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The new German Safety Criteria for Nuclear Power Plants in the view of international standards

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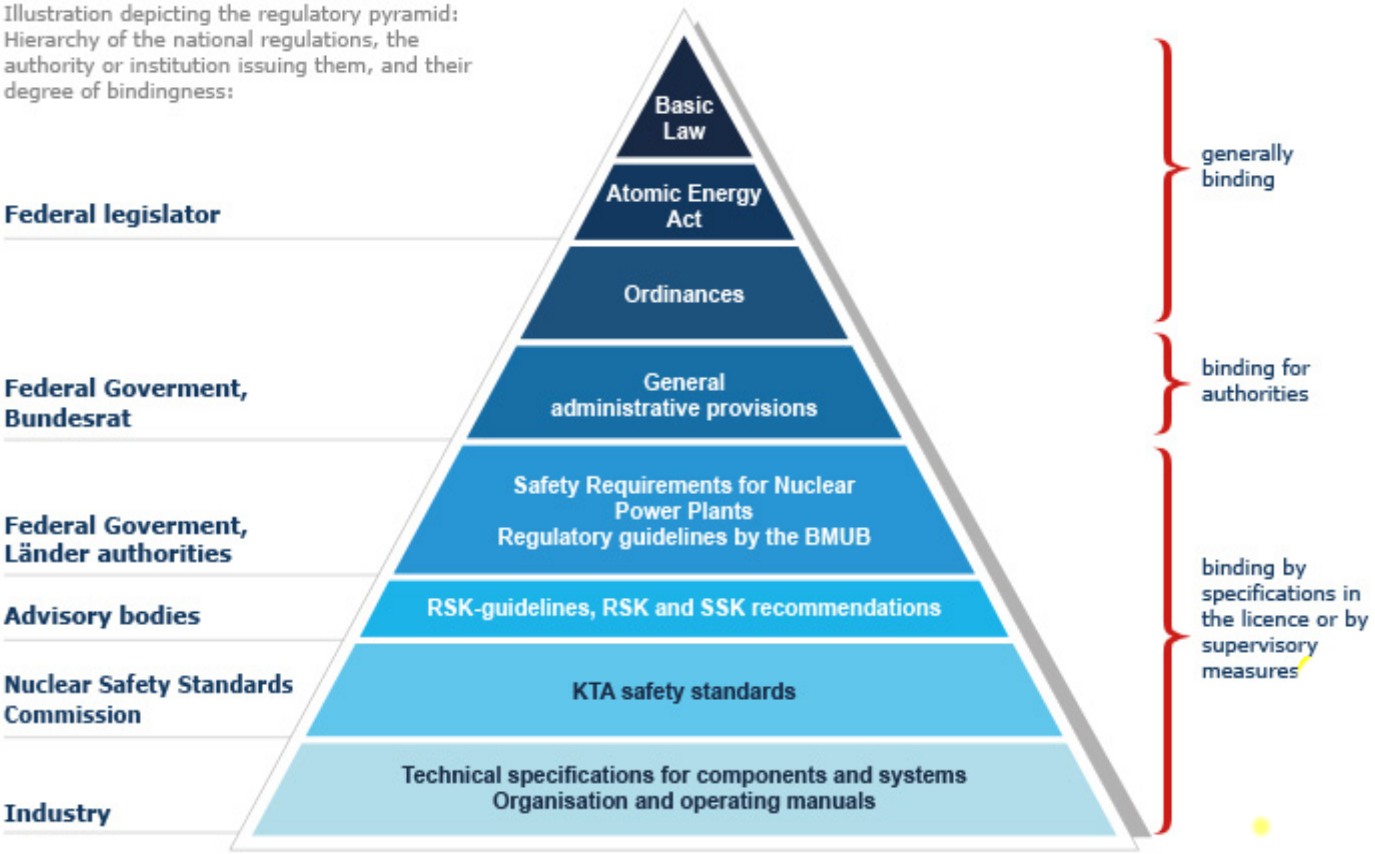

Major information sources for elaboration of the new “Safety Requirements for Nuclear Power Plants” (1)

- Previous German requirements and regulations
  - safety criteria for NPPs (of 1977)
  - incident guidelines (of 1983)
  - fundamentals for safety management systems in NPPs (of 2004)
- RSK requirements
  - guidelines for pressurized water reactors (of 1981 with updates of 1996)
  - statements and recommendations
- Safety Standards of the IAEA
- Recommendations of INSAG
- Lessons learned from the Fukushima accident

Major information sources for elaboration of the new “Safety Requirements for Nuclear Power Plants” (2)

- WENRA recommendations for harmonised safety requirements in Europe
  - WENRA reference levels
  - WENRA safety objectives for new build
- „Good Practices“ from other countries
- Insights gained from national licensing and supervision practice
- Insights gained from national and international operating experience

Process of participation and discussion (1)

- The “Safety Requirements for Nuclear Power Plants” were subject to a comprehensive discussion and participation process with the involvement of:
  - the Reactor Safety Commission (RSK)
  - the Commission on Radiological Protection (SSK)
  - the supervisory and licensing authorities of the *Länder*,
  - the technical inspection organisations (TÜVe),
  - vendors and operators of nuclear power plants.

Process of participation and discussion (2)

- Focal points of the comments during this process were, among others:
  - application of safety requirements to older nuclear power plants,
  - the role of the PSA in safety assessments,
  - requirements on the beyond design basis area,
  - requirements on digital I&C
  - the technical realisation of the defence-in-depth concept, in particular with regard to the independence of the individual levels-of-defence.

Structure of the “Safety Requirements for NPPs”

- One main document “Safety Requirements for NPPs” (comprises the general requirements for design and operation) (*)
  - comparable to the level of detail of IAEA Safety Requirements (general and specific SRs)
  - comparable to WENRA reference levels
- 5 annexes
  - “Postulated initiating events”,
  - “Internal and external hazards”,
  - “Single-failure concept”,
  - “Safety demonstration and documentation”
  - “Definitions”
- Specific safety-related issues are described in 8 interpretations (**)

(*) http://www.bmub.bund.de/en/topics/nuclear-safety-radiological-protection/nuclear-safety/legal-provisions-technical-rules/safety-requirements-for-npp/

(**) http://www.verwaltungsvorschriften-im-internet.de/bsvwvbund_29112013_RSI5130301.htm

Interpretations of specific safety-related issues

- 8 Interpretations
  - contain important specific requirements
  - can be considered as comparable in detail to the level of IAEA Safety Guides
- Interpretations are related to Requirements for
  - I-1 Design and Operation of the Reactor Core
  - I-2 Design of the Reactor Coolant Pressure Boundary, the Pressure Retaining Walls of the External Systems and the Containment System
  - I-3 Instrumentation and Control and Accident Instrumentation
  - I-4 Electric Power Supply
  - I-5 Design and Safe Operation of Plant Structures, Systems and Components
  - I-6 Handling and Storage of the Fuel Elements
  - I-7 Accident Management
  - I-8 Radiation Protection

Significant applied safety objectives (1)

- The safety concept is aimed at prevention.
- Safety requirements concerning levels 1 and 2 of the defence-in-depth are directed at
  - reducing the potential for escalation to accident situations by enhancing plant capability
    - to stay within normal operation,
    - to control abnormal events.

Significant applied safety objectives (2)

- On levels 3, 4a and 4b (*) of the defence-in-depth (accidents without core meltdown) the following requirements are to be applied:
  - ensuring that accidents induce no off-site radiological impact or may have only minor radiological impact.
  - reducing, as far as reasonably achievable,
    - the core damage frequency, taking into account all types of hazards and failures and combinations of events;
    - the release of radioactive material from all sources.
  - considering the impact of all external hazards (**).

(*) Level 4 is subdivided into

- 4a: very rare events (ATWS)
- 4b: events involving the multiple failure of safety equipment
- 4c: accidents involving severe fuel assembly damage

(**) external hazards

- ambient conditions, natural events
- very rare human-induced external hazards

Significant applied safety objectives (3)

- On level 4 (4c) of the defence-in-depth (accident with core meltdown) the following requirements are to be applied
  - reducing potential radioactive releases to the environment from such accidents, also in the long term, by following the qualitative criteria below:
    - accidents with core meltdown which would lead to early or large releases requiring measures of external accident management have to be practically eliminated (*);
    - for accidents with core meltdown that have not been practically eliminated measures have to be taken so that only limited protective measures in area and time are needed for the public (no permanent relocation, no need for emergency evacuation outside the immediate vicinity of the plant, …..) and that sufficient time is available to implement these measures.

(*) The occurrence of an accident or accident sequence can be considered as practically eliminated if it is physically impossible to occur or if it can be considered with a high degree of confidence to be extremely unlikely to arise.

Significant applied safety objectives (4)

- Defence-in-depth assumes that the measures considered on the first three levels have to ensure the structural integrity of the core and to limit the release of radiactive material.

- Accident management may not be used to excuse design deficiencies on lower levels.

Significant applied safety objectives (5)

- Independence between all levels of defence-in-depth
  - Enhancing the effectiveness of the independence between all levels of defence-in-depth, in particular through diversity provisions (in addition to the strengthening of each of these levels separately) to provide, as far as reasonably achievable, an overall reinforcement of defence-in-depth.
- Ensuring effective management of safety
  - Installation of an “Integrated Management System (IMS)”
  - Enhancing the
    - responsibility of the company management
    - responsibility of the plant management

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Selection of applied IAEA Safety Standards – “Safety Requirements for NPPs”

Safety Requirements for NPPs with annexes	IAEA Safety Standards	
Design of NPP	SSR-2/1	Design Specific Safety Requirements
Commissioning and Operation	SSR-2/2	Commissioning and Operation Specific Safety Requirements
Internal and external hazards	NS-R-3	Site Evaluation for Nuclear Installations
	NS-G-1.5	External Events Excluding Earthquakes in the Design
	NS-G-1.6	Seismic Design and Qualification
	NS-G-1.11	Protection against Internal Hazards other than Fires and Explosions in the Design
	NS-G-2.1	Fire Safety in the Operation of NPP
	NS-G-2.13	Evaluation of Seismic Safety for Existing Nuclear Installations
	NS-G-3.1	External Human Induced Events in Site Evaluation
Management System	GS-R-3	The Management System for Facilities and Activities Safety Requirements
Safety Assessment	GSR (Part 4)	Safety Assessment for Facilities and Activities General Safety Requirements Part 4

Selection of applied IAEA Safety Standards – Interpretations

Interpretations		IAEA Safety Standards	
I-1	Reactor Core	NS-G-1.12	Design of Reactor Core
I-2	Reactor Coolant Pressure Boundary	NS-G-1.9 NS-G-1.10	Design of RCS and Associated Systems Design of Reactor Containment Systems
I-3	Instrumentation and Control	NS-G-1.3 NS-G-1.1	I & C systems important to safety SW for computer based systems important to safety
I-4	Electric Power Supply	NS-G-1.8	Design of Emergency Power Systems
I-5	Design and Safe Operation of SSCs	NS-G-1.9 NS-G-2.12 NS-G-2.14	Design of RCS and Associated Systems Ageing Management Conduct of Operations
I-6	Handling and Storage of Fuel Elements	NS-G-1.4	Design of Fuel Handling and Storage Systems
I-7	Accident Management	NS-G-2.15	Severe Accident Management Programmes
I-8	Radiation Protection	NS-G-1.13	Radiation Protection Aspects of Design

Essential additions to the „Safety Requirements for NPPs“ compared with the previous nuclear regulations (1)

- Fundamental (radiological) safety objective for new build now also applies to existing plants:
  - Large or early releases shall be excluded or their radiological consequences limited such that emergency preparedness measures will only be necessary to a limited extent within a certain area and for a certain period of time.

The occurrence of an event or event sequence can be considered as (practically) excluded if it is physically impossible to occur or if it can be considered with a high degree of confidence to be extremely unlikely to arise.

- For new build: safety objective is the design target.
- For existing plants: practical exclusion shall be demonstrated by the interaction of plant operation, high reliability of the safety system and comprehensive accident management.

Essential additions to the „Safety Requirements for NPPs“ compared with the previous nuclear regulations (2)

- Allocation of safety requirements to all four levels of defence of the defence-in-depth concept, especially
  - consistent integration of the beyond-design-basis area (Level 4) in the safety concept with the aim to control
    - events with (postulated) multiple failure of safety equipment,
    - phenomena resulting from accidents involving severe fuel damage (reactor core, spent fuel pool).
- The levels of defence are characterised by events and plant states of power operation and low-power and shutdown states as well as by equipment for their control.
- Fundamentally independent effectiveness of the equipment on the different levels of defence.

Essential additions to the „Safety Requirements for NPPs“ compared with the previous nuclear regulations (3)

- As a principle for the planning of accident management:
  - long-term re-establishment of all safety objectives in the preventive area
    - esp. guarantee of long-lasting and reliable heat removal and electricity supply.
  - exclusion of core meltdown under high pressure.
  - guarantee of containment integrity under core meltdown conditions.
  - recommendations for severe accident management guidance (SAMG) in case that „everything gets out of hand“.
- Adequate consideration of internal and external hazards in the planning of accident management.
- Accident management must not impair the effectiveness and reliability of the safety equipment (absence of feedback effects).

Essential additions to the „Safety Requirements for NPPs“ compared with the previous nuclear regulations (4)

- Joining together of safety requirements for the protection against internal and external hazards as well as against human-induced external hazards in one „protection concept“.
- Fundamental requirements for the protection concept:
  - safety system as well as emergency equipment must remain effective.
  - failure of equipment not included in the safety design must not have any impermissible effects on the safety equipment needed for controlling the hazards.
- Specific requirements:
  - internal hazards: redundancy-wide loss shall be prevented.
  - external hazards: all safety equipment shall be designed against the loads resulting from an external hazard.
  - human-induced external hazards:
    - at least one redundant system train of the equipment needed shall be maintained.
    - self-reliance of the safety functions shall be ensured for at least 10 hours; for the subsequent control of the event including shutdown, sufficient water supply options shall be provided.
    - no adverse safety-related effects on the safety system.

Essential additions to the „Safety Requirements for NPPs“ compared with the previous nuclear regulations (5)

- Strategy against the common-cause failure of safety equipment :
  - Provisions to ensure that a multiple failure of safety equipment on level of defence 3 need not be assumed.
  - For redundant safety equipment where possible common-cause failures have been identified, diverse safety equipment shall also be provided as far as technically feasible.
  - The diverse system shall be assigned to the same safety class as the safety equipment itself.

Essential additions to the „Safety Requirements for NPPs“ compared with the previous nuclear regulations (6)

- Comprehensive introduction of requirements for low-power and shutdown operation
  - Listing of events of LP&S including events during refuelling and fuel storage
  - Identification of safety-relevant equipment during LP&S and requirements for their redundancy
- Complete integration of safety requirements for BWRs
- Summary of requirements for the performance of safety assessments
  - To supplement deterministic safety demonstration, probabilistic safety analyses are necessary
  - Set of probabilistic qualitative criteria
- Requirements for a safety-oriented integrated management system (IMS)
  - The IMS shall be regarded as an instrument with the company meets its obligations at all managerial levels to operate the nuclear power plant safely.
  - The IMS is to ensure a process of continual improvement and a learning organisation.

Lessons learned from the Fukushima accident and their consideration in “Safety Requirements for NPPs” (examples)

- Residual-heat removal
  - 3.3(5) Residual-heat removal from the plant shall be ensured in all operating conditions by a diverse heat sink, even in the case of a loss of the primary heat sink due to failure causes in the area of the cooling-water intake and cooling water return.
    The availability of the diverse heat sink shall be ensured even in the case of the postulated natural external hazards.
- Instrumentation and control installations
  - 3.7 (8) The power plant shall be equipped with instrumentation and control installations which in the event of event sequences and plant states of levels of defence 3 and 4 as well as in case of internal or external hazards

    (…)

    – d) will be supplied with electricity for at least 10 hours (even in the case of a failure of the electrical energy supply that is not battery-buffered), (…)

Thank you

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