PROVISIONS FOR INTERNAL AND EXTERNAL HAZARDS AT A NUCLEAR FACILITY

continues

With regard to new nuclear facilities, this Guide shall apply as of 1 December 2013 until further notice. With regard to operating nuclear facilities and those under construction, this Guide shall be enforced through a separate decision to be taken by STUK. This Guide replaces Guide YVL 2.6.

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Authorisation

According to Section 7 r of the Nuclear Energy Act (990/1987), *the Radiation and Nuclear Safety Authority (STUK) shall specify detailed safety requirements for the implementation of the safety level in accordance with the Nuclear Energy Act.*

Rules for application

The publication of a YVL Guide shall not, as such, alter any previous decisions made by STUK. After having heard the parties concerned STUK will issue a separate decision as to how a new or revised YVL Guide is to be applied to operating nuclear facilities or those under construction, and to licensees' operational activities. The Guide shall apply as it stands to new nuclear facilities.

When considering how the new safety requirements presented in the YVL Guides shall be applied to the operating nuclear facilities, or to those under construction, STUK will take due account of the principles laid down in Section 7 a of the Nuclear Energy Act (990/1987): *The safety of nuclear energy use shall be maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered justified considering operating experience, safety research and advances in science and technology.*

According to Section 7 r(3) of the Nuclear Energy Act, *the safety requirements of the Radiation and Nuclear Safety Authority (STUK) are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety standards in accordance with this Act, the Radiation and Nuclear Safety Authority (STUK) may approve a procedure or solution by which the safety level set forth is achieved.*

Translation. Original text in Finnish.

1 Introduction

101. This Guide presents how internal and external hazards shall be taken into account in the design of a nuclear facility.

102. General requirements for the protection of a nuclear power plant against external hazards are given in Section 17 of the Government Decree on the safety of nuclear power plants (717/2013): *"The design of a nuclear power plant shall take account of external hazards that may challenge safety functions. Systems, structures and components shall be designed, located and protected so that the impacts on plant safety of external hazards deemed possible remain minor. The operability of systems, structures and components shall be demonstrated in their design basis external environmental conditions. External events shall include exceptional weather conditions, seismic events, impact of accidents taking place in the plant's vicinity and other factors resulting from the environment or human activity. The design shall also consider unlawful actions with the aim of damaging the plant and a large commercial airplane crash."*

103. General requirements for the protection of a nuclear waste facility against internal and external hazards are given in Section 8(3) of the Government Decree on the safety of disposal of nuclear waste (736/2008): *"The design of a nuclear waste facility shall take account of any impacts caused by potential natural phenomena and other events external to the facility. As external events, even unlawful activities aiming at damaging the facility shall be taken into account."*

104. General requirements for the protection of a nuclear power plant against internal hazards are given in Section 18 of the Government Decree on the safety of nuclear power plants (717/2013): *"The design of a nuclear power plant shall take account of any internal hazards that may challenge safety functions. Systems, structures and components shall be designed, located and protected so that the probability of internal events remains low and impacts on plant safety minor. The operability of systems, structures and components shall be demonstrated in the room specific environmental conditions used as their design bases. Internal events to be considered shall include fire, flood, explosion, electromagnetic radiation, pipe breaks, container breakages, falling of heavy objects, missiles resulting from explosions and component failures, and other possible internal events."*

105. General requirements for the protection of a nuclear waste facility against internal and external hazards are given in Section 8(4) of the Government Decree on the safety of disposal of nuclear waste (736/2008): *"In a nuclear waste facility, the placement and protection of systems alongside operative methods shall ensure that fire, explosions or other events inside the facility do not pose a threat to safety."*

106. Under Section 3 of the Government Decree (716/2013) on emergency arrangements at nuclear power plants, *"emergency arrangements shall be planned to ensure that emergency situations are quickly brought under control, the safety of the individuals in the site area is assured, and timely action is taken to prevent or limit the radiation exposure to the public in the emergency planning zone. Planning shall take account of simultaneous emergency situations occurring in all nuclear facilities within the site area and their potential consequences, especially the radiation situation on the site and in the surrounding area and the possibilities to access the area. Planning shall take account of the fact that the emergency situation could continue for a prolonged period. Planning shall be based on analyses of time-behaviour progress of severe accident scenarios resulting in a potential release. In such a case, variations in the state of the plant, the development of events as a function of time, the radiation situation at the plant, radioactive releases, release routes and weather conditions shall all be taken into account. Planning shall take account of events deteriorating safety, their controllability and the severity of consequences, and threats related to unlawful action and the potential consequences thereof."*

107. Protection against internal and external hazards is provided by the nuclear facility's layout design, application of the redundancy, separation and diversity principles, structural dimensioning of components and structures, and the environmental qualification of the components. Furthermore, the nuclear facility shall have documented procedures for protection against internal and external hazards. Layout design is important in protecting the nuclear facility against internal and external hazards.

2 Scope of application

201. This Guide applies to provisions for internal and external hazards at a nuclear facility during the different phases of its life cycle. Certain requirements separately mentioned in this Guide only apply to a nuclear power plant.

202. This Guide applies to an applicant for and the holder of a Government decision-in-principle in accordance with the Nuclear Energy Act, an applicant for and the holder of a construction licence for a nuclear facility, as well as an applicant for and the holder of an operating licence for a nuclear facility.

203. During a nuclear facility's construction, before nuclear fuel or nuclear waste has been brought to the facility, this Guide shall apply in the scope necessary to ensure the integrity and operability of systems, structures and components important to safety during facility operation.

204. This Guide applies, in accordance with a separate decision, to a nuclear facility undergoing decommissioning in the scope justifiable considering the amount of radioactive substances contained in the nuclear facility and the risk of their release.

205. This Guide does not apply to underground rooms for final disposal of nuclear waste or to a research reactor.

206. This Guide applies to hazards arising from natural phenomena and external hazards pertaining to human activities, such as explosions and chemical spills not intended for harming the nuclear facility on purpose. Requirements pertaining to protection against unlawful action are given in Guide YVL A.11.

207. This Guide concerns hazards that may occur at the current or planned Finnish nuclear facility sites or similar sites during a facility's life cycle. The Radiation and Nuclear Safety Authority imposes, where necessary, additional requirements that might be needed for sites essentially deviating from the current facility sites.

208. Requirements for the nuclear facility's layout design as well as protection against internal and external hazards are given also in the following Guides:

- Guide YVL A.2 "Site for a nuclear facility", including examination of external conditions
- Guide YVL A.7 "Probabilistic risk assessment and risk management of a nuclear power plant", including seismic PRA and fragilities as well as the PRA of other external events
- Guide YVL A.11 "Security of a nuclear facility"
- Guide YVL B.1 "Safety design of a nuclear power plant" including general separation requirements, protection against electromagnetic disturbances and the design criteria for air conditioning systems
- Guide YVL B.8 "Fire protection at a nuclear facility"
- Guide YVL C.1 "Structural radiation safety at a nuclear facility", radiation protection considerations in layout design.
- YVL C.5 "Emergency arrangements of a nuclear power plant", consideration of external events in the planning of emergency arrangements.

209. Detailed layout design requirements as well as requirements for protection against internal and external hazards are also provided in other YVL Guides. Chapter-specific reference to the most important YVL Guides is made later in the text.

210. Acts, decrees and regulations in force in Finland, which pertain to construction as well as fire and rescue services also apply to the construction and design of the nuclear facility. Layout design shall take into account in particular the requirements presented in Guides E1, E2 and F2 of the Finnish Building Code (RakMK). Fire protection requirements for the nuclear facility are provided in Guide YVL B.8.

211. The requirements of this Guide apply to systems, structures and components important to the nuclear facility's safety, unless a requirement separately specifies its scope of application. A system, structure or component important to safety shall refer to any system, structure or component that is directly or indirectly required for the purpose of bringing the nuclear power plant to a safe state, maintaining the safe state, or preventing and monitoring the dispersion of radioactive materials during normal operation and in disturbances and accidents. For the purposes of this Guide, systems, structures and components important to safety refer to Safety Class 1, 2 and 3 systems, structures and components as well as systems, structures and components belonging to Class EYT/STUK (classified non-nuclear), which protect systems performing safety functions from internal or external threats, or whose operation is required to manage a DEC C event, as referred to in Guide YVL B.1.

3 Layout design of the nuclear facility

3.1 Layout design of the site area

301. Design of the site area layout shall be appropriate considering the facility's nuclear and radiation safety, preparedness and rescue arrangements as well as nuclear security.

302. The site area layout design shall take into account the possibility of simultaneous accidents at several facility units.

303. To be taken into account in planning traffic and access arrangements at the site area are rare meteorological conditions, floods and other rare external conditions as well as radiation conditions during an accident. The site area layout design shall take into account accessibility of buildings and structures in the event of fires and accidents as well as rare external conditions.

304. Traffic and access arrangements at the site area, taking into account transports of dangerous materials, shall be so planned that a transport accident does not endanger the safety of the facility or the emergency preparedness arrangements.

305. Buildings and rooms containing explosive materials shall be so located that a potential explosion does not endanger systems, structures or components important to safety.

306. The site area layout design shall be so implemented as to prevent the possibility of the spreading of the effects of fires, floods and other hazards from one building to another.

307. The site area layout design shall be implemented in such a way that missiles generated by the failure of a turbine, generator or other heavy rotating machines do not endanger systems, structures and components important to safety. Hazard assessment shall include all facilities at the same site area or in its immediate vicinity.

308. The placement of sea water intake and outlet channels shall be so designed as to make the danger of the simultaneous loss of redundant systems from external causes as small as possible.

309. The design of external power grid connections shall take into account phenomena simultaneously endangering redundant and diverse systems.

310. If several nuclear power plant units or other nuclear facilities are intended to be located at the same site area or in its immediate vicinity, the layout design of the site shall take into account the potential effects of construction and transport on the operating nuclear facilities.

3.2 Protection of the nuclear facility against internal hazards

311. Provisions shall be made in the design of the nuclear facility to protect the facility against internal hazards. This can be done by means of layout design, for example. Internal hazards to be taken into account in design shall be determined on a facility-specific basis. At least the following phenomena shall be analysed as internal hazards:

- fires and the spread of smoke and hazardous gases as well as explosions generated in consequence of a fire
- explosions and chemical reactions of materials handled at the facility
- release of dangerous gases and liquids
- arcing
- electromagnetic interference
- consequent effects of the failure of components, piping and tanks containing liquids or gases (missiles, jet forces, pipe whips, pressure waves)
- missiles caused by the failure of rotating machines and other equipment
- falling of heavy loads
- floods
- unnecessary operation of the fire water and extinguishing system
- loss of the cooling, heating and ventilation of rooms as well as their unnecessary operation.

312. Rooms where exceptionally high or low temperatures could endanger the operability of equipment important to safety housed in them shall be equipped with temperature monitoring from which alarm signals shall be led to the main control room.

313. When designing the location and protection of components, impacts, water jets , steam discharges and possible missiles caused by the breaking of piping and equipment, as well as water-induced hydrostatic pressure, shall be taken into account.

314. Floods shall be taken into account in the layout design. The design shall, at minimum, take account of internal flooding due to the following causes: pipe, component, container and pool leakages due to breaking or functional reasons, automatic actuation of systems as designed or erroneously, failure of automatic pump trips, and operator errors. Sea water pipe breaks during exceptionally high sea water levels shall also be examined. External floods are addressed in chapter 5.4.

315. Design relating to protection against floods shall take into account conditions where process systems have been opened for maintenance or repair work.

316. Structural dimensioning shall take into account hydrostatic pressure caused by floods, buoyancy and possible other loads. The requirements on how floods shall be taken into consideration in the separation of safety divisions are addressed in more detail in chapters 3.3. and 3.4.

317. Safety division compartments containing flood sources shall be provided with leakage monitoring. Leakage monitoring alarm signals shall be led to the main control room. In the compartments in question, any leak water shall be directed to the drainage system or rooms from which it can be removed.

318. Lifting of heavy objects shall be taken into account in the nuclear facility's layout design. The hoisting routes and the structures beneath them shall be so designed that the falling of heavy loads does not endanger systems, structures or components important to safety.

319. Layout design shall take into account the requirements pertaining to the following matters, among other things, which are presented in other YVL Guides:

- YVL A.8: requirements concerning the possibilities of conducting inspections and ageing management
- YVL A.11: requirements concerning nuclear security and airplane crash
- YVL B.1: general requirements concerning environmental conditions in facility rooms, air conditioning and ventilation requirements, protection against electromagnetic interference
- YVL B.2: requirements concerning seismic classification of systems, structures and components
- YVL B.5: pipe whips
- YVL B.6: requirements concerning containment design
- YVL B.8: requirements concerning fire compartmentation, emergency exits and protection against fire-load induced explosions

- YVL C.1: requirements concerning structural radiation protection and protection against the release of radioactive substances into facility rooms, including leakage management in rooms housing systems containing radioactive liquid
- YVL C.5: rooms required for emergency operations
- YVL D.1: requirements concerning nuclear safeguards
- YVL D.3 and YVL D.4: requirements concerning nuclear waste management
- YVL E.4: leakage control requirements pertaining to the leak-before-break principle to be complied with to assure primary circuit integrity and requirements for shielding to protect against pipe breaks
- YVL E.6: design principles for pool structures housing radioactive fuel including their technical verification and monitoring.
- YVL E.11: hoisting routes, falling of heavy loads, fuel handling.

320. In situations involving discrepancies between requirements concerning the different technical domains, their order of importance shall be assessed from the perspective of nuclear and radiation safety.

3.3 Requirements for the separation and protection of safety divisions

321. The technical requirements to be set for structures between safety divisions and other separating structures as well as for separation by distance shall be determined on the basis of the internal or external hazards examined as well as the Finnish Building Code RakMK and applicable standards.

322. Doors, hatches and penetrations between safety divisions shall be avoided.

323. Openings in structures between safety divisions shall be kept closed and leaktight during the nuclear facility's normal operation.

324. Guide YVL B.1 prescribes that in rooms where safety divisions cannot be constructed as separate compartments, they shall be separated by partly separating structures or by distance. The methods of separation to be used in these cases shall take into account the defence-in-depth concept of fire protection [Guide YVL B.8] and they shall be justified by analyses. Examples of such cases include the containment as well as the control room and the cable spaces below it.

325. If cables that do not functionally belong to the systems of a safety division must be routed through the safety division, the cables shall be placed in separate cable ducts that fulfil the requirements for separation between safety divisions.

326. Systems and fire loads in the safety divisions and in rooms adjacent to them and a fire considered possible in the said rooms, the release of poisonous gases, flooding and the related hydrostatic pressure, as well as other internal or external hazards considered possible shall be taken into account in the design of the separation of the safety divisions, separating structures and the boundary between a safety division and other rooms or outside areas. In designing parts of buildings below ground level, the pressure difference between safety divisions as a result of the water level reaching ground level shall be taken into account.

327. The effects of the failure of pipes and pressure equipment on other systems, structures or components in the safety division shall be analysed. Vapour spreading as well as the effects of humidity and heat shall also be considered in the analysis.

328. Protection against pressure increases caused by fractures and bursts of pipes and pressure equipment shall be provided in the rooms in question by controlled pressure relief routes, such as discharge hatches, that open on pressure increase to prevent structural damage.

329. To restrict the effects of floods, penetrations between safety divisions shall be avoided in parts of buildings below ground level. Technical means shall be used to prevent the spreading of internal floods, to manage water leaks and to limit leak volumes. Flooding and the spreading of floods through the basement and ground water drainage systems of buildings shall be prevented by appropriate design solutions.

330. The principles for separating the redundant subsystems of safety-classified systems into separate safety divisions are provided in Guide YVL B.1.

331. The separating structures between the safety divisions shall fulfil the fire resistance requirements of Guide YVL B.8.

3.4 Requirements for penetrations and openings in the boundaries of safety divisions

332. The functional need for doors, hatches and penetrations in structures between safety divisions shall be justified, and they shall be designed to fulfil the leaktightness, pressure resistance, fire resistance and other environmental requirements set for structures between safety divisions.

333. The number of doors, hatches and penetrations shall be kept to a minimum between a safety division and any other compartment containing heavy fire loads or substantial flood sources.

334. The doors between safety divisions as well as between safety divisions and other rooms or outdoor areas shall be provided with a monitoring and alarm system for relaying status information to the control room or alarm centre. Ordinary access doors shall be self-closing and self-locking.

335. In case access is provided between safety divisions in rooms below ground level (door step level of buildings) there shall be two successive doors in place (a double door or passage via a neutral room). Both doors shall be designed to withstand the design basis water pressure for the separating structures between safety divisions.

336. The possibility of floods spreading from one safety division to another in rooms above ground level shall be assessed. If spreading is possible, doors between safety divisions shall be subject to the same requirements as doors located below ground level (door step level of buildings).

337. Fire compartmentation-related requirements for doors, penetrations and fire dampers between safety divisions are provided in Guide YVL B.8.

338. The nuclear security related requirements for doors and the locking system are provided in Guide YVL A.11.

339. The requirements on how an airplane crash shall be taken into consideration in the layout design of the nuclear facility are provided in Appendix B to Guide YVL A.11.

3.5 Demonstration of the implementation of requirements, and the documents to be submitted to STUK

Application for a decision-in-principle

340. The licensee shall submit to STUK for the review of the application for a decision-in-principle, as part of the plant description, a preliminary plot plan of the site area on a grid map. To be presented in connection with the preliminary layout design plan is a plot plan presenting the geographical location of the facility and its various structural elements, power grid connections and sea water intake and discharge openings. A preliminary traffic plan for the site area shall be presented in connection with the preliminary plot plan of the site area.

341. The licensee shall submit to STUK for the review of the application for a decision-in-principle, as part of the plant description, the facility's preliminary layout design plan describing the location of the main components and rooms reserved for the systems, structures and components important to safety.

Application for a construction licence

342. The licensee shall submit to STUK for the review of the construction licence application an updated layout design plan for the site area and the associated plot plan and traffic plan.

343. The licensee shall submit to STUK for the review of the construction licence application a layout design plan including reports and layout drawings. Furthermore, a 3D computer model shall be submitted to STUK, which presents, the following, including their preliminary dimensioning: buildings, structures, main components, process equipment, piping, cable routes, control rooms, electrical and I&C rooms and I&C and switchgear cabinets. The 3D computer model and/or drawings shall also present from the safety point of view the penetrations between safety divisions and compartments, access routes, crane routes and other space reservations based on which it is possible to verify the implementation of separation principles and the requirements derived from them in order to provide protection against internal and external hazards. The adequacy of separation shall be justified by analyses to be submitted to STUK.

344. The licensee shall submit to STUK for the review of the construction licence application a preliminary description of protection against internal hazards.

345. The licensee shall submit to STUK, with the documents submitted for the review of the construction licence application, the standards to be applied in the separation of safety divisions.

Application for an operating licence

346. The licensee shall submit to STUK for the review of the operating licence application the aforementioned final reports on the layout design plan as well as on protection against internal and external hazards.

347. The adequate scope and implementation of the protection against internal and external hazards shall be ensured by facility walkdowns prior to the nuclear facility's commissioning. The requirements on facility walkdowns are given in chapter 5.10.

4 Earthquakes

4.1 Design basis earthquake

401. When applying for a construction licence for the nuclear facility, a report on the determination of the design basis earthquake used in seismic design shall be provided. A design basis earthquake refers to facility site ground motion used as the basis for the nuclear facility's design. The design basis earthquake shall be so defined that in the current geological conditions the anticipated frequency of occurrence of stronger ground motions is less than once in a hundred thousand years (1×10^{-5}/y) at a median confidence level. The determination of the design basis earthquake shall be described and justified and in addition to the area's seismic history, also regional and local geology as well as tectonics shall be considered.

402. The external impact of the design basis earthquake on the nuclear facility shall be presented as a ground response spectrum. The ground response spectrum represents the maximum vibrations of a family of idealised single-degree-of-freedom damped oscillators anchored in site bedrock as a function of the natural frequencies for a given damping ratio.

403. In determining the ground response spectrum, data on earthquake locations and magnitudes collected in Finland shall be used. Instrumental observation data and historic data obtained by sensory observations shall be used. Analyses shall take into account the various observation thresholds of different types of observation and the location-related uncertainty factors of historical observations.

404. Acceleration induced at a facility site by an earthquake of a certain magnitude at a certain distance is evaluated by means of an attenuation function. If no detailed measurement data covering Finland are available to determine the attenuation function, it shall be determined based on data measured in an area corresponding as well as possible to the geological conditions in Finland. The selection of attenuation functions to determine the ground response spectrum shall be justified.

405. The design basis earthquake's seismic ground response spectrum shall be based on information and measurement results describing the facility site as well as possible. The spectrum shall be scaled to correspond to vertical and horizontal peak ground acceleration (PGA) values and, if necessary, a separate spectrum for both directions of vibration shall be given.

406. The floor response spectrum (spectrum and zero period acceleration of the floor) can be determined as an envelope spectrum, which in addition to seismic earthquake induced vibrations covers vibrations caused by other reasons, such as an airplane crash.

407. The vertical and horizontal PGA values used shall be justified on a site-specific basis. The horizontal component minimum value shall be 0.1·g as prescribed in the Guides IAEA NS-G-1.6 [9] and IAEA SSG-9 [8]. Guides SSG-9 and NUREG/CR-6728 [18] give guidelines on the determination of the relation between the horizontal and vertical components of the PGA values at different acceleration and frequency levels.

408. Earthquakes stronger than the design basis earthquake shall be taken into account as design extension conditions (DEC C) in accordance with Guide YVL B.1. This can be done using the seismic fragility curves of equipment needed for safe shutdown of the facility.

409. The source information and methods used in determining the design basis earthquake shall be assessed and the design basis earthquake updated, as necessary, in connection with periodic safety reviews.

4.2 Seismic design of structures and components

4.2.1 General

410. The licensee shall present the design bases for structures and components in the design procedure to be submitted to STUK for approval as part of the construction licence application documentation. The design standards used shall be presented as part of the design bases – for example, ASCE 4-98 [11], ASCE/SEI 43-05 [15] and NUREG/CR-6926 [17]. The design standards shall be conservatively applied, for instance, in evaluating the vibrations transferred to the components by the structural framework.

411. For calculations made for structures and components, the impact of the design basis earthquake can also be presented with an acceleration-time diagram constructed using the ground response spectrum. The acceleration values used and the method of their derivation shall be presented and justified.

412. The acceleration-time diagram shall be verified by comparing the acceleration-frequency curve derived from it with the initial acceleration-frequency curve.

413. In case the loading caused by the design basis earthquake is intended to be modelled by other methods, a separate approval for the method in question shall be obtained from STUK.

414. In designing earthquake resistant nuclear facility structures and components, proven general design principles shall be considered, such as the following:

- Structures shall be designed and components located in such a way that the loads propagated by them on buildings occur as close to ground level as possible. Sharp changes in the profile of horizontal accelerations between floor levels shall be avoided.
- The shape of load-bearing structures shall be as regular and simple as possible.
- With regard to bracing structures, a building's different parts shall be so located as to avoid structural eccentricity.
- Massive buildings and equipment foundations important to safety shall be preferably founded directly on bedrock. In case of deviations from this, soil-structure interaction studies between bedrock, soil and buildings shall be required, in addition to the ground response spectrum.
- Detailed design principles provided in Guide IAEA SG NS-G-1.6 [9].

4.2.2 Loads

415. The seismic design of structures and components assigned to seismic category S1 and S2A in accordance with Guide YVL B.2 shall consider loads generated by the design basis earthquake. To determine the loads, the floor response spectra or acceleration-time diagrams corresponding to the ground response spectrum shall be derived by dynamic analyses for the building levels housing the structures and components under examination.

416. In the dynamic analysis of buildings, mass and stiffness characteristics essentially affecting vibration behaviour shall be modelled. The damping ratio values selected shall be justified taking into account the corresponding utilisation rate of the structural capacity (the matter is addressed in the report NUREG/CR-6919 [19]). No analysis of the dynamic interaction between buildings and the bedrock is required when the general design principles in requirement 414 apply.

417. Uncertainty factors relating to source information and spectral peaks at natural frequencies shall be considered. Applicable instructions are provided in Guide YVL E.4 and the Guide IAEA NS-G-1.6 [9].

418. The damping ratios representing a building's structural framework shall be evaluated in accordance with a corresponding postulated structural failure level (see requirement 416). A sensitivity analysis shall be conducted on the loading assumptions between the structural framework and S1/S2A classified components in which the certainty level of the design solution is evaluated from the viewpoint of the building's structural framework as well as component design.

419. The highest horizontal and vertical acceleration values arising at the component locations shall be used in the dimensioning of individual structures and components. Relative vibration displacements between buildings or building sections shall be considered in case they generate significant loads. The horizontal acceleration component of each object is chosen according to its structurally weakest direction, whenever this can be established. In other cases, components will be chosen for two orthogonal horizontal directions (the object's principal directions). These components can be combined in accordance with the standard ASCE 4-98 [14] or EN 1998 [16], for example.

420. Other simultaneous loads shall be added to the loads generated by the design basis earthquake. They include loads from normal operation and loads simultaneously generated by possible anticipated operational occurrences caused by an earthquake. The design basis earthquake need not be considered simultaneously with the loading generated by a postulated accident condition when an earthquake's consequent effects have been prevented by corresponding earthquake resistance of structures and components.

421. In so far as the failure of S2B seismic category structures and components is acceptable in such a way that additional loads are exerted on structures and components in a higher seismic category during an earthquake, the additional loads in question can be taken into account in corresponding floor response spectra. Seismically induced hydraulic burst pressures generated by EYT/S2B category pressure vessels, for example, can be included in the floor response spectra of the affected area.

422. Load cases shall be combined in dimensioning and strength calculations in accordance with an approved standard. Load combinations shall be determined in the design procedures of the construction licence phase in such a way that extreme load combinations are addressed.

423. As the partial safety coefficient of loads, the value 1.0 may be used. Characteristic strengths [13] are used as material design strengths. A dynamic load includes inertial forces generated within a structure and the components supported by it.

4.2.3 Dimensioning principles

424. The licensee shall present the dimensioning principles for implementation of the earthquake resistance of different types of structures and components including their methods of support, fixing and protection. In addition, a plan shall be presented for demonstration of compliance with the requirements as regards the functioning of different types of structures and components during earthquake conditions.

425. System, structure and component-specific seismic design as well as the dimensioning calculations required to take into account seismic loads in compliance with chapter 4.2.2 shall be presented in the design documents of structures and components.

426. The dimensioning calculations of seismic category S1 and S2A pressure equipment, other mechanical structures and components, and particularly any related supports and fixings shall examine the loads caused by the design basis earthquake. Requirements for pipe supports and fixings are presented in Guide YVL E.3.

427. In the suitability analyses of seismic category S1 and S2A electrical and I&C equipment, dimensioning calculations for supports and fixings subjected to substantial loads during earthquakes shall be presented.

4.3 Demonstration of earthquake resistance

4.3.1 General

428. The licensee shall demonstrate that seismic category S1 and S2A structures and components meet the requirements for earthquake resistance established in chapter 4.2. Demonstration may be in the form of analyses, tests, up-to-date empirical assessments or combinations thereof. Such demonstrations or corresponding result documentation are to be presented in connection with STUK's inspections required for the types of structure or component in question before commissioning. Guide YVL B.2 sets forth a seismic category-dependent requirement level for the functionality and integrity of systems, structures and components required in order to ensure earthquake resistance. Analyses and experimental methods are addressed in more detail in the Guide IAEA SG NS-G-1.6 [9].

429. Ageing management in accordance with Guide YVL A.8 shall take into account the maintenance of earthquake resistance.

430. The probabilistic risk assessment (PRA) shall be applied to demonstrate that the implementation of seismic design is acceptable from the viewpoint of the nuclear facility's overall safety.

4.3.2 Analyses

431. The earthquake resistance of pressure equipment and the steel containment structure shall be demonstrated by a stress analysis conducted in accordance with the Guides YVL E.4, YVL E.6, YVL E.8, YVL E.9 and YVL E.10 for loads induced by the design basis earthquake.

4.3.3 Tests and combining tests with analyses

432. The earthquake resistance of components and/or their parts that cannot be analysed with adequate reliability shall be experimentally demonstrated.

433. In combining analyses and tests it shall be presented how the testing combinations to be determined correspond to the design assumptions and how the fulfilment of seismic resistance requirements is demonstrated.

4.3.4 Empirical assessments

434. The earthquake resistance of a component or structure can be assessed based on an earlier report prepared for a corresponding item in conformity with chapter 4.3.2 or 4.3.3. Commensurate up-to-date experiences of earthquakes that have occurred may also be utilised.

4.3.5 Electrical and I&C equipment

435. The type tests of electrical and I&C equipment shall include sufficient requirements for endurance of mechanical stress in comparison to the design basis earthquake. The durability of inter-component cabling and connections shall be demonstrated by analyses and/or tests.

4.3.6 Equipment aggregates

436. Aggregates comprising electrical and I&C equipment, mechanical components, piping and equipment foundations shall be evaluated in such a way that, in addition to the verification of the seismic qualification of individual components, interactions between these components are also taken into account.

437. A summary of justifications verifying the nuclear safety of equipment aggregates shall be submitted to STUK for approval indicating how an aggregate's seismic resistance has been demonstrated by verification of the quality of individual components and an analysis/evaluation of the aggregate.

4.3.7 Safe shutdown of the nuclear power plant

438. The nuclear power plant's safe shutdown after an earthquake shall be based on unambiguous procedures (IAEA SSG-9) [8]. The pre-shutdown vibration acceleration level and the method of its establishment are presented in the procedures. Shutdown procedures shall be based on appropriately qualified category S1 systems, structures and components. The shutdown procedure shall be assessed by means of a PRA.

439. Seismic monitoring shall be performed at the nuclear power plant based on dynamic frame structure properties corresponding to design basis earthquake acceleration levels, as well as the planned location at the facility of systems and components used for a safe shutdown. Requirements for sensors are given in requirements 445–449.

4.3.8 The use of PRA to support earthquake resistance design

440. The most important initiating events due to earthquake-induced failures and component malfunctions shall be incorporated in the PRA to be drawn up in accordance with Guide YVL A.7. The seismic PRA shall, irrespective of seismic classification, consider components plus their supports, as well as experiences of the susceptibility to failure of different types of structures and components in actual earthquakes of varying intensities. Failure sequences attributable to the simultaneous dynamic loading of large equipment aggregates and the possibility of common cause failures shall be analysed.

441. PRA analyses shall demonstrate systems significant for safe shutdown and the HCLPF estimates for corresponding fragilities of components and structures. The fragility estimates shall be based on 3D analyses of structural framework and actual fixing methods in such a way that all directions of vibration have been appropriately evaluated.

4.4 Earthquake resistance control during construction and operation

442. Earthquake induced loads shall be considered in the construction plans of seismic category S1 and S2A structures and components. Earthquake resistance related requirements are provided in chapters 4.2 and 4.3.

443. The scope and implementation of the seismic design of structures and components shall be ensured by facility walkdowns prior to the nuclear facility's commissioning. The inspections shall be carried out by competent technical experts and under STUK's supervision. Experts participating in the facility walkdowns shall acquaint themselves with the seismic design documents. The facility walkdowns include verification of the appropriateness of seismic support and fixing solutions as well as identification and assessment of potential seismic risk factors requiring further measures.

444. A plan for facility walkdowns shall be drawn up. Approved construction plans as well as the seismic PRA and fragilities shall be taken into account in the planning, among other documents and information. A facility walkdown report shall be drawn up describing walkdown implementation and any detected non-conformances detected affecting safety.

445. An essential part of the seismic monitoring system is composed of sensors. The appropriateness of the seismic sensors is demonstrated in connection with the procedures for safe shutdown specified in chapter 4.3.7.

446. Seismic sensors shall be located in the bedrock of the nuclear facility site to verify the vibration data and assumptions used in defining the design basis earthquake. Furthermore, at least one reactor building of each type having similar seismic characteristics shall have at least two sensors one of which is attached to the base plate and the other above the building level housing seismic category S1 structures and components.

447. The sensors shall be suitable for design-basis acceleration and frequency values. The sensors shall be capable of recording reliably and at sufficiently short intervals the accelerations of earthquakes in vertical direction and in two mutually perpendicular horizontal directions.

448. After a significant earthquake, sensor recordings shall be available when assessing the necessary scope of inspections of seismic category S1 and S2A structures and components as well as the prerequisites for continued plant operation.

449. Records yielded by seismic sensors and the availability of components shall be regularly checked during plant operation. Observations exceeding the set threshold values shall be recorded as time series in such a way that they can be used to conduct the appropriate analyses later on. Procedures shall be specified for operations and they shall be included in periodic inspection programmes.

4.5 Demonstration of the implementation of requirements, and the documents to be submitted to STUK

450. The licensee shall present in the nuclear facility's Preliminary and Final Safety Analysis Reports or the related topical reports the nuclear facility's design basis earthquake, the methods and input data used in its determination as well as the general principles to be followed in the facility's earthquake design.

451. Research and analyses to determine and reassess the design basis earthquake shall be traceable, and the related source information, result documentation and reference material shall be archived. The methods and procedures of research and analysis as well as the organisations and persons involved and their tasks shall be described. The documentation in question shall be archived for the entire life cycle of the nuclear facility and be accessible to STUK, when necessary.

452. The licensee shall, in the documents submitted to STUK for the review of the nuclear facility's construction licence application, present the information concerning the seismic design bases referred to in requirement 424.

453. Plans, analyses and test plans to demonstrate the seismic resistance of structures and components, as well as result documentation, shall be presented to STUK in documents to be submitted in accordance with Guides YVL E.6, YVL E.7, YVL E.8, YVL E.9, YVL E.10 and YVL E.11.

454. Seismic test plans shall be submitted to STUK sufficiently early for STUK to be able to oversee the tests. Test reports shall be submitted to STUK for information for the approval review of an corresponding final suitability assessment or construction plan.

455. The effects of non-conformances occurring during manufacturing, construction and installation shall be presented in suitability analyses (Guide YVL E.7) or a summary of justifications (Guides YVL E.5, YVL E.6).

456. The licence-applicant/licensee shall submit to STUK for approval the facility walkdown plan referred to in requirement 444 before the facility walkdowns and the facility walkdown report before the commissioning inspections. The summary of justifications pertaining to the equipment aggregates referred to in requirement 437 shall be submitted to STUK before the facility walkdown.

457. The requirements for the submission of a seismic PRA during the different licensing phases are given in Guide YVL A.7.

5 Other hazards external to the nuclear facility

5.1 General requirements for protection against external hazards

501. To be taken into account in the design of the nuclear facility's systems, components and structures are natural phenomena assessed as possible at the facility site, as well as other external hazards affecting at the facility.

502. The licensee shall draw up a report on the external hazards considered in the facility design and the methods of preparing against them. The report shall describe the external conditions and events postulated in connection with different transient and accident conditions (Guide YVL B.1).

503. The following general principles shall be followed in selecting design values for systems, structures and components important to safety that pertain to external events and conditions:

a. Design values shall include an adequate margin in relation to the peak values measured at the facility site and in its vicinity
b. In determining design values, at least phenomena whose estimated probability of occurrence at the site over one year is higher than 10^{-5}/year at a median confidence level shall be considered.
c. If it can be reliably demonstrated that an external event or condition does not affect the probability of occurrence of a certain postulated accident, the design value regarding the external event or condition in question can be chosen for the systems required for the management of the postulated accident so that its maximum probability of exceedance in one year is 10^{-4}.
d. The safety significance of systems, structures and components important to safety shall be considered in selecting their design values, and the adequacy of the design values shall be justified.

504. In addition to the above, to be ensured in selecting the sea water level design value is that the design value is higher than

a. the water level estimated possible at the site at a median confidence level once in a hundred years added with two metres and a site-specifically evaluated wave margin, and
b. the extreme level equivalent to the least favourable combination of factors evaluated in accordance with requirement 515 added with a site-specifically evaluated wave margin.

505. To be taken into account in selecting design values as well as in applying the redundancy and separation principles (YVL B.1) are dependencies affecting the simultaneous occurrence of external events. A hazard arising from unlawful action need not be taken into account as a load simultaneously with external hazards caused by exceptional natural phenomena or regular human activities.

506. Exceptional external events and conditions with an estimated frequency of occurrence less than 10^{-5}/year shall be considered design extension conditions (DEC C events) [YVL B.1]. The licence applicant/licensee shall present and justify external phenomena considered as DEC C events. In selecting the phenomena and their magnitude, the limit values for core damage frequency and a large release presented in Guide YVL A.7 shall be taken into account. To be incorporated in the DEC C design values is a justified marginal in relation to the observed maximum values of the phenomena analysed.

507. The nuclear facility shall have in place procedures for the monitoring of external hazards affecting the safety of the facility, and for operation during events involving a clearly increased hazard of an external event affecting the safety functions, and in conditions where an external event that has compromised implementation of the safety functions.

508. The adequacy of design values for external events and conditions shall be verified by means of probabilistic risk assessment (Guide YVL A.7). The probabilistic studies shall take into account interdependencies between natural phenomena. Guide YVL A.7 presents the limits for core damage frequency and large release frequency, which also include the external hazard contribution.

5.2 Hazard curve

509. To determine the nuclear facility's design bases, the occurrence frequencies of external events affecting plant safety shall be assessed. A hazard curve shall be drawn up for phenomena for which measurements time series are available; the curve shall present the exceedance frequency of the parameter value representing the phenomenon.

510. If a hazard curve needs to be determined for a recurrence period exceeding the period covered by the measurement results, fitting of an extreme value distribution to the time series shall be employed. The mathematical form of the extreme value distribution shall be selected with the aim that the final outcome will not be non-conservatively sensitive to the effects of individual measurement results.

511. The uncertainties of hazard curves determined for the nuclear facility site shall be evaluated and uncertainties shall be taken into account in determining design values. For evaluation of uncertainties, hazard curves based on time series measured in several localities in the vicinity of the nuclear facility site shall be analysed. Adequate utilisation of national measurement data and expertise shall be ensured in determining hazard curves and estimating uncertainties.

5.3 Meteorological phenomena

512. The design of the nuclear facility shall take into consideration the exceptional meteorological phenomena assessed as possible at the facility site. At least the following meteorological phenomena shall be considered in the design:

- high and low atmospheric temperature
- high winds including tornadoes and downbursts
- high and, low air pressure as well as fluctuations of air pressure
- rain, snow, hail
- freezing rain and splashes from sea or watercourses
- atmospheric moisture, fog, mist, rime ice
- lightning
- drought
- electromagnetic interference caused by solar flares.

513. Design solutions shall ensure that freezing, snow or other events causing clogging do not prevent cooling air supply to systems important to safety or combustion air supply to emergency power engines.

5.4 High and low sea water level and external floods

514. Provisions for abnormally high and low sea water levels shall be taken in the design of a nuclear facility located by the sea The wave height evaluated as possible at the site shall be taken into account in the design. Furthermore, the hazard to the nuclear facility from the flooding of rivers, lakes and other potential sources of flooding in the nuclear facility's vicinity shall be examined and, where necessary, taken into account in the facility design.

515. Hazard curves in accordance with chapter 5.2 shall be drawn up for high and low sea water levels. In addition to a statistical approach, factors affecting sea water level shall be specified, and the maximum impact of every identified factor shall be evaluated, along with the extreme level equivalent to the least favourable combination of factors. As factors affecting sea water level, at least the total volume of water in the Baltic Sea, air pressure, wind, seiche and tide shall be examined. The analysis shall include the estimated change in the water level of oceans and the uncertainties arising from it during the nuclear facility's design lifetime.

516. The design of the nuclear facility's buildings and systems shall reliably prevent sea water from flooding the facility via drainage or open systems located below door step level. The design shall also cover conditions during maintenance as well as sea water pipe breaks during exceptionally high sea water levels.

517. The flooding of facility rooms due to exceptionally high sea or other watercourse level as well as exceptional precipitation shall be analysed as external floods. Flooding due to external sources in consequence of pipe breaks, malfunctions and human error shall be included in the examination. Potential flood routes shall be identified. The analyses shall include at least doors, hatches, penetrations, drainage systems as well as sea water pumping station pools and sea water discharge routes.

5.5 Ice and frazil ice

518. For the purpose of the nuclear facility's design, ice conditions at the site shall be established – in particular, the loadings caused by ice movement and pack ice to water intake structures and other structures near the shoreline. The design shall take into account ice-induced loadings.

519. The hazard posed by the blockage of sea water intakes by frazil ice and other forms of ice shall be evaluated and reduced as far as possible by appropriate design solutions. The solutions chosen shall be presented and their adequacy

justified in the Preliminary and Final Safety Analysis Reports.

520. The nuclear facility's sea water systems shall be equipped with suitable temperature measurements to identify the hazard posed by frazil ice. During the nuclear facility's operation,the sea water freezing point shall be determined at regular intervals under conditions favourable for the formation of frazil ice (low atmospheric temperature and sea without ice cover).

5.6 Other external events endangering seawater and raw water supply

521. The design of sea water intake and outlet structures as well as sea water systems shall apply design solutions where the possibility of a blockage is minor. Furthermore, protection shall be provided, as prescribed in Guide YVL B.1, against loss of the final heat sink caused by a total loss of sea water flow.

522. The following matters, among others, shall be examined as events causing the danger of a blockage: water-carried impurities entering the sea water systems, such as algae, other plant life and organisms and their remains, as well as oil and other fouling chemicals. In the design and operation of the sea water systems provisions shall also be taken to protect against growth of plant life and organisms, such as mussels, in the seawater systems.

523. The sea water systems shall be equipped with suitable cleaning systems to handle impurities.

524. The cleanliness of the nuclear facility's sea water supply at intake shall be monitored. Monitoring shall be enhanced during conditions involving a higher than normal risk of impurities entering the sea water systems.

525. The safety significance of disturbances in the supply of fresh raw water and the water treatment system shall be assessed. Protection shall be provided against disturbances in the supply of raw and treated water to ensure that the accomplishment of safety functions is not endangered

5.7 External fires and explosions

526. Nuclear facility design shall take into account explosion pressure waves external to the facility buildings induced by a chemical explosion pressure wave or a burst pressure wave. The design bases for a pressure wave caused by the bursting of pressure vessels belonging to the facility shall be based on analyses. The requirements pertaining to the magnitude of a design basis external explosion pressure wave attributable to other reasons are given in Guide YVL A.11.

527. The effects of heat and smoke arising from forest fires and wildfires as well as other fires external to the facility shall be taken into account in the nuclear facility's design.

528. The requirements for protection against flammable, toxic and asphyxiating gases are provided in Guides YVL B.1 and YVL A.11.

529. Requirements for the facility's fire protection systems and operative fire fighting and rescue preparedness are provided in Guide YVL B.8.

5.8 Electromagnetic interference

530. The requirements for protection against electromagnetic interferences are provided in Guides YVL B.1, YVL E.7 and YVL A.11.

5.9 Hazards caused by flora and fauna

531. Access into equipment rooms of rodents and other animals endangering cables and electrical equipment shall be reliably prevented.

532. Access of birds, swarms of insects and other animals into ventilation and air-conditioning systems, as well as into the combustion and cooling air systems of emergency power engines, shall be prevented.

5.10 Demonstration of the implementation of requirements, and the documents to be submitted to STUK

533. Research and analyses to determine and reassess the design bases for external events shall be traceable, and the related source information, test results and reference material shall be archived. The methods and procedures of research and analysis as well as the organisations and persons involved, along with their tasks, shall be described. The documentation in question shall be archived for the entire life cycle of the nuclear facility and be accessible to STUK, where necessary.

Application for a decision-in-principle

534. The documents to be submitted to STUK for review of a decision-in-principle application shall include an overview of the meteorological, hydrological and geological conditions at the plant site, as well as of human actions that may affect the safety of the facility and the implementation of emergency preparedness measures.

535. The documents to be submitted to STUK for the review of a decision-in-principle application shall include an overview of the intended protection against external events that are assessed as possible at the facility site.

Application for a construction licence

536. The documents to be submitted to STUK for the review of a construction licence application shall include detailed information of the meteorological, hydrological and geological conditions at the plant site, as well as of human actions that may affect the safety of the facility and the implementation of emergency preparedness.

537. The licensee shall submit to STUK for the review of the construction licence application a description in accordance with requirement 502 of the protection provided against external hazards. It may be included in the Preliminary Safety Analysis Report or in a separate document (topical report).

538. Design values pertaining to external events and other design bases shall be given and the design solutions to protect against external events shall be presented in the system descriptions.

Documents during construction

539. The adequacy of design solutions to protect against external events shall be justified by analyses or tests if the reliability of the analysis methods cannot be demonstrated. STUK shall be afforded the possibility of overseeing the tests. Test plans shall be submitted to STUK sufficiently early on before the tests. Analyses of electrical and I&C equipment as well as test reports shall be submitted to STUK for the approval review of final suitability assessments. Analyses of mechanical components and structures shall be submitted with construction plans to STUK or an authorised inspection body in accordance with the division of inspection responsibilities set forth in the E Series of the YVL Guides, and the test reports shall be submitted to STUK or an authorised inspection body before the commissioning inspections of the components or structures.

Application for an operating licence

540. The documents to be submitted to STUK for the operating licence review shall include the data referred to in requirement 536 in updated form, and the report on protection against external hazards referred to in requirement 502 in updated form.

541. The adequate scope and implementation of the protection against internal and external hazards shall be ensured by means of facility walkdowns prior to the nuclear facility's commissioning. Inspections shall be carried out by competent technical experts and STUK shall be afforded the possibility of overseeing them. The experts participating in facility walkdowns shall familiarise themselves with the design documents. The facility walkdown requirements are provided in chapter 4.

542. A facility walkdown plan shall be prepared and submitted to STUK for approval for the review of the operating licence application. A facility walkdown report shall be drawn up describing walkdown implementation and observations affecting safety. The report shall be submitted to STUK for approval sufficiently early on before the facility's commissioning.

6 Regulatory oversight by the Radiation and Nuclear Safety Authority

601. During the decision-in-principle phase, STUK reviews the reports attached to the application for a decision-in-principle in accordance with

Section 24(2) of the Nuclear Energy Decree (161/1988) as regards internal and external hazards, the preliminary reports on protection against internal and external hazards, as well as the layout design reports referred to in requirements 340 and 341. The review's main results are presented in STUK's preliminary safety assessment pertaining to the application.

602. In reviewing the construction licence application, STUK reviews, as regards internal and external hazards as well as layout design, the Preliminary Safety Analysis Report, reports on protection against internal and external hazards, as well as the reports on layout design referred to in requirements 342–345. The review's main results are presented in STUK's safety assessment pertaining to the application. Detailed review findings and remarks are presented to the construction licence applicant in a STUK decision.

603. During the nuclear facility's construction, STUK conducts inspections in accordance with a pre-determined programme (construction inspection programme RTO) and ensures in connection with the review of plans for systems, structures and components that the requirements for protection against internal and external hazards and layout design have been taken into account in the plans.

604. At the licensee's request, STUK reviews facility site-specific PGA values and ground response spectra for the design basis earthquake. The approval justifications include corresponding sensitivity analyses depicting the design criteria assessment methods and their essential computation parameters with uncertainties. An example of an accepted ground response spectrum is provided as an attachment to this Guide.

605. STUK reviews the safe shutdown analyses necessitated by requirement 438 in connection with the facility walkdown report prescribed by requirements 443 and 444.

606. In reviewing the construction plans and suitability analyses, STUK also reviews, as regards internal and external hazards, the assessment presented by the licensee of the fulfilment of nuclear safety requirements.

607. STUK oversees, to the necessary extent, the tests to demonstrate the resistance of the nuclear facility's systems, structures and components against internal hazards, earthquakes and other external hazards.

608. In reviewing the operating licence application, STUK reviews, as regards internal and external hazards as well as layout design, the Final Safety Analysis Report submitted as an attachment to the operating licence application as well as the final reports on layout design and protection against internal and external hazards, as mentioned in requirement 346. The review's main results are presented in STUK's safety assessment pertaining to the application. Detailed review findings and remarks are presented to the operating licence applicant in a STUK decision.

609. During the nuclear facility's operation, STUK reviews and, based on the review, accepts conceptual design plans, pre-inspection documents and changes to the Final Safety Analysis Report that are prepared for system modifications. During the reviews, provisions against internal and external hazards as well as layout design are also reviewed.

610. During the nuclear facility's operation, STUK conducts plant operation-related inspections in accordance with a pre-determined programme (operational inspection programme KTO).

611. Requirements pertaining to operating licence applications, as set forth in Guide YVL A.1, apply to periodic safety assessment implemented during an operating licence period.

Definitions

Initiating event

Initiating event shall refer to an identified event that leads to anticipated operational occurrences or accidents.

Fragility curve (seismic)

Fragility curve (seismic) shall refer to a curve that describes the probability of component or structure failure as a function of ground acceleration.

Physical separation

Physical separation shall refer to the separation of systems or components from one another by means of adequate barriers, distance or placement, or combinations thereof. (Government Decree 717/2013)

Hazard curve

Hazard curve shall refer to a curve that describes the frequency of exceedance (probability per year, for example) of a particular parameter value. A hazard curve can be presented for multiple statistical confidence levels.

HCLPF (High confidence of low probability of failure) capacity

HCLPF (High confidence of low probability of failure) capacity shall refer to a ground acceleration value that results in a component or structure damage probability of 5% at a confidence level of 95%.

Ventilation

Ventilation shall refer to maintaining and improving the quality of indoor air by circulating it; in some rooms of a nuclear power plant, ventilation systems are also used to limit the spread of radioactive substances.

Air conditioning systems

Air conditioning systems shall refer to systems designed to manage the purity, temperature, humidity and movement of indoor air by treating supply air or circulating air.

System

System shall refer to a combination of components and structures that performs a specific function.

Peak ground acceleration (PGA)

Peak ground acceleration (PGA) shall refer to the highest acceleration of ground motion due to an earthquake.

Ground response spectrum

Ground response spectrum shall refer to a method of presentation that describes the maximum vibrations of single-degree-of-freedom oscillators assumed to be anchored in site bedrock at various natural frequencies and using a particular damping ratio.

Redundancy

Redundancy shall refer to the use of alternative (identical or diverse) structures, systems or system components, so that any one of them can perform the required function regardless of the state of operation or failure of any other.

Anticipated operational occurrence

Anticipated operational occurrence (DBC 2) shall refer to such a deviation from normal operation that can be expected to occur once or several times during any period of a hundred operating years. (Government Decree 717/2013)

Postulated accident

Postulated accident shall refer to a deviation from normal operation which is assumed to occur less frequently than once over a span of one hundred operating years, excluding design extension conditions; and which the nuclear power plant is required to withstand without sustaining severe fuel failure, even if individual components of systems important to safety are rendered out of operation due to servicing or faults. Postulated accidents are grouped into two classes on the basis of the frequency of their initiating events: a) Class 1 postulated accidents (DBC 3), which can be assumed to occur less frequently than once over a span of one hundred operating years, but at least once over a span of one thousand operating years; b) Class 2 postulated accidents (DBC 4), which can be assumed to occur less frequently than once during any one thousand operating years.

Design extension condition (DEC)

Design extension condition (DEC) shall refer to:

a. an accident where an anticipated operational occurrence or class 1 postulated accident involves a common cause failure in a system required to execute a safety function (DEC A);
b. an accident caused by a combination of failures identified as significant on the basis of a probabilistic risk assessment (DEC B); or
c. an accident caused by a rare external event and which the facility is required to withstand without severe fuel failure (DEC C).

Accident

Accident shall refer to postulated accidents, design extension conditions and severe accidents (Government Decree 717/2013).

Internal events

Internal events shall refer to events occurring inside a nuclear power plant that may have an adverse effect on the safety or operation of the plant.

Damping ratio

Damping ratio shall refer to the ratio of the actual damping coefficient (the ratio of the viscous damping force to velocity) for a single-degree-of-freedom oscillator to the critical damping coefficient (the maximum value of the damping coefficient at which periodically attenuating oscillation is possible). The damping ratio is usually expressed as a percentage.

Design basis earthquake

Design basis earthquake shall refer to facility site ground motion used as the basis for the nuclear facility's design. The design basis earthquake shall be so defined that in the current geological conditions the anticipated frequency of occurrence of stronger ground motions is not more often than once in a hundred thousand years (1×10^{-5}/a) at median confidence level. A design basis earthquakes are represented using peak ground acceleration and ground response spectra.

Probabilistic risk assessment (PRA)

Probabilistic risk assessment (PRA) shall refer to a quantitative assessment of hazards, probabilities of event sequences and adverse effects influencing the safety of a nuclear power plant. (Government Decree 717/2013)

Functional isolation

Functional isolation shall refer to the isolation of systems from one another so that the operation or failure of one system does not adversely affect another system; functional isolation also covers electrical isolation and isolation of the processing of information between systems. (Government Decree 717/2013)

System/structure/component important to safety

System/structure/component important to safety shall refer to a system, structure or component needed, either as such or indirectly, to bring a nuclear power plant to a safe state, maintain it in a safe state, or monitor and prevent the dispersion of radioactive substances in normal operation as well as in disturbances and accidents. This refers to systems, structures and components in safety classes 1, 2 and 3 and systems, structures and components in class EYT/STUK that protect the systems executing the safety functions against internal or external hazards, or that are needed to control a DEC C event as laid down in Guide YVL B.1.

Safety system

Safety system shall refer to a system that has been designed to execute safety functions.

Safety divisions

Safety division shall refer to premises, physically separated from one another, and the components and structures contained therein, where one of the redundant parts of each safety system is placed.

Safety-classified system/structure/component

Safety-classified system/structure /component shall refer to a system, structure or component assigned to safety classes on the basis of its safety significance.

Safety functions

Safety functions shall refer to functions important from the point of view of safety, the purpose of which is to control disturbances or prevent the generation or propagation of accidents or to mitigate the consequences of accidents. (Government Decree 717/2013)

External events

External events shall refer to exceptional situations or incidents occurring in the vicinity of a nuclear power plant that could have a detrimental effect on the safety or operation of the plant.

Attenuation function

Attenuation function shall refer to a function presenting the acceleration, speed or displacement of the ground motions caused by an earthquake of a certain magnitude as a function of the distance between earthquake's centre and the point of observation, and the frequency of oscillations. The attenuation function can be presented separately for longitudinal and transversal waves.

Severe reactor accident

Severe reactor accident shall refer to an accident in which a considerable part of the fuel in a reactor loses its original structure. (Government Decree 717/2013)

(N+1) failure criterion

(N+1) failure criterion shall mean that it must be possible to perform a safety function even if any single component designed for the function fails.

(N+2) failure criterion

(N+2) failure criterion shall mean that it must be possible to perform a safety function even if any single component designed for the function fails and any other component or part of a redundant system – or a component of an auxiliary system necessary for its operation – is simultaneously out of operation due to repair or maintenance.

Site area

Site area shall refer to an area in use by nuclear power plant units and other nuclear facilities in the same area, and to the surrounding area, where movement and stay are restricted by the Decree of the Ministry of the Interior issued under Section 52 of the Police Act (493/1995). (Government Decree 716/2013)

Nuclear facility

Nuclear facility shall refer to facilities used for the generation of nuclear energy, including research reactors, facilities implementing the large-scale final disposal of nuclear waste, and facilities used for the large-scale production, generation, use, processing or storage of nuclear material or nuclear waste. However, nuclear facility shall not refer to: a) mines or milling facilities intended for the production of uranium or thorium, or premises and locations with their areas where nuclear waste from such facilities is stored or located for final disposal; or b) premises finally closed and where nuclear waste has been placed in a manner approved as permanent by the Radiation and Nuclear Safety Authority. (Nuclear Energy Act 990/1987, Section 3)

Nuclear power plant

Nuclear power plant shall refer to a nuclear facility for the purpose of electricity or heat production, equipped with a nuclear reactor, or a complex consisting of nuclear power plant units and other related nuclear facilities located at the same plant site. (23 May 2008/342) (Nuclear Energy Act 990/1987)

Common cause failure

Common cause failure shall refer to a failure of two or more structures, systems and components due to the same single event or cause.

Single failure

Single failure shall refer to a failure due to which a system, component or structure fails to deliver the required performance.

References

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8. Seismic Hazards in Site Evaluation for Nuclear Installations, SSG-9, IAEA, 2010.
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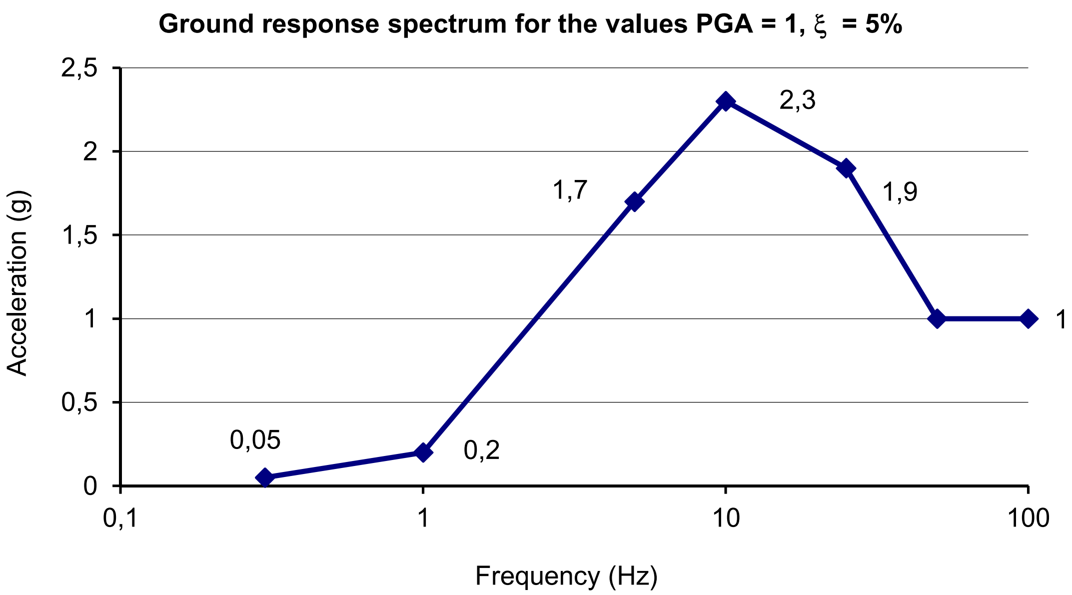
Appendix An example of an acceptable spectrum

A01. An example of an acceptable ground response spectrum corresponding to peak ground acceleration PGA = 1 g and the damping ratio ξ = 5%

Ground response spectrum acceleration values are directly proportional to peak ground acceleration (PGA), which corresponds to the spectrum value at frequencies exceeding 50 Hz. At frequencies below 50 Hz, accelerations decrease with increasing values of the damping ratio ξ of an idealised single-degree-of-freedom oscillator anchored in the bedrock. The spectrum applicable to the bedrock of Finland's land area south of the 63rd latitude north, corresponding to the values PGA = 1 and ξ = 5%, can be presented as follows:



The acceleration values corresponding to the below frequencies are:

Frequency (Hz)	0.3	1	5	10	25	50	100
Acceleration (g)	0.05	0.2	1.7	2.3	1.9	1	1

The spectrum shape applies to both vertical and horizontal accelerations. The spectrum shape is to be scaled using an actual PGA value, which is vertically 2/3rds of the horizontal PGA value. The spectrum shape for other ξ values is to be determined separately.

Source: STUK decision Rec. no. C30/78, 6 November 2001.