosive gases
Using three examples (gas pipeline DN 200, a 50,000 litre tanker, and a ship transport with 8,000 t), the operator shows that the actual distances are significantly larger than the required minimum distances. The operator does not address the planned CCGT plant and the Baltic Sea Pipeline Link (*Ostseepipeline-Anbindungsleitung – OPAL*) realised. However, they both have sufficient safety distance to the ZLN so that the protection goals will not be compromised by these industrial installations.

Potential damage in case of facilities with no special design
This issue does not apply to the ZLN since it is designed to withstand blast waves.

Summary assessment on blast waves
The blast wave represents a two-dimensional impact on the building structure. Due to the seismic design of the building, protection is generally also given against blast waves. In case of a failure of the building structure postulated nonetheless, energy from the pressure wave will be dissipated by the building structure and its failure so that only a reduced impact on the casks would have to be postulated. The TLBs are designed to withstand blast waves and compliance with the protection goals will also be ensured when postulating the collapse of the storage building.

Although there may be explosives at the site, these can cause no impacts affecting the TLBs in their function. Earthquake-induced damage to the buildings themselves cannot result in an undue impairment of heat removal from the TLBs.

The ESK holds the view that the TLBs cannot suffer any damage caused by a blast wave that could jeopardise the vital functions so that degree of protection 3 can be confirmed here. Cliff edge effects are not to be expected.

8 Assessment of facilities for the treatment of spent fuel

Other facilities for the management of spent fuel than those considered above are currently not in operation in Germany. However, there are plants at two sites that are also to be considered within the stress test:

- The pilot conditioning plant (PKA) in Gorleben. For this plant, the operating licence does not cover conditioning but certain cases of repairs on fuel storage casks.

- The reprocessing plant (WAK) in Karlsruhe including its ancillary facilities. This plant was shut down a long time ago and has been under decommissioning for years which is not completed yet.

As part of the stress test, the ESK only considers the currently licensed and currently possible activities and the related radioactive inventories for the two plants. For the case of licences granted in the future for other activities and then with other inventories, the ESK assumes that any stress test considerations will then be made. Therefore, studies on types of operation currently not being licensed can be omitted here.

8.1 Gorleben pilot conditioning plant (PKA)

Facility description
The PKA was built to test and demonstrate the conditioning of spent fuel and heat-generating waste for disposal. This, however, is not covered by the existing licence and can therefore not be performed.

The existing licence only allows the operation of the plant for maintenance and service function for transport and storage casks (acceptance and repair of a defective cask). The entire PKA plant is maintained through a maintenance management (ageing management) to comply with the state of the art in science and technology. Only those systems are fully operational which are required for receiving defective casks. The other systems are not available for active operation.
Licensed operation will only be required if a storage cask in the storage facility has become defective in a manner that it cannot be durably repaired with the means approved for the storage facilities (e.g. leakage at the primary lid). For this case it is provided for the PKA to open the lids (secondary lid and, if required, primary lid) to the extent necessary and to repair the seal/lid system. Removal of the fuel assemblies from the cask is not provided, and opening of the primary lid is only allowed if the cask is docked to the hot cell of the PKA. For these activities, appropriate technical installations of the PKA are used.

Until now, no repair of a defective cask has been required at the PKA.

For the sake of completeness it is pointed out that the following considerations will only be applicable in the event that there is a defective cask within the PKA for repair just when a stress event occurs. Moreover, at least the secondary lid must have been removed because with a mounted secondary lid, full sealing and protective effect of the TLB is to be expected, which is then to be regarded analogous to the considerations on the storage facilities in Chapter 7.

The PKA has the following safety concept: the hot cell and the TLB assume the functions for compliance with the following protection goals:

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

During repair in the docked state, the cell wing of the PKA and the docked cask body take over the protective functions with respect to operation, as well as against the effects of design basis accidents and beyond design basis events. The cell wing and the bottom plate of the PKA are structurally designed to withstand design basis accidents and beyond design basis events such as earthquakes, aircraft crashes and gas cloud explosions. Outside the cell wing, the TLB performs these functions.

Basis of assessment
The assessment was primarily based on the letter from the Lower Saxony Ministry for the Environment, Energy and Climate Protection [6] with notes on the PKA [6, Annex 1] and the response from the operator GNS of 06.08.2012 [6, Annex 3]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test for the PKA were taken into account.

A Earthquake

Design
The design against earthquakes was considered within the licensing procedure. Cell wing and basement tanking were designed as structures of Class I according to nuclear safety standard KTA 2201.1. Cask storage area as well as supply wing and staff facilities are designed as structures of Class II* according to DIN 4149 in analogy to nuclear safety standard KTA 2201.3.

Precautionary measures
The design against earthquakes is not based on precautionary measures.

Behaviour in the event of beyond design basis earthquakes
The PKA is designed to withstand a design basis earthquake. According to the operator, the maximum design intensity is in a range for which no serious damage to the building is to be expected also in case of an earthquake with an intensity level higher by 1 than this intensity. In the event of an earthquake, safety catch devices are available that protect a docked cask against crashing.

The ESK notes with regard to the operator's statement that the maximum design intensity is in a range for which no serious damage is to be expected also for the stress level, that this is plausible for the cell wing, which is also designed against aircraft crash and blast wave, but has not been explicitly demonstrated.

Applicability of damage mechanisms
There are no considerations on damage mechanisms from other load cases that can be applied.

Combinations with other load cases
Consequential impacts from interdependent combinations with other load cases are not to be postulated since due to the low fire loads, fires in the cell wing and the cask storage area will have no significant impacts. Explosions of systems with high energy potential (pressure, temperature) are not to be postulated.

Accident management measures
There are no accident management measures provided.

Soil liquefaction
As part of the planning for the PKA, the boundary conditions for the Gorleben site with regard to subsoil, soil mechanics including seismology, and hydrological conditions were confirmed by a geotechnical report. According to the report, soil liquefaction is excluded for the site due to the bulk density of the foundation soil with medium dense compaction that exists here.

Summary assessment on earthquakes
The seismic design of the plant was considered and demonstrated within the licensing procedure. Due to the structural design of the storage facility, a failure is not to be postulated. The ESK considers the margins that

may exist due to the design not to be sufficiently quantified to confirm compliance with the stress level for the building.

The ESK considers it possible that compliance with the stress level can be confirmed by appropriate verification calculations.

B Flooding

Design

The site is located within the catchment area of the River Elbe, which is about 2 km away. It is located on a lower terrace 21.50 m above sea level of the Weichselian Elbe-Urstromtal (*glacial meltwater valley*), approximately 5 m above the Elbe-Jeetzel lowland. There is no surface runoff nearby.

The Elbe water levels only have indirect impacts on the groundwater levels. The site terrain with an average natural ground elevation of 21.50 m above sea level is located about 1 m higher than the nearby Elbe dams and dykes with a height of up to 20 m above sea level. The dams are higher than the highest flood levels measured over many years. Flooding of the site area is not to be postulated in case of dyke overtopping or failure due to the large Elbe-Jeetzel lowland which is located at a significantly lower level.

Within the framework of the planning for the PKA, the design water level was based on the maximum groundwater level of +20.00 m above sea level. At its 64th/65th meeting in 1983, the German-German Border Waters Commission specified the design basis flood level of 18.90 m above sea level for the altitude of Gorleben. The traffic areas at the plant site are at least at +21.50 m above sea level. Impairment by flood is not given.

Precautionary measures

Due to the exclusion of a danger from flooding, further precautionary measures are not required.

Behaviour at the stress level

Due to the topographical situation of the PKA, flooding during high water can be excluded.

Accident management measures

There are no accident management measures provided.

Summary assessment on flooding

The potential impacts of a flood were considered in the design of the PKA. For compliance with the protection goals, no flood-specific precautionary measures are needed since due to the topographical situation flooding during high water can be excluded. Cliff edge effects are not foreseeable.

The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. The ESK holds the view that a hazard is to be excluded site-specifically and thus stress level 3 is complied with.

C Heavy rain

Design
For the collection and drainage of rainwater, there is a rainwater retention basin at the PKA site. This rainwater retention basin collects the amounts of water from heavy rain.

The design was based on a rainfall intensity of $r_{15.5}$ = 196.2 l/(s·ha) [1]. For a sealed area of 1.2871 ha, this leads to a rainwater volume of 236 m^3 in 15 minutes. The available retention basin with a capacity of 565 m^3 collects 2.4 times the amount of the design rainfall.

With regard to the 15-minute rain, verifications were performed for the entire retention in the retention basin.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
With regard to heavy rain, the following values were applied for sealed areas (nearest town: Wittenberg) in accordance with DIN 1986-100, Table A.1:

- 5-minute rain every five years $r_{5,5}$ = 260 l/(s·ha)
- 5-minute rain every 100 years $r_{5,100}$ = 459 l/(s·ha)

Thus, the DIN value $r_{5,5}$ = 260 l/(s·ha) is complied with. The DIN value $r_{5,100}$ = 459 l/(s·ha) corresponds to a volume of 591 m^3 in relation to the area.

The rainwater retention basin collects a volume of 565 m^3. The remaining 25.8 m^3 run off from the retention basin directly into the adjacent drainage basin.

Accident management measures
There are no accident management measures provided.

Summary assessment on heavy rain
The PKA is designed to withstand weather-related impacts in accordance with the applicable rules and regulations. Should, however, water enter the building due to heavy rainfall, the TLBs ensure compliance with the protection goals. This applies to all rainfall intensities.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the retention function for radioactive substances by heavy rain and therefore considers the stress level to be complied with.

D Other weather-related events

Design
When designing the plant, all conceivable other natural hazards at the site, such as extreme weather conditions (storms, lightning, heavy rain, hail, black ice, etc.) and their causally related combinations, were taken into account. To what extent this also applies to hurricanes is unclear.

Site-specific weather-related events
Due to the geographical situation, additional weather-related events are not to be considered.

Precautionary measures
The design is not based on precautionary measures.

Behaviour at the stress level
The relevant basis for assessing the stability of the conditioning building are the load cases earthquake and aircraft crash. A failure caused by weather-related events is excluded due to the robust construction of the building. This is also to be assumed for direct impacts caused by hurricanes. However, further investigations were not carried out.

Summary assessment on other weather-related events
The PKA is designed against external hazards, such as wind and snow loads and lightning. The relevant basis for assessing the stability of the conditioning building are the load cases earthquake and aircraft crash. Building failure caused by weather-related events is excluded due to the robust construction of the storage hall.

Cliff edge effects are not to be expected. The ESK cannot see any impairment of the functional condition of the PKA and considers the stress level to be complied with due to the design.

E Loss of electrical power

Safety functions dependent on power supply
The requirements with regard to continuous power supply differ in dependence of the system. They range from permissible longer interruption to earthquake-resistant uninterruptible power supply. Consumers of the earthquake-proof uninterruptible power supply are the safety-relevant devices and parts of the measuring air system, the accident instrumentation, emission monitoring and the lighting of the emergency monitoring room.

For the licensed plant operating state (acceptance and repair of a defective cask) in the PKA, the following functional areas are dependent on power supply:

- cask handling,
- waste treatment,
- I&C,
- media supply,
- cooling,
- ventilation systems, and
- safety and physical protection.

In the PKA expert report, greater importance is attached to the following systems due to increased safety requirements:

- fire protection systems and equipment which must also allow for early fire detection and effective fire fighting after malfunctions or incidents,

- exhaust air systems that are required for pressure differentials between plant rooms and whose function is postulated for plant-internal incidents within the accident analysis,

- installations at the emergency monitoring room for the provision of information about the plant condition also after occurrence of an earthquake, and

- emission monitoring systems for which redundant design is provided for reasons of reliability.

Design of the power supply

The power for the PKA is supplied from the superordinate 20 kV grids of the local power utility. This supply is ensured by four power supply lines from the utility. Each of these supply lines can cover the total power requirements of the PKA.

The PKA power supply consists of the normal and backup power supply and is divided into the following functional areas:

- switchgear 20 kV,
- main distribution 0.4 kV,
- sub-distribution 0.4 kV,
- backup power generation with interruption (E1) 0.4 kV,
- backup power distribution with interruption (E1) 0.4 kV,
- backup power generation without interruption (E2) 220 V,
- backup power distribution without interruption (E2) 0.4 kV und
- earthing and lightning protection.

The 20 kV switchgear, the two low-voltage transformers and the two backup power generators are located structurally separated from each other in the power supply building.

The components of the safety-relevant, two-train backup power supply, distributions, batteries, rectifiers and inverters are physically separated from the normal power supply per train in switchgear rooms. The battery systems are also located in structurally separated battery rooms. The systems are designed to withstand earthquakes.

Design of the emergency and backup power supply
Both backup power generators are equipped with a 1,000 litre day tank and a 20,000 litre storage tank. The day tank is designed for an operating time of 2 hours, the storage tank for an operating time of 72 hours during full load operation. In addition, there is a bypass line to the fuel supply, which can be activated manually if required. This supply consists of three tanks, each with a capacity 100,000 litres of heating oil for a total service time of at least 30 days.

In case of loss of normal power supply and backup power supply with interruption, the consumers of the uninterruptible backup power supply will continue to be supplied via the battery systems. There are no manual actions required.

The batteries are designed for a service life of ten hours for the nuclear measuring air system, emission monitoring, accident instrumentation and the lighting of the emergency monitoring room. All other consumers of the uninterruptible backup power supply must be switched off manually after an hour.

Behaviour in case of longer-term total loss of power supply
In case of loss of normal power supply for three days, the required consumers are supplied via backup power supply with and without interruption (stress level 1).

By manual switch over to heating oil supply, the backup power generators can be operated longer than a week so that in case of loss of normal power supply for a week the required consumers are supplied via backup power supply with and without interruption (stress level 2).

Under the conditions of stress level 3, the following situation arises:

The connected consumers will no longer be supplied with electrical energy so that the systems fail.

Due to the current operating state of the PKA, loss of power for a longer period of time has no safety significance since all work can be interrupted or completed within a shorter period of time.

A temporary failure of the monitoring systems does not lead to violation of the protection goals. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices.

A special situation arises for the exhaust air systems: if the primary lid of a TLB to be repaired is opened, the maintenance of negative pressure in the cell would have to be functional to maintain a directed filtered exhaust air stream. Two cases have to be distinguished regarding the fuel in the TLB: there are no significant leakages or there are relevant leakages. In the first case, there would be no relevant risk to the environment if the exhaust air system should fail. In the second case, there are no reliable estimates of potential releases into the environment so far.

Accident management measures
Power supply can be restored through external supply (e.g. an external emergency power generator).

Summary assessment on the loss of electrical power
A loss of power supply has no safety-relevant impacts on the PKA and the radioactive inventory in the TLBs in all situations where the primary lid is still on the cask since safety is ensured by passive systems. In this case, active systems will not be required for fulfilment of the protection goals, including heat removal and leak tightness.

The monitoring systems only have indirect safety functions or are used to monitor safety functions, respectively. A failure of the systems can be compensated by administrative measures, such as additional inspections or mobile devices. Thus, safety will also be ensured in case of a long-term total loss of electrical power.

The ESK holds the view that severe impacts due to the loss of electrical power are not to be expected.

For the case of a long-term total loss of power, it has not been clarified yet whether there may be relevant releases after removal of the primary lid of the cask to be repaired. Stress level 2 is complied with.

F Internal fires

Design
The design is based on the following fire loads:

- cable insulations,
- hydraulic oil,
- cleaning rags,
- Zircaloy chips resulting from fuel rod segmentation (Note: this activity is not permitted under the current licence).

There are only local and temporary fires conceivable. In the conditioning building of the PKA, there are no larger fire loads. All areas, such as cable ducts, are monitored. The design of the conditioning building and the installed fire protection measures are appropriate for preventing spread of a local fire to a larger area.

Precautionary measures
There are, according to the operator, the following precautionary measures:

- all rooms are monitored by fire detectors,
- manual fire fighting equipment (portable fire extinguishers, hydrants, etc.),
- on-site fire brigade,
- the hot cell is equipped with a metal powder fire extinguishing system and a water-based foam extinguishing system for which the amount of water used is limited.

A simultaneous failure of redundant precautionary measures is very unlikely. The resulting fire will not result in the violation of the protection goals since it can only spread to a very small area. However, the licensing authority holds the view that a failure of precautionary measures, such as the loss of water supply for fire fighting, the fire of a transport vehicle in the truck lock may result in a fully developed fire. For this case, there is no proof of integrity of a TLB. In the process of "introducing the transport vehicle into the truck gate", however, it is defined as a further precautionary measure that the towing vehicle is removed from the truck lock immediately after introduction of the towed vehicle. Due to its design and the amount of fuel, the towing vehicle has a higher fire load than the transport vehicle including the transported cask. This measure reduces the higher fire load in the truck lock to very short periods of time while this generally also ensures that personnel (drivers, etc.) is present during this time so that an incipient fire would be detected with a higher probability.

Behaviour at the stress level
According to the operator, fires beyond the design basis are, in principle, not possible due to the limited fire loads.

Accident management measures
Local fires can be fought quickly by the on-site fire brigade.

Summary assessment on internal fires
Fire durations beyond the design basis are not possible due to the limited fire loads. Cliff edge effects are not to be expected. Thus, the ESK considers stress level 2 to be complied with.

For the special case of fire in the truck lock it is important to note that this could only be relevant for the very short period of time during which the TLB on the transport vehicle and the towing vehicle stay in the truck lock at the same time. The thermal impact on the sealing area of the cask would, however, also then be definitely smaller than in the event of an aircraft crash with subsequent fire for which control was demonstrated.

G External fires

Site-specifically adjacent fire loads
The site area is surrounded by pine forest. To the east, there is the K2 district road. There are no regular transports with increased fire loads.

Design
Due to the distance of the PKA to the plant fence (> 35 m) and the fire protection measures, spread of fires from outside the plant will be prevented.

Precautionary measures
The design against external fires is not based on precautionary measures.

Behaviour at the stress level
Due to the distance of the PKA to the plant fence (> 35 m) and the fire protection measures, spread of fires from outside the plant will be prevented.

Accident management measures
A camera-based forest fire monitoring system is installed in the area of the Lüneburg police headquarters for early detection of incipient forest fires so that volunteer fire departments can be alerted for fire fighting in time. Should there be a major forest fire, the regional fire brigade task force may be called for assistance. Task forces from neighbouring districts may also be alerted. Together with the volunteer fire departments and the on-site fire brigade, a fire barrier zone around the plant can be established. These measures can also still be performed in case of a fire of stress level 1.

Summary assessment on external fires
Due to the distances to forest areas and/or buildings with increased fire loads and/or to traffic routes on which larger fire loads are regularly transported, direct danger from external fires can be excluded. Spread of external fires to the PKA is excluded due to appropriate zones with low fire loads in the surrounding area (grassland/wasteland). Moreover, the PKA consists of non-combustible materials (mainly steel and concrete) so that development of a fire at the building is not possible.

Fires beyond the design basis are not possible due to the limited fire loads in the area adjacent to the plant. Thus, stress level 2 is complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were the subject of in-depth examinations performed within the licensing procedure for the PKA.

The overall conclusions according to an expert assessment are as follows: “With the structural and plant-specific protection measures provided for the PKA, there is generally a high degree of protection against the event aircraft crash. This is achieved, in particular, by a so-called full protection for areas with high activity inventory and by the redundant and spatially separated design of passive cooling for the buffer storage facilities.” and “With these measures, a massive release and uncontrolled self-heating of the radioactive inventory can be prevented. The scope of protection provided for the PKA corresponds to the standard measures against the load case aircraft crash in the context of nuclear power plants according to the state of the art in science and technology which are considered to be appropriate to minimise risks.”

Further, it was stated in the expert assessment that the accident planning values according to § 50 of the Radiation Protection Ordinance (StrlSchV) in conjunction with § 117 (16) of the Radiation Protection Ordinance (StrlSchV) are complied with for the crash of a high-speed military aircraft.

Location in an airport approach path
The PKA is not located in the approach path of an airport.

Summary assessment on aircraft crashes
By the licensing authority it was determined by an expert assessment that for a crash of a high-speed military aircraft onto the PKA, the accident planning values are complied with for the next locations where persons may be present. From the results of this expert assessment the ESK concludes that a release of radionuclides where the reference levels for the initiation of major disaster control measures would be reached can neither occur in case of mechanical loads nor in case of a subsequent kerosene fire.

Moreover, it should be noted that this calculation is not based on the case of 1 cask in the PKA, permissible according to the current licence, but on a much higher number of casks in the PKA originally applied for. Thus, degree of protection 2 is complied with for thermal and mechanical loads.

The statement of the operator that this design also covers the impact of commercial aircrafts is plausible for small commercial aircrafts or specific crash scenarios, but there are, according to the licensing authority, indications that this does not apply to large commercial airliners and unfavourable impact situations. Therefore, the thermal and mechanical degree of protection 3 can currently not be confirmed by the ESK. Cliff edge effects are not foreseeable.

I Blast wave

Design
The cell wing of the PKA is designed to withstand blast waves. The design extends to the stability of the cell wing and the transport channels and to the tightness of the entire basement tanking of the conditioning building with base plate, outer walls in the ground and waterproofing.

In addition, in the ventilation installations, the isolation dampers of the cells and cell filters are designed against induced vibrations due to a blast wave. As design assumption for the cell wing, the pressure-time curve of the Guideline for the Protection of Nuclear Power Plants against Pressure Waves from Chemical Reactions was referred to. The safety margins required by this guideline between the conditioning building and possible locations where explosive substances are handled are complied with.

Impacts of stronger blast waves
When postulating a 20 % stronger blast wave that hits the conditioning building, it is to be expected that, due to the design of the building against earthquakes and aircraft crashes and the resulting structural and strength-related margins available, neither the stability nor the appropriately ensured confinement of the activity inventory will be affected. Impacts on the lid area of the cask in the facility for repair are not to be expected.

Site-specific amounts of explosive gases
In the vicinity of the PKA, there is no handling of explosive substances and no industry with a high hazard potential. The distance of the PKA to the gas pipeline to Gorleben is also sufficient with more than 800 m. If the gas pipeline would be the starting point of a blast wave, the blast wave could not jeopardise the stability of the conditioning building due to the distance.

The case of the explosion of a tanker with 30 m^3 (equivalent to about 18 t) of liquefied gas (propane) on the road Lüchower Straße just in front of the entrance gate, as reviewed in the expert assessment, does not lead to a hazard for the PKA either. This amount assumption covers the transport of liquefied gas on the road.

Summary assessment on blast waves
The blast wave is a two-dimensional impact on the building structure. The design provides general protection against blast waves. There are no scenarios obtained that may lead to further damage to the transport cask in the facility for repair or may lead to further releases.

Therefore, the ESK holds the view that the PKA cannot suffer any damage from a blast wave that would have to be considered in the stress test. Cliff edge effects are not to be expected. Due to the location of the PKA regarding potential sources for the release of explosive gases and due to the design of the PKA, the ESK considers degree of protection 3 to be complied with.

8.2 Karlsruhe reprocessing plant (WAK)

Facility description
The licensing authority describes the current situation for the WAK as follows:

The WAK finally ceased its reprocessing operation at the end of 1990 and is now in the process of being dismantled. The plant still consists of the plant sections process building (*Prozessgebäude - PG*), main waste storage building (*Haupt-Waste-Lager - HWL*), storage and evaporation facility (*Lagerungs- und Verdampfungsanlage - LAVA*) and the Karlsruhe Vitrification Facility (*Verglasungseinrichtung Karlsruhe - VEK*).

The PG is largely emptied. The remaining activity inventory in the entire PG is estimated at $< 10^{13}$ Bq, which is contamination on the floors and walls. Due to the low average activity, catastrophic impacts are not to be expected even in case of beyond design basis events.

- The main waste storage building HWL accommodates, among others, former storage tanks for liquid high active waste concentrate (HAWC) with a capacity of approx. 63 m^3 that could be filled with solutions with a specific activity of up to 4E13 Bq/l. The storage tanks have been emptied and dry since the late 1980s. The vast majority of the remaining activity of about 1E15 Bq is located in the former storage tank 81.21 in the form of a hardly soluble solid. This was shown by repeated attempts to resolve it or to mobilise it otherwise. The activity inventory in the HWL decreased compared to the design value by orders of magnitude. Since there is no liquid but a solid now, the potential for release during incidents and accidents decreased considerably. Dismantling was permitted with the 22nd decommissioning licence. The preparatory measures (creation of breakthroughs, establishment of lock transfer logistics, etc.) are being implemented so that start of disassembly of the first HWL tank is expected for 2013. In the medium term, most of the remaining activity will thus be removed from the HWL and conditioned in the Central Decontamination Department (*Hauptabteilung Dekontaminationsbetriebe - HDB*).

- The storage and evaporation facility LAVA accommodates the storage tanks that were used after emptying the HWL tanks in 1986 as HAWC storage tanks. These tanks were designed like the HWL tanks for an activity of approx. 5E18 Bq. Before vitrification of these solutions in 2010, the activity inventory was approx. 8E17 Bq. The solutions were completely vitrified and the tanks subsequently rinsed. The still existing residual inventory of about 1E15 Bq will be in the form of a solid after drying of the residual liquid. The disassembly of the two storage tanks was permitted with the 22nd decommissioning and will be performed immediately after disassembly of the HWL tanks. In the medium term, the existing activity will thus be removed from the HWL in packages, conditioned in the Central Decontamination Department (HDB) and stored there.

- In the VEK, the HAWC was completely vitrified and the facility rinsed subsequently. The remaining solution after final cessation of vitrification operation was transferred into two tanks in cell V1 and has been completely evaporated since the end of 2012. The activity inventory in the VEK of about 1E16 Bq is mainly located in the two tanks in cell VI (receipt cell). There are also higher activities in the order of 1E15 Bq in the V2 cells (melter cell) and V8 (wet off-gas treatment system). First decommissioning activities in the VEK have already been permitted with the 2nd partial operating licence for the VEK and the 21st WAK decommissioning licence. The remaining installations, such as filling level measuring probes, T measuring probes, purge air supply, were permanently taken out of operation. Dismantling measures in the cells have not yet been applied for.

Basis of assessment

The assessment was primarily based on the letters from the Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector dated 31.08.2012 [13] and 13.11.2012 [14], the response from the operator WAK Rückbau- und Entsorgungs-GmbH of 30.08.2012 ([13, Annex 3] and [14, Annex 2]) and a statement of the TÜV SÜD Energietechnik GmbH [14, Annex 1]. Moreover, the results of informational talks with the competent supervisory and licensing authority on the stress test and supplementary electronic messages of the supervisory and licensing authority [12, 15] were taken into account.

A Earthquake

Design

Due to the very different times of construction of the individual plant sections that are located at the WAK site today, there were different requirements for the seismic design being typical in the various periods. Where this was necessary for the seismic safety of the outage and dismantling operation after termination of the reprocessing operation in 1990, corresponding upgrading was performed. For the newly constructed VEK, the design against earthquakes, currently required in accordance with the state of the art in science and technology, has been implemented from the outset. Relevant for the consideration in the stress test is only the design against earthquake-induced release of the still existing radioactive inventories.

Process building (PG): Radioactive residues are only present there in small amounts. Any damage to the building itself, to building structures and to internals and auxiliary equipment for dismantling resulting from seismic impacts would have no significant radiological impacts.

HWL and LAVA: Due to the design implemented against earthquakes, the consequences of a design basis earthquake will also be limited during the dismantling activities.

VEK: The two tanks with the evaporated residual liquid, the melter with the remnants of glass loaded with fission products, and different lower-level residues are accommodated in containers/components or cells that are designed to withstand seismic loads with the requisite stability and integrity in accordance with nuclear safety standard KTA 2201. The design is, in particular, such that the design basis event earthquake will also be coped with during the dismantling of the VEK.

Precautionary measures

The effectiveness of the precautionary measures taken during construction and operation of WAK plant sections and the VEK that are relevant for the seismic design was confirmed in the respective construction and operating licences.

Behaviour in the event of beyond design basis earthquakes

The design of the WAK plant sections and the VEK against earthquakes with intensity I = VIII provides margins for beyond design basis earthquake events. The design intensity is at least one intensity level above the earthquakes historically observed for the site. An earthquake with intensity I = IX at the site of the

WAK plant sections and the VEK is excluded due to the geological and seismological boundary conditions.

Due to the design, the VEK is protected against aircraft crashes and also against the impacts of a design basis earthquake. Studies on the behaviour of the WAK plant sections and the VEK in case of beyond design basis earthquakes are not available.

Applicability of damage mechanisms
There are no considerations from other load cases that can be applied.

Combinations with other load cases
a) Debris loads
PG: The small amount of radioactive inventory of < 1E13 Bq still present in the building is located in the PG in the form of contamination on walls and cell floors. Possible debris loads from building structures fallen down would at most lead to a negligible dust contamination in the vicinity of the crash site.

HWL: In the area of HWL extension South, debris loads are to be expected. The confinement of the radioactivity in the cells will not be endangered by debris loads.

LAVA: The confinement of the radioactivity in the cells will not be endangered by debris loads. Consequential impacts from debris loads do not have to be considered.

VEK: Due to the design against aircraft crashes, the roof of the VEK is also designed against debris loads so that its integrity will also be ensured after an earthquake. The HAWC transition is also designed to withstand debris loads. Consequential impacts from debris loads do not have to be considered.

b) Consequential fire (cable fire)
Due to numerous precautionary measures, the probability of a fire caused by an earthquake is low. The fire protection measures provided will also be effective in case of earthquakes. Postulated fires within the plant, e.g. caused by short circuit, are limited locally and with regard to the existing fire load and they cannot lead to a radiological release.

PG, HWL, LAVA: According to the considerations in the safety report on step 4, significant release of radioactive aerosols in the environment is not to be expected. Consequential impacts from fires after an earthquake lead to no larger radionuclide release than identified in the accident analysis.

VEK: The residual inventory of the VEK is exclusively located in the former process cells. In these cells, there are no fire loads. This means that no radioactive releases are to be feared as a result of an earthquake when postulating a fire in the VEK.

Accident management measures
When postulating that the building areas PG, HWL and LAVA do not withstand a beyond design basis earthquake and the building structures fail, the building debris would be covered with a tarpaulin to prevent the propagation of adherent radioactivity by wind and moisture.

For the VEK, no accident management measures are provided. Due to the full protection of the VEK against aircraft crashes, no protection goals will be violated in case of beyond design basis earthquakes that would require immediate accident management measures.

Soil liquefaction
PG and HWL: Due to the advanced decommissioning activities and the low activity inventory, considerations on soil liquefaction are no longer relevant here.

LAVA: The soil investigations and the additional drilling at the site of the WAK indicate that there is sand and gravel beneath the foundation level. The buildings are to be regarded as rigid units. No soil-improving measures were provided.

VEK: Prevention of potential soil liquefaction in the event of an earthquake was implemented by improvement of the soil.

Summary assessment on earthquakes
The ESK holds the view that the design of the individual building complexes of the WAK in conjunction with the size and technical form of the remaining residual inventory shows a significant robustness in the event of an earthquake. Cliff edge effects are not foreseeable, in particular due to the condition of the radioactive material. Based on the verifications from the various licensing procedures, the ESK assumes that a detailed calculation for the stress level would show that it can be complied with.

B Flooding

Design
For the design of the WAK plant sections and the VEK, the impacts of a 10,000-year flood were postulated in accordance with the requirements of nuclear safety standard KTA 2207. There is protection in case of occurrence of a 10,000-year flood. The WAK site is located at an altitude of about 110 m above sea level on the upper fluvial terrace of the Rhine Graben Valley, a plain that is about 10 m above the adjoining floodplain of the Rhine River and separated from it by a brim. There is no danger from flooding both at the site of the WAK plant sections and the VEK as well as for the main access roads.

Precautionary measures
Due to the exclusion of a danger from flooding, further precautionary measures are not required.

Behaviour at the stress level
Due to the topographical situation, flooding during high water can be excluded.

Accident management measures
There are no accident management measures provided.

Summary assessment on flooding
The potential impacts of a flood were considered in the design of the WAK facilities to be considered here. For compliance with the protection goals, no flood-specific precautionary measures are needed since due to the topographical situation flooding during high water can be excluded.

There are no indications to cliff edge areas. The assessment by the operator is based on studies conducted in the framework of the licensing procedure. The results are plausible and comprehensible. The ESK holds the view that a hazard is to be excluded site-specifically and thus stress level 3 is complied with.

C Heavy rain

Design
The design of the WAK plant sections and the VEK against heavy rain considers the relevant building standards (DIN 1986). To determine the design basis values, historically recorded precipitation statistics and the precipitation measurements of the Karlsruhe Institute of Technology - Campus North (KIT CN) were referred to. The design of the rainwater drainage system of the WAK is based on a rainwater volume of 138 l/(s·ha) for a duration of 15 minutes.

Ingress of rainwater into the building is prevented by structural measures. All exterior doors were provided with a threshold exceeding the ambient level by about 7.5 cm. In front of the exterior doors, rain gutters are installed to collect the rainfall. The drainage of the roof surfaces takes place via downpipes installed outside which feed directly into the rainwater network. Underground cables are routed such that they cannot be affected by groundwater and any rainwater ingress.

Precautionary measures
The design against heavy rain is not based on precautionary measures.

Behaviour at the stress level
According to the precipitation distribution in the Leopoldshafen area, the rainfall intensity of a 15-minute rain and an annual exceedance frequency is $r_{15,1}$ = 138 l/(s·ha). For surface water from building roofs, a rainfall of a 15-minute rain of 300 l/(s·ha) is defined which approximately corresponds to a 70-year exceedance frequency.

The rainwater in the area of the WAK plant sections and the VEK is drained into the WAK rainwater network via several shafts. This is sufficient, also taking into account the existing sewers with storage capacities, to cope with the rainfall volumes at the WAK site.

The residual radioactivities in the WAK plant sections and the VEK are located within material barriers that cannot be affected by the ingress of rainwater. Even when postulating that significant precipitation quantities would flow through the accesses into the WAK plant sections and the VEK, the required protection status “confinement of radioactive material” would be maintained.

When postulating water ingress into the rooms, this water cannot escape into the groundwater in an uncontrolled manner due to the design of the waterproofing of each facility. Amounts of water inside the facilities are localised and would be collected (pumped out) and disposed of in a controlled manner after sampling.

Impairment of the dismantling operation associated with a loss of barriers and thus a release of radioactive material into the environment resulting from water ingress is not to be expected.

Accident management measures
For the postulated case of ingress of large amounts of water from torrential rains into the basement rooms of the supply centres, water pumps are available for pumping out. Access to the pumps and their provision on site will not be hampered by heavy rain.

Summary assessment on heavy rain
Due to their design, the WAK plant sections and the VEK are protected against influences from extreme weather conditions. The vital safety functions will also be maintained in case of extreme weather conditions. Cliff edge effects are not to be expected. The ESK cannot see any impairment of the confinement of radioactive material by heavy rain and considers the stress level to be complied with.

D Other weather-related events

Design
For design and operation of the plant, all conceivable other natural hazards at the site, such as extreme weather conditions (storms, lightning, heavy rain, hail, black ice, etc.) and their causally related combinations, were taken into account.

Site-specific weather-related events
Due to the local conditions, additional weather-related events are not to be considered.

Precautionary measures
The design is not based on precautionary measures.

Behaviour at the stress level
The structural design of the WAK was dimensioned with adequate safety margins. An additional safety feature is (depending on the plant section) the design against earthquake, aircraft crash and/or pressure wave. Studies

on the behaviour of the WAK plant sections and the VEK in case of beyond design basis external weather conditions have not been conducted.

Summary assessment on other weather-related events
The ESK considers the design against other weather-related events to be given. Load cases well above the respective design are covered by the design against earthquake, aircraft crash and/or pressure wave. Moreover, the technical form of the remaining radioactive inventories cannot lead to a large release caused by extreme weather events.

Cliff edge effects are not to be expected. The ESK cannot see any relevant impairment of the functioning of retention by other weather-related events and considers the stress level to be complied with.

E Loss of electrical power

Safety functions dependent on power supply
At present, the power supply of the WAK plant sections and the VEK provides emergency power supply for the ventilation systems, the LAVA/VEK exhaust gas system, radiation protection instrumentation, emission monitoring, communication facilities (call and alarm systems, fire alarm systems, telephone and paging system), monitoring of the residual facilities, escape route lighting, emergency lighting and the physical protection installations. Some of these consumers are backed up by UPS installations or batteries.

The mechanical equipment used for dismantling is only supplied from the normal grid. In case of failure of the normal network, all dismantling activities will be discontinued.

The operating states in the HWL, LAVA and VEK are stationary. A failure of I&C installations cannot lead to a release of radioactivity.

Design of the power supply
Power supply of the WAK consists of three grid qualities:

- for normal power supply
- for emergency power supply (not uninterruptible),
- for uninterruptible emergency power supply (UPS).

The normal power for the WAK is supplied redundantly at the 20-kV level from a superordinate public ring network. For emergency power supply, there are two emergency generators in the energy supply centre (EVZ III) available. All safety-relevant consumers are not connected to the uninterruptible emergency power. Selected safety-relevant consumers are connected to the UPS emergency power system.

Design of the emergency and backup power supply
In case of loss or disruption of normal power or emergency power supply, two emergency generators will start automatically. After 15 seconds, the load of the emergency power consumers is gradually transferred to the preselected generator. The second generator continues operation. Should the preselected generator not be available, there will be an automatic redundancy switchover to the other generator.

Consumers that are not connected to the uninterruptible emergency power system are buffered by decentralised UPS systems whose capacity is sufficient to bridge the time until start of the emergency power generators.

The design of the backup power supply is dimensioned so that emergency power supply is ensured for 72 hours with no further measures. After that, the running generators need to be supplied with diesel fuel.

Should emergency power operation exceed the specified design duration, mobile backup power generators can be connected via supply points that are accessible on the outside of the building.

Behaviour in case of longer-term total loss of power supply
Unavailability of all power supply systems, including the backup power generators, will lead to a complete failure of all electrical consumers within a short time. Thus, the barrier function of the ventilation will be impaired with respect to the pressure differentials.

Since there are only small amounts of radioactive substances left in the WAK plant sections and the VEK that are to be decommissioned, and these mostly in solid form, the need for emergency power supply (e.g. for cooling of container contents) is low. There are no active systems needed for heat removal. Releases into the environment exceeding the licensed limits in the operational phase of the plant are not expected even in case of a total loss of power supply for a longer period of time.

Accident management measures
Should the emergency power generators fail in case of loss of offsite power, too, mobile backup power generators can supply individual consumers separately via the existing externally accessible plug-in stations (remote shutdown and control stations). Mobile backup power generators are available at the WAK site.

Summary assessment on the loss of electrical power
The impacts of a total loss of power supply for the WAK plant sections being dismantled and the residual VEK operation are negligible. Impermissible release of radioactive substances into the environment is not to be expected. The protection goals are met. Cliff edge effects are not to be expected. Stress level 3 is complied with.

F Internal fires

Design
In the WAK plant sections to be considered and in the VEK, effective preventive fire protection is realised by only admitting negligible fire loads within the buildings. Compliance with this preventive fire protection is

ensured by administrative regulations. There are studies on the effectiveness from the various licensing procedures. In addition, there are studies on potential fire loads and their impacts from the various licensing procedures. They show that relevant releases are not possible due to the technical form of the remaining radioactive inventories.

Precautionary measures
Protection against internal fires includes a number of passive and active precautionary measures which are made use of according to the safety significance of the plant components to be protected. They correspond to the usual measures of preventive fire protection.

Behaviour at the stress level
The fire loads inside the facilities are low. Therefore, longer-lasting fires are not possible. Moreover, release takes place within the ventilation barriers. Impacts beyond the design considered within the licensing procedure are not to be expected even for stress level 1.

Accident management measures
PG, HWL and LAVA: Water for fire fighting is supplied via the underground ring main system DN 200 of the KIT CN. Outside and around the building, there are surface hydrants to which the fire brigade can connect in case of fire. Inside the building, fire extinguishers are available in sufficient number. In the cable basement, there is a stationary fire extinguishing system with permanently installed pipes and open nozzles which is triggered manually in the event of a fire. The water used will be removed through a drain in the basement. The spray deluge system is equipped with a connection for water supply by the fire brigade.

VEK: Water for fire fighting is supplied via the underground ring main system DN 200 of the KIT CN. Outside and around the building, there are surface hydrants to which the fire brigade can connect in case of fire. For fire fighting in other areas, a riser with fresh water is available. Within the EVZ III and within the controlled area of the VEK, mobile, hand-operated small extinguishers are used which are installed at easily visible places near the exits and escape routes.

For fire fighting, the on-site fire brigade of the KIT CN available. Its technical equipment is designed for use within the WAK, including the VEK and the EVZ III. The accident management measures to limit the consequences of internal fires are also feasible at stress level 1.

Summary assessment on internal fires
Fires beyond the design basis are not possible due to the limited fire loads. Cliff edge effects are not to be expected. Thus, the ESK considers stress level 2 to be complied with.

G External fires

Site-specifically adjacent fire loads

The WAK plant sections and the VEK are located on a site surrounded by forests. The individual facilities are separated from the trees by a sufficiently large distance and fireproof locks. There are no traffic routes running directly along the WAK premises.

On the premises, combustible material is located with sufficient distance to safety-relevant buildings so that fires within the WAK premises can be excluded to a degree relevant for the safety of the facilities.

Design

The distance of the buildings from the trees exceeds the minimum distance of 30 m required according to the *Land* building code (LBO).

For the LAVA, a wildfire near the LAVA with a duration of one hour (forest fire) and 15 minutes (kerosene fire after aircraft crash), respectively, was postulated as a design basis fire. Structural measures prevent the entry of flue gases. In the event of an external fire, the supply air dampers of the LAVA building will be closed. The supply air fans will be switched off.

The VEK is structurally designed against external fires (forest fires). Reinforced concrete parts were made in accordance with fire resistance class F90. The temperature differences within the concrete structure of the VEK building during external fire were considered in the structural design as special load case.

Due to the land clearing work performed as part of the building site preparation, there is a distance of about 60 m from the VEK to the forest boundary.

An expert assessment confirmed that due to the vegetation, the existence of fireproof locks and the non-existence of undergrowth a fully developed fire is not to be expected. The patrolling of the site by the physical protection service (*Objektsicherungsdienst - OSD*) of the WAK and the short intervention time of the fire brigade of the KIT CN reduce the fire risk even further.

Precautionary measures

The precautionary measures refer to the structural designs and to the isolation dampers (activated by automatic smoke detection) of the VEK and the energy supply centre (EVZ III) to prevent the entry of flue gases. The ventilation systems will be switched off. Due to the short duration of the fire and the sufficient distance from potential sources of fire, a failure of building structures of the WAK plant sections and the VEK is excluded.

The failure of precautionary measures is in no case associated with a release of radioactive material.

Behaviour at the stress level
Due to the distance of the building storage hall to the edge of the forest, spread of fires from outside the plant will be prevented. Due to this and due to the limited fire loads in the areas adjacent to the plant, fire durations beyond the design basis are, in principle, not possible.

Accident management measures
In case of fire, the fire brigade of the KIT CN will be on the WAK premises within a short time.

Summary assessment on external fires
Due to the distances to forest areas and to traffic routes on which larger fire loads are regularly transported, direct danger from external fires is excluded. Due to the limited fire loads in the area adjacent to the plant, fires beyond the design basis are not possible. Cliff edge effects are not to be expected. Thus, the ESK considers stress level 2 to be complied with.

H Aircraft crash

Consideration of impacts
The impacts of an aircraft crash were assessed in the framework of the individual licensing procedures for the WAK plant sections and the VEK. The scenario of an aircraft crash was considered in the design of WAK facilities LAVA (cell wing) and the VEK appropriately. In conclusion, the accident planning values according to §§ 49/50 of the Radiation Protection Ordinance (StrlSchV) are complied with for crash of a high-speed military aircraft.

In the wake of the events of 11.09.2001, the impacts of a deliberate aircraft crash and the crash of a large commercial airliner were also examined. The examination showed that a release of radionuclides where the reference levels for the initiation of major disaster control measures (evacuation) would be reached can neither occur in case of mechanical loads nor in case of a subsequent kerosene fire.

Since there is only a small amount of solid residues in the VEK any releases into the environment would today be significantly lower than in the above calculations for the operation of the VEK with the corresponding inventory that was much higher back then.

PG and HWL: The process building and the HWL are, in accordance with the former licensing practice, not designed to withstand the impacts of an aircraft crash.

Since there are only small amounts of solid residues in the two plant sections today, any releases into the environment will remain below the accidental releases for the licensed operation of the WAK plant sections and thus below the accident planning values.

Location in an airport approach path
The WAK is located in an area with restricted airspace prohibiting overflight by civilian and military aircrafts up to an altitude of 2,300 ft above ground level (approx. 700 m). The WAK is not located in the vicinity of airfields.

Summary assessment on aircraft crashes
The design of the facilities in the WAK and the current residual inventory ensure that the values reached for a postulated crash of a high-speed military aircraft are well below the accident planning values. Additional studies dealt with the impacts of a crash of large commercial airliners.

Cliff edge effects are not to be expected. Thus, mechanical degree of protection 2 and thermal degree of protection 2 are given in any case. In particular due to the low residual inventory and its technical form, the ESK assumes that fulfilment of the mechanical and thermal degree of protection 3 could be verified by a corresponding examination.

I Blast wave

Design
PG and HWL: The WAK plant sections PG and HWL were designed to withstand a blast wave with a maximum pressure of 3,040 Pa. The design basis was a postulated pressure wave from an ammunition depot, which has meanwhile been emptied, at a distance of about 1.4 km north of the WAK premises. The northern walls were designed for twice the peak pressure load. The expansion of the energy supply centre EVZ II was designed to withstand a built-up pressure of 3,920 Pa. Recent calculations on the stability of the PG and the HWL regarding the impacts of pressure waves resulting from chemical explosions are not available.

The design of the plant sections against earthquakes also covers the impacts of the blast wave load case.

LAVA: The cell wing of the LAVA and the emergency well building are designed to withstand pressure waves in accordance with the requirements of the pressure wave guideline of the Federal Ministry of the Interior (BMI). The load case of an explosion in the ammunition depot at a distance of 1.4 km - meanwhile emptied - is covered by an equivalent static load of 6,082 Pa for the northern wall and of 3,041 Pa for the other walls, the roof and the vent stack. The loads on the cell wing and the cell internals are covered by the design against the aircraft crash load case.

VEK: The VEK is designed to withstand a pressure wave with an excess peak pressure of 0.45 bar and a sequence in accordance with the requirements of the pressure wave guideline of the Federal Ministry of the Interior (BMI). The neighbouring buildings are separated from it by a gap of 2.6 m so that interactions between the buildings as a result of pressure wave impacts are prevented. The vibrations acting on the components within the building caused by a pressure wave are less intense than the vibrations considered for the design basis earthquake.

Impacts of stronger blast waves
In case of a much stronger blast wave than designed, no releases are to be expected that lead to doses exceeding the dose limits according to § § 49/50 of the Radiation Protection Ordinance (StrlSchV).

PG and HWL: The seismic design of the plant sections also covers the impacts caused by a much stronger blast wave.

LAVA: The impacts of a much stronger pressure wave for the cell wing are covered by the aircraft crash load case.

VEK: The relevant load case for the structural design is the aircraft crash. Thus, there are design margins for the blast wave load case. This ensures the safe confinement of the radioactive inventory also in case of a blast wave beyond the design basis.

Site-specific amounts of explosive gases
The sufficiently large safety distances to industrial facilities, gas pipelines and transport routes for potentially dangerous goods ensure that no higher loads from a blast wave can occur for the WAK plant sections and the VEK than the loads resulting from the design basis pressure wave. Moreover, there is no handling of larger amounts of explosive substances in the surroundings of the WAK premises.

Potential damage in case of facilities with no special design
The WAK plant sections and the VEK are designed to withstand blast waves.

Summary assessment on blast waves
Due to the sufficiently large safety distances to potential explosion sources, hazards due to blast waves are excluded for the WAK plant sections and the VEK. In case of a blast wave postulated nonetheless, the design of the WAK sections and the VEK ensure maintenance of the vital safety functions. Cliff edge effects are not to be expected. The ESK considers degree of protection 3 to be complied with.

9 Summary assessment and recommendations

With this statement, the ESK assesses, on behalf of the BMU, the robustness of nuclear fuel supply facilities, storage facilities for spent fuel and heat-generating radioactive waste and facilities for the treatment of spent fuel against beyond design basis events. With this stress test, it is expressly not intended to assess the design requirements reviewed as part of the licensing procedure but design margins that go beyond them. In this way, it is investigated how the facilities behave under beyond design basis loads and whether a sudden rise of the radiological effects outside the facility (cliff edge effect) due to the failure of components or measures is foreseeable. As assessment criteria for the radiological effects associated with the beyond design basis loads in the stress test, the intervention reference levels according to the basic recommendations for disaster control are

referred to. Existing precautionary measures and accident management measures provided are also considered in the stress test.

The robustness of the storage facilities for low- and intermediate-level radioactive waste, of the conditioning facilities for low- and intermediate-level radioactive waste and of the repositories for radioactive waste (Asse II mine, Morsleben repository for radioactive waste (ERAM) and repository Konrad mine) will be assessed by the ESK in a later statement.

The ESK assesses the robustness of the facilities systematically on the basis of predefined load cases and assessment criteria (stress levels, degrees of protection) on which a list of questions was submitted to the competent nuclear licensing and supervisory authorities of the *Länder* with the request to forward it to the operators of the facilities concerned. The written answers to this list of questions and the oral explanations given at the meetings of the ESK, i.e. the ad hoc working group especially set up for the stress test, served as a basis for the assessment in the framework of this stress test.

The assessment only takes into account the radiological impacts of the beyond design basis loads. Chemotoxic impacts as well as issues related to physical protection against interference by third parties are not considered.

In summary, the ESK has come to the following conclusions:

The two fuel supply facilities, the fuel fabrication in Lingen and the uranium enrichment plant in Gronau, have substantial margins against beyond design basis events. For almost all postulated load cases, they comply with the highest stress level and reach the highest degree of protection. In individual cases where this is not achieved, the impacts caused by these beyond design basis loads would not necessitate major disaster control measures according to the basic recommendations for disaster control (*Rahmenempfehlungen für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen*) [24].

The storage of spent fuel and heat-generating waste is based on a robust protection concept according to which compliance with the fundamental protection goals during storage in case of specified normal operation and design basis events is primarily ensured by the thick-walled metal casks. The design of the casks also ensures that even in case of beyond design basis events, no major disaster control measures are required.

The analyses and assessments carried out by the ESK on the basis of the documents submitted have shown that the storage facilities for spent fuel and heat-generating waste comply with the highest stress levels and reach the highest degree of protection for almost all load cases. For some storage facilities, compliance with the site-specific stress levels in the context of flooding would depend on the presentation of additional verifications and their confirmation. Irrespective of this, the ESK cannot see any impairment of the functional condition of the fuel assembly casks by flooding.

For the AVR cask storage facility, verifications in the context of earthquakes and aircraft crashes are not available. However, appropriate studies are being carried out within the current licensing procedure.

The facilities for the treatment of spent fuel, the Gorleben pilot conditioning plant and the facilities of the Karlsruhe reprocessing plant not dismantled yet also have substantial margins against beyond design basis events. For many postulated load cases, they comply with the highest stress level and reach the highest degree of protection. However, in cases where this is not achieved, the impacts caused by these beyond design basis loads would not lead to releases requiring major disaster control measures.

In conclusion, the ESK states that at present a failure of components or measures due to the postulated beyond design load cases that may lead to a sudden rise of the radiological effects outside the facility (cliff edge effect) is to be feared for none of the facilities considered in the stress test. Furthermore, no deficiencies in the design requirements of the facilities considered have become apparent in the stress test.

Moreover, the ESK generally refers to the GRS information notice on rainwater entry into the Brunsbüttel nuclear power plant on 04.09.2011 (*"Regenwassereintrag in das Kernkraftwerk Brunsbüttel am 04.09.2011" (WLN 2012/03)*) [23] which reports on an increase of the requirement for heavy rain events by a factor of 1.8. It recommends for all facilities considered in the stress test to determine whether they are designed to withstand such a heavy rain event and if appropriate measures may have to be taken. In this regard, it also has to be taken into account whether there are rainwater drainage pipes within buildings through which rainwater may enter the building.

Furthermore, the ESK refers to the revised version of nuclear safety standard KTA 2201.1 as amended in November 2011. To what extent this will result in changes to the boundary conditions of the seismic design for the facilities considered is currently not known and would have to be examined in the corresponding procedures.

10 Documents

[1] BMU-Beratungsauftrag (Az.: RS III 3 – 17 005/0) vom 22.06.2011, betr. Sicherheitsüberprüfung von Einrichtungen zur Entsorgung radioaktiver Abfälle und bestrahlter Brennelemente, Wärme entwickelnder und anderer Arten radioaktiver Abfälle

[2] BMU-Beratungsauftrag (Az.: RS III 3 – 17 005/0) vom 18.07.2011, betr. Sicherheitsüberprüfung von Einrichtungen zur Entsorgung radioaktiver Abfälle und bestrahlter Brennelemente, Wärme entwickelnder und anderer Arten radioaktiver Abfälle

[3] Frageliste der ESK für den Stresstest für die Anlagenkategorien 1, 3 und 6
29.05.2012, versandt an die atomrechtlichen Genehmigungs- und Aufsichtsbehörden der Länder mit BMU-Schreiben RS III 3 – 17005/0 vom 30.05.2012

[4] Schreiben des Ministeriums für Wirtschaft, Energie, Industrie, Mittelstand und Handwerk des Landes Nordrhein-Westfalen (Az.: VB2, VB3 – 8944(A) – 1.1.1.3) vom 15.08.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, betr.: Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung, Fragenliste der Entsorgungskommission vom 29.05.2012, Betreiberantworten für die Urananreicherungsanlage Gronau, das Transportbehälterlager Ahaus und das AVR-Behälterlager Jülich

mit sechs Anlagen

1 Urananreicherungsanlage Gronau
Betreiberantworten zur Fragenliste der Entsorgungskommission
Anmerkungen des MWEIMH-NRW zum Urenco-Dokument U/5187/12/BKr/KSr

2 Urenco
Verhalten der Urananreicherungsanlage Gronau bei auslegungsüberschreitenden Belastungen (Stresstest UAG)
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Beantwortung der Fragenliste der Entsorgungskommission vom 29. Mai 2012
09.08.2012

3 Transportbehälter Ahaus
Betreiberantworten zur Fragenliste der Entsorgungskommission
Anmerkungen des MWEIMH-NRW zum GNS-Dokument vom 31.07.2012

4 GNS
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
GNS B 098/2012
Transportbehälter Ahaus (TBL-A)

5 AVR Jülich
Stresstest von Anlagen und Einrichtungen der Ver- und Entsorgung
Beantwortung der Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
AVR-Behälterlager
30. Juli 2012

6 AVR-Behälterlager Jülich
Betreiberantworten zur Fragenliste der Entsorgungskommission
Anmerkungen des MWEIMH-NRW zum FZJ-Dokument vom 30.07.2012

[5] E-Mail des Ministeriums für Wirtschaft, Energie, Industrie, Mittelstand und Handwerk des Landes Nordrhein-Westfalen an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit vom 30.11.2012, Betreff: AW: AG SÜ: offene Punkte zur UAG

mit der Anlage

1 Schreiben der URENCO Deutschland GmbH (Az.: UGN/5379/12/CUt) vom 22.11.2012 an das Ministerium für Wirtschaft, Energie, Bauen, Wohnen und Verkehr des Landes NRW, betr.: Urananreicherungsanlage Gronau (UAG); Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderen Arten radioaktiver Abfälle sowie Anlagen der Versorgung

[6] Schreiben des Niedersächsischen Ministeriums für Umwelt, Energie und Klimaschutz (Az.: 41 – 01374) vom 10.09.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung, Fragenliste der ESK vom 29.05.2012 – Anlagenkategorien 3 und 6
mit sieben Anlagen

1 Anlage 1 zum Schreiben vom 10.09.2012: Sicherheitsüberprüfung von Anlagen und Einrichtungen der Entsorgung – ESK-Kategorie 3 und 6 – Schreiben der ESK vom 29.05.2012

Beitrag Niedersachsen (Stand: 10.09.2012)

2 Schreiben des Niedersächsischen Ministeriums für Umwelt, Energie und Klimaschutz (Az.: 41-02040/01/01) vom 31.07.2012 an das Bundesamt für Strahlenschutz (BfS), betr.: TBL Gorleben – Überflugbeschränkung

3 GNS
Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme der Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
GNS B 100/2012
Pilot-Konditionierungsanlage Gorleben (PKA)
06.08.2012

4 GNS
Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme der Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
GNS B 099/2012
Transportbehälterlager Gorleben (TBL-G)
06.08.2012

5 E.ON Kernkraft GmbH
Standort-Zwischenlager Rodenkirchen
Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
03.08.2012

6 Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
Standortzwischenlager Lingen
31.07.2012

7 E.ON Kernkraft GmbH
Standort-Zwischenlager Grohnde
Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
03.08.2012

[7] Schreiben des Niedersächsischen Ministeriums für Umwelt, Energie und Klimaschutz (Az.: 41 – 01374) vom 16.08.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung, Fragenliste der ESK vom 29.05.2012 – Anlagenkategorien 3 und 6

mit einer Anlage

1 Advanced Nuclear Fuels GmbH
ANFG-5.063 (138) Rev. 000, 31.07.2012
Sicherheitsüberprüfung
Frageliste der Entsorgungskommission vom 29.05.2012

[8] E-Mail des Niedersächsischen Ministeriums für Umwelt, Energie und Klimaschutz an die RSK/ESK-Geschäftsstelle vom 07.12.2012
Betr.: Prozeduren zur Überprüfung des sicheren Zustands (nach fail-safe) nach Ausfall der Stromversorgung

[9] Schreiben des Ministeriums für Inneres und Sport Mecklenburg-Vorpommern (Az.: II 250–416–10000–2011/120-002) vom 07.09.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung, Fragenliste der ESK vom 29.05.2012 – Anlagenkategorien 3 und 6
mit drei Anlagen

1 Schreiben der EWN GmbH vom 30.07.2012 (Az.: p1gg-sch-we-120730-01)

2 Schreiben der TÜV NORD SysTec GmbH & Co. KG vom 20.08.2012 (Aktenzeichen: ZLN2012/0338)

3 Schreiben der TÜV NORD EnSys Hannover GmbH & Co. KG vom 05.09.2012 (ZLN-TNS.01.1)

[10] Schreiben des Ministeriums für Inneres und Sport Mecklenburg-Vorpommern (Az.: II 250–416–10000–2011/120-002) vom 17.08.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: ESK-Stresstest für das Transportbehälterlager (TBL) des Zwischenlagers Nord (ZLN), Terminverschiebung bis Ende September 2012

[11] Schreiben des Hessischen Ministeriums für Umwelt, Energie, Landwirtschaft und Verbraucherschutz (Az.: IV6a-99.0.4.4.4) vom 27.08.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung

mit zwei Anlagen

1 RWE-Schreiben an das Hessische Ministerium für Umwelt, Energie, Landwirtschaft und Verbraucherschutz vom 10.08.2012, betr. Kraftwerk Biblis, Brennelemente-Zwischenlager (SZL)

2 RWE Power AT, Kraftwerk Biblis
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Frageliste der Entsorgungskommission (ESK) vom 29. Mai 2012
Kraftwerk Biblis, Standort-Zwischenlager (SZL)
10.08.2012

[12] E-Mail des Ministeriums für Umwelt, Klima und Energiewirtschaft Baden-Württemberg an die RSK/ESK-Geschäftsstelle vom 01.02.2013, betr.: Eindampfen der restlichen Spüllösungen in den Behältern der VEK

[13] Schreiben des Ministeriums für Umwelt, Klima und Energiewirtschaft Baden-Württemberg vom 31.08.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: ESK-Stresstest für Anlagen und Einrichtungen der Ver- und Entsorgung

mit drei Anlagen

1 EnBW Kernkraft GmbH
Kernkraftwerk Philippsburg
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Frageliste der Entsorgungskommission (ESK) vom 29. Mai 2012 für das Standortzwischenlager Philippsburg der EnBW Kernkraft GmbH
30.08.2012

2 EnBW Kernkraft GmbH
Kernkraftwerk Neckarwestheim
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Frageliste der Entsorgungskommission (ESK) vom 29. Mai 2012 für das Standortzwischenlager Neckarwestheim der EnBW Kernkraft GmbH
30.08.2012

3 WAK Rückbau- und Entsorgungs-GmbH
Stresstest
WAK-Anlagenbereiche und VEK
Verhalten bei auslegungsüberschreitenden Ereignissen
Stellungnahme zum Fragenkatalog der Entsorgungskommission (ESK) vom 12.06.2012
29.08.2012

[14] Schreiben des Ministeriums für Umwelt, Klima und Energiewirtschaft Baden-Württemberg (Az.: 3-4643.00) vom 13.11.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: ESK-Stresstest für WAK/VEK

mit zwei Anlagen

1 TÜV SÜD Energietechnik GmbH
Stellungnahme WAK vom 07.11.2012
ESK-Sicherheitsüberprüfung für Anlagen der Entsorgung
Auswirkungen auslegungsüberschreitender äußerer Einwirkungen
WAK-Schreiben PIP-SS-PSin-12-0801 vom 10.10.2012 /1/
07.11.2012

2 WAK
ESK-Überprüfung WAK/VEK
Stresstest HWL – LAVA, Störfallbetrachtung
10.10.2012

[15] E-Mail des Ministeriums für Umwelt, Klima und Energiewirtschaft Baden-Württemberg an die RSK/ESK-Geschäftsstelle vom 18.12.2012
Betr.: AG SÜ (GKN)

[16] Schreiben des Ministeriums für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein (Az.: V 711) an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: ESK-Stresstest für Anlagen und Einrichtungen der Ver- und Entsorgung
Fristverlängerung

[17] Schreiben des Ministeriums für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein (Az.: V 711) vom 16.10.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: ESK-Stresstest für Anlagen und Einrichtungen der Ver- und Entsorgungen

mit vier Anlagen

1 E.ON Kernkraft GmbH
Standort-Zwischenlager Brokdorf
Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Frageliste der Entsorgungskommission (ESK) vom 29. Mai 2012
Stand: 07.08.2012

2 Standort-Zwischenlager Brunsbüttel
Bericht 2012-0011, Technischer Bericht
Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Frageliste der Entsorgungskommission (ESK) vom 29. Mai 2012
Stand: 30.07.2012

3 Standort-Zwischenlager Krümmel
Arbeits-Bericht
Sicherheitsüberprüfung von Anlagen und Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Frageliste der Entsorgungskommission (ESK) vom 29. Mai 2012
Stand: 17.07.2012

4 HAKONA (Geb. 44) und Otto-Hahn-RDB-Schacht

[18] Schreiben des Bayerischen Staatsministeriums für Umwelt und Gesundheit (Az.: 95g-U8811.00-2012/11-12) vom 06.09.2012 an das Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), betr.: Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung – Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012

mit drei Anlagen

1 E.ON Kernkraft GmbH
Standort-Zwischenlager Niederaichbach
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
08.08.2012

2 E.ON Kernkraft GmbH
Standort-Zwischenlager Grafenrheinfeld
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
06.08.2012

3 KRB-II Gundremmingen
Standort-Zwischenlager Niederaichbach
Sicherheitsüberprüfung von Einrichtungen zur Entsorgung bestrahlter Brennelemente, Wärme entwickelnder radioaktiver Abfälle und anderer Arten radioaktiver Abfälle sowie Anlagen der Versorgung
Stellungnahme zur Fragenliste der Entsorgungskommission (ESK) vom 29. Mai 2012
25.07.2012

[19] RSK-Stellungnahme
447. Sitzung der Reaktor-Sicherheitskommission am 03.05.2012
Anlagenspezifische Sicherheitsüberprüfung (RSK-SÜ) deutscher Forschungsreaktoren unter Berücksichtigung der Ereignisse in Fukushima-I (Japan)

[20] RSK-Empfehlung
450. Sitzung der Reaktor-Sicherheitskommission am 26./27.09.2012
Empfehlungen der RSK zur Robustheit der deutschen Kernkraftwerke

[21] RS III3, Sicherheitsanforderungen für Kernbrennstoffversorgungsanlagen,
Teil 1: Sicherheitsanforderungen für Urananreicherungsanlagen nach dem Gasultrazentrifugen-Prinzip, Juni 2004

[22] Empfehlung der Entsorgungskommission
Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnder radioaktiver Abfälle in Behältern
Revidierte Fassung vom 29.11.2012
Anlage zum Ergebnisprotokoll der 30. Sitzung der Entsorgungskommission am 29.11.2012

[23] Weiterleitungsnachricht zu Ereignissen in Kernkraftwerken der Bundesrepublik Deutschland (WLN 2012/03)
Regenwassereintrag in das Kernkraftwerk Brunsbüttel am 04.09.2011
GRS, Köln, 26.04.2012

[24] Strahlenschutzkommission: Rahmenempfehlungen für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen, Stand 21.09.2008