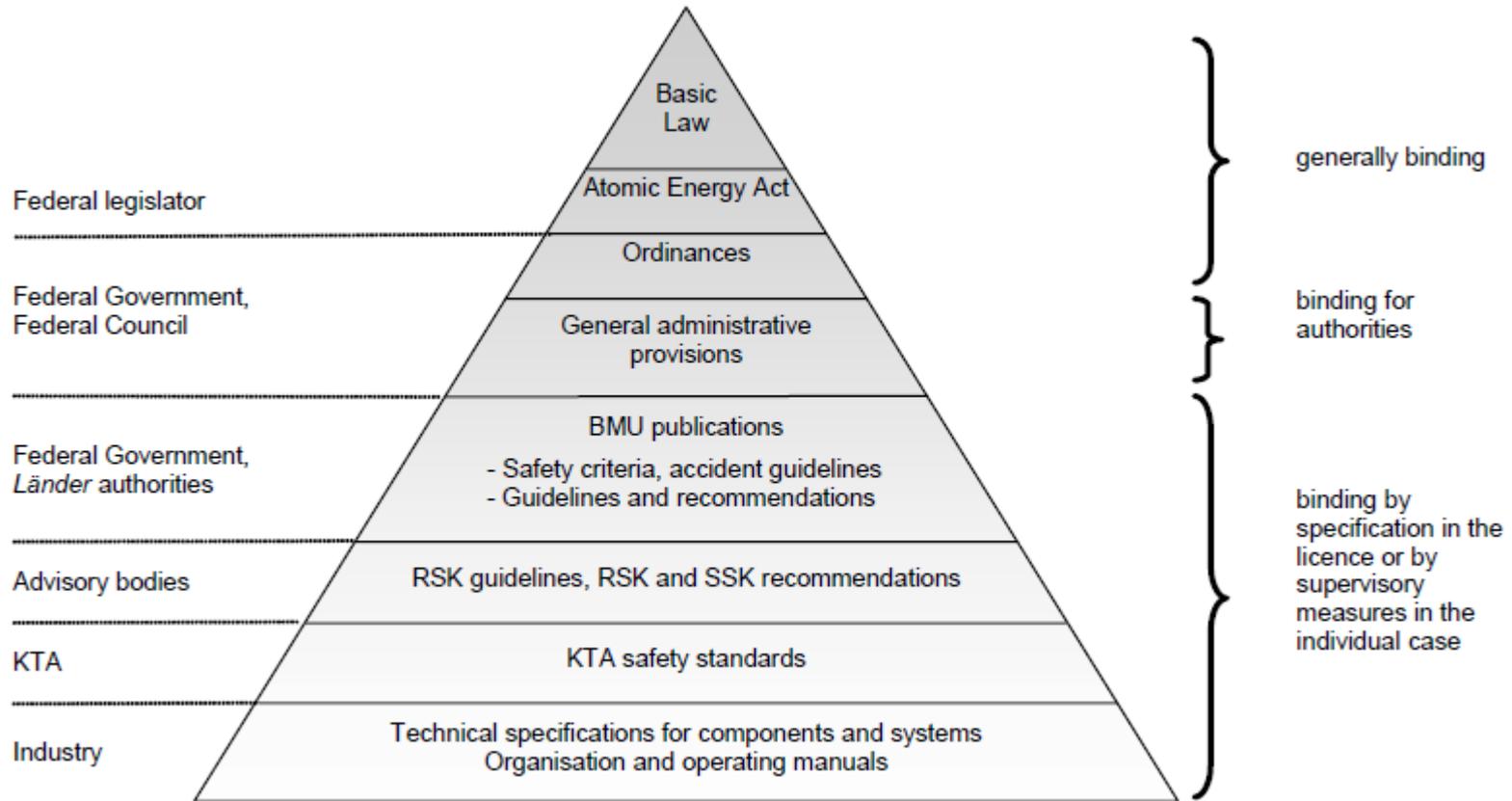


Accident Management before and after Fukushima

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23.10.2015

Nuclear Regulatory Framework in Germany



Development of Defence in Depth

	Level of defence in depth	Objective of the level	Essential means	Associated Plant condition categories
Original design of the plant	Level 1	Prevention of abnormal operation and failure	Conservative design and high quality in construction and operation	Normal operation
	Level 2	Control of abnormal operation and failure	Control, limiting and protection systems and other surveillance features	Anticipated operational occurrences
	Level 3	Control of accident within the design basis	Engineered safety features and accident procedures	Design basis accidents (postulated single initiating events)

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Beyond design situations	Level 4	Control of severe plant conditions that were not explicitly addressed in the original design of currently operating plants owing to their very low probabilities	Complementary measures and accident management	Multiple failures Severe accidents
Emergency planning	Level 5	Mitigation of radiological consequences of significant releases of radioactive materials	Off-site emergency response	-

Regulatory requirements for backfittings

- In principal: protection against damages as required according to the state of the art in science and technology → continuous improvements
- Since 1990s: periodic re-assessment of safety (since 2002 required by Atomic Law)
- In 2010: New paragraph §7d:
 „...die Sicherheitsvorkehrungen verwirklicht werden, die jeweils entwickelt, geeignet und angemessen sind, um zusätzlich ... einen nicht nur geringfügigen Beitrag zur weiteren Vorsorge gegen Risiken für die Allgemeinheit zu leisten

Implementation of accident management measures before Fukushima

- Emergency manual
- Assured containment isolation
- Filtered containment venting
- Supply-air filtering for the control room
- Emergency power supply from neighboring plant (if applicable)
- Increased capacity of batteries
- Restoration of off-site power supply
- Additional off-site power supply (underground cable)
- Sampling system in the containment

Implementation of accident management measures before Fukushima (BWR)

- Independant injection system (in new, robust building, with independent power supply and I&C)
- Additional injection and refilling of the RPV
- Diverse pressure limitation for RPV
- Containment inertisation

Implementation of accident management measures before Fukushima (PWR)

- Secondary-side bleed and feed
- Primary-side bleed and feed
- Catalytic recombiners to limit hydrogen formation (based on severe accident scenarios)

Reactions to Fukushima

- Plant-specific safety review of the reactor safety commission (RSK)
- Expert commissions of states (like in Baden-Württemberg, Bayern)
- Change of the Atomic Law
 - Shut-down of 8 plants
 - Limitation of lifetimes of remaining plants up to 2022
- Information Notice (WLN) of GRS
- Recommendations of RSK
- EU-Stresstest and National Action Plans

Recommendations of RSK

- May 2011: Plant-specific safety review (RSK-SÜ) of German nuclear power plants in the light of the events in Fukushima-1 (Japan)
- April 2012: Loss of the primary ultimate heat sink
- September 2012: Recommendations of the RSK on the robustness of the German nuclear power plants
- April 2013: Minimum value of 0.1g (approx. 1.0 m/s²) for the maximum horizontal ground acceleration in earthquakes
- November 2013: Assessment of the coverage of extreme weather conditions by the existing design
- April 2015: Hydrogen Release from the Containment

National action plan for Germany

- Ensuring DC (up to 10 hours) and AC (after a maximum of 10 hours)
 - Installation of additional emergency power generators and at least two physically separated connection points
- Independant service water supply (independent of the circulating water intake available by design)
- Additional pump with two physically sufficiently separated connection points at different redundancies of protected component cooling system
- Ensuring filtered venting assuming SBO and loss of DC, unfavourable radiological conditions, excluding hydrogen accumulation outside containment, also repeatedly and after natural external design basis hazards

National action plan for Germany

- For BWR: Installation of passive catalytic recombiners at spent fuel pools outside containment
- For PWR: reactor pressure vessel injection with borated water independent of the active emergency cooling system
- Additional permanently installed systems for spent fuel pool cooling
- Implementation of the Severe Accident Management Guidelines (SAMG)
- To ensure the vital safety functions in case of beyond design basis external or internal hazards, a systematic analysis should be conducted
 - For example: Robustness against earthquakes of one level of intensity higher than design basis values by use of earthquake PSA or by means of applicability considerations

Development of Defence in Depth

	Level of defence in depth	Objective of the level	Essential means	Associated plant condition categories	Radiological consequences
Original design of the plant	Level 1	Prevention of abnormal operation and failure	Conservative design and high quality in construction and operation	Normal operation	Regulatory operating limits for discharge
	Level 2	Control of abnormal operation and failure	Control, limiting and protection systems and other surveillance features	Anticipated operational occurrences	Regulatory operating limits for discharge
	Level 3 (1)	Control of accident to limit radiological releases and prevent escalation to core damage conditions (2)	Safety systems Accident procedures	DiD Level 3.a Postulated single initiating events	No off-site radiological impact or only minor radiological impact (see NS-G-1.2/4.102)
		Control of accident to limit radiological releases and prevent escalation to core melt conditions (3)	Engineered safety features (4) Accident procedures	DiD Level 3.b Selected multiples failures events including possible failure or inefficiency of safety systems involved in DiD level 3.a	
	Level 4	Practical elimination of situation that could lead to early or large releases of radioactive materials Control of accidents with core melt to limit off-site releases	Engineered safety features to mitigate core melt Management of accidents with core melt (severe accidents)	Postulated core melt accidents (short and long term)	Limited protective measures in area and time
Emergency planning	Level 5	Mitigation of radiological consequences of significant releases of radioactives materials	Off-site emergency response Intervention levels	-	Off site radiological impact necessitating protective measures

Accident