

Note:

This is a translation of the document entitled “Anlagenspezifische Sicherheitsüberprüfung deutscher Kernkraftwerke unter Berücksichtigung der Ereignisse in Fukushima-I (Japan)”.

In case of discrepancies between the English translation and the German original, the original shall prevail.

Plant-specific safety review of German nuclear power plants in the light of the events in Fukushima-1 (Japan)

On 17-03-2011, the German Bundestag called upon the German Federal Government to

...

conduct a comprehensive review of the safety requirements for the German nuclear power plants. For this purpose, an independent expert commission is to be tasked with carrying out a new risk analysis of all German nuclear power plants and nuclear installations with consideration of the knowledge available about the events in Japan – especially also with respect to the safety of the cooling systems and the external infrastructure – as well as of other extraordinary damage scenarios;¹

...

On 17-03-2011, the Federal Environment Ministry called upon the Reactor Safety Commission at its 433th meeting to draft a catalogue of requirements for a safety review of the German nuclear power plants and to assess the results of the review carried out on this basis. Here, the insights gained from the accident sequence in Japan are to be considered in particular with respect to whether the current design limits have been defined correctly and how robust the German nuclear power plants are regarding beyond-design-basis events.

At its 433th meeting, the Reactor Safety Commission derived the following provisional insights from the accident in Japan for operating plants as well as for plants in refuelling and overall maintenance inspection outage:

- The consequences of natural events were obviously underestimated in the design.
- The plants shut down automatically despite the extraordinarily strong earthquake; emergency power supply and safety-relevant cooling water supplies (auxiliary service water supply) were initially available.
- As a result of the impact of the tsunami approx. one hour after the earthquake, the emergency power supply - with the exception of the batteries - as well as the auxiliary service water supply failed.
- Several hydrogen explosions destroyed structures with barrier functions as well as further safety installations and contributed to an aggravation of the accident sequence.
- A long-term complete loss of power and auxiliary service water supply had apparently neither been considered in the plant design nor in the planning of accident management measures.

¹ 96th sitting of the German Bundestag on 17-03-2011; motion for a resolution of the CDU/CSU and FDP fractions on the issue of a government policy statement by the Federal Chancellor on the current situation in Japan, printed paper 17/5048

- As regards the organisation and effectiveness of accident management measures, the destruction of the infrastructure had not been adequately taken into account.

As information is still incomplete so far, it can be assumed that further and more specific insights will be added as analyses of the accident sequence proceed.

To this date, the Reactor Safety Commission has derived the following review needs for the German nuclear power plants:

- Examination of to what extent the general safety objectives of "reactivity control", "cooling of fuel assemblies in the reactor pressure vessel as well as in the fuel pool" and "limitation of the release of radioactive substances (keeping up barrier integrity)" are fulfilled in the event of impacts beyond the design requirements applied so far. For this purpose, the robustness (available design margins, diversity, redundancy, structural protection, physical separation) of the safety-relevant systems, structures and components and the effectiveness of the defence-in-depth concept have to be assessed. If this review reveals any insights that design requirements should be modified, the RSK will formulate the corresponding requirements. A generic review of design requirements has to be carried out in a later phase.
- Examination of to what extent the functions for fulfilling the safety objectives remain available for assumptions going beyond the scenarios postulated so far. In this context, postulates regarding the non-availability of safety and emergency systems have to be considered, like e.g. the longer-term loss of power supply incl. the emergency power supply, or the non-availability of the auxiliary service water supply.
- Review of the necessary scope of accident management measures and their effectiveness. Here, the extent and the quality of preliminary planning for postulated event sequences, such as the non-availability of the cooling chain for cooling of the fuel assemblies in the reactor core as well as in the fuel pool, the non-availability of electricity supply, and any massive fuel assembly damage that may occur up to core meltdown, have to be assessed. Furthermore, a substantial destruction of the infrastructure and inaccessibility due to high local dose rates as well as the availability of personnel also have to be assessed.

One focus of the review regarding the robustness of all installations and measures is on the identification of an abruptly occurring aggravation in the event sequence (cliff edges) and, if necessary, on the derivation of measures for its avoidance (example: exhaustion of the capacity of the batteries in the event of a station blackout).

According to present knowledge, the scope of the review has to include the following:

- Natural events such as earthquakes, flooding, weather-related consequences as well as possible simultaneous occurrences.
- Postulates that are independent of concrete event sequences, such as failures affecting several redundant system trains, (common-cause failures, systematic failures), station blackout for longer than two hours, long-lasting loss of auxiliary service water supply.

- Aggravating boundary conditions for the performance of emergency measures, such as non-availability of electricity supply, hydrogen formation and explosion risk, restricted availability of personnel, inaccessibility due to high radiation levels, aggravation of external technical support.

Furthermore, due to further-reaching aspects, man-induced events such as e.g. aircraft crash, blast pressure wave, and deliberate attack on safety-relevant installations are included in the scope of examination.

For each topic to be dealt with, the RSK shall prepare a definition of the task and pose the associated questions.

From the point of view of the RSK, GRS should take the leading role in the review, acting on the instructions of the RSK and involving other expert organisations. The RSK will assess the individual results on the basis of criteria to be defined by itself, show up the safety status of the plants with application of the extended requirements, and recommend measures if necessary. It is intended to carry out the review sequentially over time. According to the order given by the BMU, a first statement has to be submitted by 15 May 2011.

Note:

This is a translation of the document entitled “Anforderungskatalog für anlagenbezogene Überprüfungen deutscher Kernkraftwerke unter Berücksichtigung der Ereignisse in Fukushima-I (Japan)”.

In case of discrepancies between the English translation and the German original, the original shall prevail.

Catalogue of requirements for plant-specific reviews of German nuclear power plants in the light of the events in Fukushima-I (Japan)

- The following catalogue of requirements, listed in keywords, for the reviews may be supplemented, in particular in case of changed knowledge about the event sequences and causes in Fukushima-I.
- The catalogue of requirements refers to the entire reactor complex, including the fuel pools, and covers all operating conditions.
- The catalogue of requirements includes a partial overlap by the fact that postulated superimpositions are addressed from two sides (e.g. necessary accident management measures in cases of extreme flood ↔ impact of floods on emergency measures); for the implementation of the reviews, attention is therefore to be paid to appropriate co-ordination.
- When preparing the catalogue of requirements, it has been taken into account, as required according to Criterion 1.1 of the Federal Ministry of the Interior (BMI), that measures and installations have to be available
 - to avoid incidents and failures (“first and overriding principle”), and
 - to control accidents (“second principle”).

With regard to the defence-in-depth concept applicable in the field of nuclear technology it would not be effective to limit the considerations only to accident management measures that may have to be supplemented.

Review topics

Natural hazards such as earthquakes, floods, weather-related consequences and possible overlaps

- Topic “earthquakes”
 - Review of the boundary conditions for the site-specific determination of the design earthquake
 - Review of the design on the basis of the design earthquake, stating the reserves
 - Review with regard to the maintenance of vital functions in case of increased earthquake impact

- Review of secondary damages with regard to the event sequence, including aftershocks: e.g. rise or fall of river level, fire, loss of coolant, flooding, destruction of infrastructure, impairment of staff availability, dynamic loads due to building failure, H₂ explosion (e.g. generator)
- Topic “floods”
 - Review of the boundary conditions for the site-specific determination of the design flood
 - Review of the design and precautionary measures on the basis of the design flood, stating the reserves
 - Review with regard to the maintenance of vital functions in case of a beyond design basis flood, e.g. by failure of dams/barrages or major flood protection measures, long-lasting flood, extreme storm surge, tsunami, effects of flotsam, taking into account the destruction of infrastructure and impairment of staff availability
 - Review of the impacts on accident management measures in case of beyond design basis water level (maybe after short advance warning time)

Topic “other natural hazards (including climatic influences)”:

Review of the maintenance of vital functions in case of storm, tornado, wind loads, snow loads, high and low temperatures, drought, heavy rain, lightning, landslides, etc., and their superposition, as far as beyond the design basis

Man-made hazards

- Topic “aircraft crash”

Review of the maintenance of vital functions in case of commercial aircraft or military aircraft crash (accidental, deliberate) under consideration of the following:

 - Crash scenarios (aircraft type, speed, loading, impact location, etc.)
 - Structural reserves in case of loads caused by aircraft impact
 - Mechanical impacts including impact of wreckage
 - Fuel fire effects
 - Effectiveness of spatial separation
 - Leak as consequential event (induced vibrations)
 - Possibility and effectiveness of accident management measures under consideration of impacts on infrastructure and personnel

- Topic “gas release”
Review of the boundary conditions for the determination of the site-specific impacts caused by toxic and explosive gases and blast wave

- Topic “impact of an accident in a power plant unit on the neighbouring unit”
Review of the impact of a beyond design basis event in a power plant unit on the neighbouring unit

- Topic “terrorist attacks”
Review of the maintenance of the vital functions or accident management measures in case of
 - Loss of individual infrastructures or buildings (parts thereof)
 - Selective local destruction of systems

- Topic “external attacks on computer-based controls and systems”
Review of the maintenance of the vital functions in case of external attacks on computer-based controls and systems

Extended postulates independent of specific event sequences

- Topic “station blackout” (SBO)
Review of the maintenance of the vital functions in case of station blackout for more than two hours with regard to
 - Plant behaviour
 - Battery capacity
 - Provision and effectiveness of accident management measures

- Topic “long-lasting loss of offsite power”
Review of the maintenance of the vital functions in case of a long-lasting loss of offsite power for more than 72 hours with regard to
 - Diesel supply (fuel, oil, cooling water)

- Repair or replacement of diesel engines by alternative emergency power supply (gas turbine, hydroelectric power plant)
- Replacing diesel by diverse network connection
- Topic “loss of service water supply”
Review of the maintenance of the vital functions in case of loss of the redundant service water supply with regard to
 - Diversified cooling facilities (e.g. well cooling)
 - Options for accident management measures (technical/administrative)

Robustness of precautionary measures

- Topic “effectiveness of special preventive measures”
Review of the robustness of the precautionary measures e.g. with regard to the following:
 - Assessment of plant-specifically realised redundancy separation and structural protection measures
 - Cross-redundancy impact of internal hazards, such as fire, flooding in the reactor building, inadvertent opening of valves
 - Ensuring the supply of cooling water in case of natural impacts, such as jellyfish, shells, flotsam and man-made hazards (e.g. ship accidents)

Unfavourable boundary conditions for the implementation of accident management measures

- Topic “accident management measures”
Review of accident management measures with regard to their completeness and effectiveness in case of loss of fuel cooling possibilities
 - before occurrence of fuel damage
 - in the reactor pressure vessel
 - in the fuel pool
 - after occurrence of fuel damage
 - in the reactor pressure vessel
 - in the fuel pool
 - after containment failure
 - after failure of the reactor pressure vessel
 - core melt in the reactor cavity (PWR)

- core melt in the control rod drive chamber or lining chamber (BWR)
- fuel element melt in the fuel pool

For the review of the above three issues, statements are to be made, in particular,

- on the suitability and availability of the required instrumentation,
- on possible H₂ reactions (radiolysis + zircon reactions + melt/concrete interaction)
- on potential H₂ accumulations in the containment and surrounding buildings,
- on the prevention of, e.g., H₂ deflagration or H₂ detonation (inertisation, recombiner concept), also taking into account venting processes, and
- on the prevention of recriticality.

The description of the accident management measures or procedures provided has to include the following aspects:

- Organisation
- Use of existing facilities
- Provision of mobile devices
- Supplies
- Communication and information systems (internal, external)
- Feasibility of accident management measures taking into account the following:
 - Extensive destruction of infrastructure including the communication facilities (making technical and personnel support from outside more difficult)
 - Feasibility and effectiveness of accident management measures under the boundary conditions of external hazards (earthquakes, floods, aircraft crash)
 - Activity release at the site
 - Inaccessibility and impairment of work performance due to high local dose rates or debris formation
 - Unavailability of power supply
 - Potential failure of instrumentation
 - Failure of instrumentation
 - Evacuation of the plant with staffing of the emergency control room and another room (ensuring communications, task planning and co-ordination, incident measurement programme)