

CLASSIFICATION OF SYSTEMS, STRUCTURES AND COMPONENTS OF A NUCLEAR FACILITY

1	INTRODUCTION	3
2	SCOPE OF APPLICATION	3
3	CLASSIFICATION REQUIREMENTS	3
3.1	Principles of safety classification	3
3.2	Classification criteria relating to safety functions	4
3.3	Classification criteria ensuring structural resistance, integrity and leaktightness	5
3.4	Seismic classification	6
3.5	Classification document	7
4	REGULATORY OVERSIGHT BY THE RADIATION AND NUCLEAR SAFETY AUTHORITY	8
	DEFINITIONS	8
	REFERENCES	9

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 2.1.

First edition
Helsinki 2014

ISBN 978-952-309-070-5 (print) Kopijyvä Oy 2014
ISBN 978-952-309-071-2 (pdf)
ISBN 978-952-309-072-9 (html)

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.*

1 Introduction

101. Under Section 4 of the Government Decree on the Safety of Nuclear Power Plants (717/2013), *“the safety functions of a nuclear power plant shall be defined and the systems, structures and components implementing them and related to them classified on the basis of their safety significance. In addition, “systems, structures and components that implement or are related with safety functions shall be designed, manufactured, installed and used so that their quality level, and the assessments, inspections and tests, including environmental qualification, required to verify their quality level, are sufficient considering the safety significance of the item in question”.*

102. Under Section 7 of the Government Decree on the Safety of the Disposal of Nuclear Wastes (736/2008), *“The systems, structures and components of a nuclear waste facility shall be classified on the basis of their significance in terms of the operational safety of the facility, or the long-term safety of disposal. The required quality level of each classified object, and the inspections and testing necessary for verifying the quality, shall be adequate as regards the significance of the object in terms of safety.*

103. The quality management requirements applied to the systems, structures and components of different safety classes are given in Guides YVL A.3 Management system for a nuclear facility, YVL B.1 Safety design of a nuclear power plant and, with regard to components and structures in various fields of technology, in the E Series YVL guides.

2 Scope of application

201. This Guide applies to the safety classification and seismic classification of nuclear facilities, classification document review as well as the design, construction and operation requirements for facility parts that ensue from classification.

202. Systems, structures and components associated primarily with nuclear security are subject to oversight under Guide YVL A.11 and are not classified based on this Guide.

3 Classification requirements

3.1 Principles of safety classification

301. Classification of the nuclear facility’s systems, structures and components shall primarily be based on deterministic methods supplemented, where necessary, by a Probabilistic Risk Assessment (PRA) and expert judgement.

302. For management of the nuclear facility’s safety functions, the facility shall be divided into structural and functional entities, i.e. systems. The systems shall be further divided into structures and components. The division shall be such that every structure and component affecting the nuclear facility’s operation and safety shall belong to a system.

303. The nuclear facility’s systems, structures and components shall be grouped into the Safety Classes 1, 2, and 3 and Class EYT (non-nuclear safety).

304. The safety classification of systems shall be based on the facility’s safety functions and the significance of the systems that perform them in terms of the reliability of these safety functions, with due consideration to ensuring safety by defence-in-depth.

305. The safety classification of structures shall be based on the structural strength, integrity and leaktightness required to accomplish safety functions or to prevent the spreading of radioactive substances. A structure’s safety class is determined based on which of these justifications requires a higher safety class.

306. The safety classification of components shall be based on the function required of them to accomplish safety functions or to prevent the spreading of radioactive substances as well as on the structural strength, integrity and leaktightness required of them. A component’s safety class is determined based on which of these justifications requires the highest safety class.

307. All components defined as a safety class boundary are assigned to a higher safety class.

308. In establishing and applying safety classification, attention shall be paid to the fact that ensuring safety sets different requirements on different types of equipment. For example, structural integrity, mechanical strength and corrosion resistance for pressure equipment and pressurised piping are required. Also functional reliability is required for pumps and valves, Non-pressurised piping and vessels shall, above all, be resistant to corrosion. In fuel storage, the preservation of the storage geometry within safe limits of the storage geometry is of vital importance. With the help of safety classification, requirement levels are graded among systems, structures and components of the same type. The requirements to be set for different types of components need not be similar, but the requirements shall underline the reliability of each component, the focus being on their most important safety features.

309. The quality requirements for systems, structures and components as well as for quality assurance shall be so defined that the requirement level is higher in a higher safety class. The requirements shall focus on matters affecting the reliability of safety functions: verification of the structural integrity of structures and components as well as the operational reliability of systems. The requirements shall cover the design, manufacture, construction, installation, commissioning, inspection and actions during the operation of the classified item. In the requirement specification, standards applicable to the component in question shall be applied.

3.2 Classification criteria relating to safety functions

310. Systems shall be grouped into Safety Classes 2 and 3 as well as Class EYT (non-nuclear safety) based on their significance for the reliability of safety functions from the viewpoint of the management of initiating events.

311. When a structure or component is needed to accomplish a system's safety function, or when

the structure or component essentially affects the system's safety significance, the system structure or component is assigned to the same safety class as the system that forms the structural or functional entity. Individual components may also be assigned to a safety class higher than the system itself, for example, in positions where the system connects to a system in a higher safety class. Individual components may also be assigned to a lower safety class if it can be justifiably demonstrated that they have no effect on the accomplishment of the system's safety function.

312. Systems accomplishing safety functions shall be assigned to Safety Class 2 if they are designed to provide against postulated accidents to bring the facility to a controlled state and to maintain this state for as long as the prerequisites for transfer to a safe state can be ensured.

313. Safety Class 3 shall include systems accomplishing safety functions that

1. are designed to bring the facility into a safe state over a long period of time
2. are designed for severe reactor accident management
3. accomplish the diversity principle and are designed to ensure the bringing of the facility into a controlled state in case of the failure of systems primarily taking care of a corresponding safety function
4. mitigate the consequences of anticipated operational occurrences unless they are assigned to a higher safety class for some other reason
5. are designed to control reactor power, pressure or make-up water (the main controllers of the nuclear power plant) provided that they, in case of their failure, directly initiate a Safety Class 2 safety function.
6. contribute to fuel handling or lifting of heavy loads and may, in case of their failure, damage structures important to safety or cause fuel failure
7. have been installed as fixed parts of the plant contributing to the monitoring of dose rates and air activity concentration at the nuclear power plant's rooms and monitoring of radioactive substances in the systems or the monitoring of radioactive releases from the plant.

8. are designed to cool spent fuel
9. prevent the spreading of radioactive substances outside the containment
10. are essential for the maintenance of control room habitability
11. are essential for the control and management of anticipated operational occurrences and accidents (measurement systems).

314. The following part of systems belonging to Class EYT shall be allocated to Class EYT/STUK if the system

1. has facility-specific risk importance in consequence of the initiating events caused by its failure
2. protects safety functions, such as fire protection systems, against internal or external threats
3. monitors the radiation, surface contamination or radioactivity of the plant, instruments, workers or the environment (e.g. the environmental radiation monitoring network) but is not assigned to Safety Class 3.
4. is necessary for bringing the facility to a controlled state in case of an event involving a design basis category DEC combination of failures (DEC B) or a rare external event (DEC C).

3.3 Classification criteria ensuring structural resistance, integrity and leaktightness

315. Based on the structural strength, integrity and leaktightness required of them to prevent the spreading of radioactive substances, structures and components shall be grouped into three Safety Classes 1, 2 and 3 as well as Class EYT (non-nuclear safety).

316. Safety Class 1 shall include nuclear fuel as well as structures and components whose failure could result in an accident compromising reactor integrity and requiring immediate actuation of safety functions. Safety Class 1 includes the reactor pressure vessel and those components of the primary circuit whose failure results in a primary circuit leak that cannot be compensated for by systems relating to normal plant operation.

317. The following primary circuit components not assigned to Safety Class 1 shall be classified in Safety Class 2:

1. small-diameter piping which, in the event of a break, do not cause a leak that cannot be compensated for by systems relating to normal plant operation.
2. components connected to the reactor coolant system through a passive flow-limiting device and which do not, in case of rupture, cause a leak larger than is manageable by systems relating to normal plant operation.
3. components which, in the event of their rupture, can be isolated from the reactor coolant system by two successive, automatically closing valves having a closing time that is short enough to allow for safe reactor shutdown and cooldown

318. To be assigned to Safety Class 2 are structures and components whose

1. integrity is required for reactor decay heat removal or the containment of radioactive substances inside the facility following a Safety Class 1 component failure or pipe rupture
2. failure brings about the danger of an uncontrolled chain reaction
3. failure endangers nuclear fuel integrity
4. failure endangers integrity of a Safety Class 1 barrier.

These structures and components include

- main components and piping of the emergency core cooling system
- structures of the core support and reactor shutdown system
- primary circuit piping supports and brackets
- the reactor containment including structures relating to the containment isolation function as well as other structures directly connecting to the containment
- fuel storage racks.

319. To be assigned to Safety Class 3 are

1. buildings and structures ensuring the operability and physical separation of Safety Class 2 systems

2. buildings and structures ensuring Safety Class 3 functions
3. structures and components relating to barriers to the dispersion of radioactive substances or structures relating to the handling of radioactive materials not assigned to higher safety classes and whose failure could result in a significant release of radioactive substances on-site or to the environment.

320. When determining the safety class of small-diameter piping ($DN \leq 50$), the following principles shall be followed:

1. Small-diameter piping ($DN \leq 20$) connected to Safety Class 1 piping or equipment belongs to Safety Class 2. The leakage control pipes ($DN \leq 20$) of the sealings of primary circuit equipment belong to Safety Class 3.
2. Small-diameter piping connected to Safety Class 2 piping or equipment belongs to Safety Class 3.
3. Small-diameter piping connected to Safety Class 3 piping or equipment belongs to Class EYT (non-nuclear safety).

321. The classification of small-diameter piping is not lowered if a leak in the pipe results in the loss of the safety function on which the classification is based. Small-diameter piping of this kind includes impulse lines relating to protection I&C systems measurements, fuel pipes of diesel generators and coolant pipes of pumps.

322. Piping supports and brackets shall be placed in a safety class one step lower than the class of piping they support. The supports of Safety Class 3 and EYT piping belong to Class EYT.

3.4 Seismic classification

323. The systems, structures and components of nuclear facilities shall be assigned to three categories, S1, S2A and S2B, based on the seismic resistance requirements set for them.

324. Systems, structures and components assigned to seismic category S1 shall maintain their integrity, leaktightness, functionality and proper position in a loading situation caused by a design basis earthquake. If justifiable, some components may be assigned only a certain feature,

such as leaktightness, which must be maintained in a loading situation induced by a design basis earthquake.

325. Seismic category S1 comprises

1. in a boiling water reactor, the reactor pressure vessel, steam pipes up to turbine quick-closing valves and also other piping connecting to the primary circuit up to the containment isolation valves
2. in a pressurised water reactor, the reactor pressure vessel, primary circuit piping and valves, pressuriser, primary circulation pumps, steam generators and secondary circuit pipelines up to the containment isolation valves.
3. reactor internals
4. Safety Class 2 systems, structures and components required to bring the plant to a controlled state during anticipated operational occurrences or Category 1 accidents at least to the extent that the system's earthquake-resistant subsystems accomplish the single-failure criterion.
5. systems, structures and components which, in case of failure, may bring about a significant spreading of radioactive substances inside or outside the facility
6. systems, structures and components required to bring the reactor into a safe state and maintain this state
7. systems and structures ensuring the subcriticality and cooling of nuclear fuel, spent fuel storage pools included
8. systems, structures and components that are essential for emergency response activities
9. systems which are located in rooms containing safety-classified systems, components or structures and which contain oil, other inflammable fluids or combustible gases or oxygen and other systems whose failure in consequence of a seismic event causes a fire hazard, and systems containing great amounts of toxic or asphyxiating gases
10. the fire detection and alarm systems as well as fire extinguishing systems with extinguishing agents in rooms containing safety-classified components, unless the consequences of a fire can be demonstrated as highly insignificant by analyses.

326. Seismic category S2A comprises systems, structures and components the maintenance of whose operability and integrity is not essential for the accomplishment of safety functions but which may have effects depending on their location (e.g. collapse, falling) or due to other reasons (release of a hazardous substance, fire, flooding) on the safety-related operation or integrity or automated safety functions of seismic category S1 structures and components.

327. All seismic category S1 and S2A components shall be assigned the characteristics (e.g. functionality, integrity) that they must maintain after a loading situation caused by a design basis earthquake.

328. Seismic category S2B shall comprise all other systems, structures and components of the nuclear facility.

329. Seismic categorisation shall be verified by means of Probabilistic Risk Assessment (PRA).

330. The design of systems, structures and components in seismic categories S1 and S2A shall take into account vibration-induced loadings following a large commercial airliner crash and an explosion pressure wave, unless it can be demonstrated, based on the failure criteria applied to the event that it is unnecessary for some systems, structures and components. These matters shall be mentioned in the relevant seismic category-related part of the classification document.

3.5 Classification document

331. Sections 35 and 36 of the Nuclear Energy Decree contain the requirement that the classification document be submitted to STUK as part of the construction and operating licence application.

332. The classification document shall present

1. a marking system for nuclear facility systems and components
2. a list of systems

3. system-specific lists of structures and components for Safety Class 1, 2 and 3 components as well as lists of Class EYT pressure equipment and Class EYT/STUK systems
4. flow diagrams for process systems and air conditioning
5. main diagrams for electrical systems
6. conceptual diagrams of I&C systems
7. safety classification criteria
8. safety class of systems, structures and components
9. connection between safety class and quality requirement
10. seismic classification criteria
11. seismic classification of systems, structures and components
12. environmental qualification of structures and components
13. software and their recording equipment.

333. In the list of systems, the systems shall be consistently arranged into groups and provided with identification markings and safety class designations.

334. Classification of buildings, structures and the facility's main components and their physical location at the facility shall be presented in drawings or in some other manner appropriate for presenting building classification.

335. System boundaries shall be unambiguously indicated in the classification document's main diagrams for electrical systems and in the schematic diagrams of I&C systems.

336. The flow diagrams of process systems shall show at least system and class boundaries as well as the process-technical location of components in the system. The safety classification of piping shall be indicated in the flow diagrams of the process systems.

337. The classification document shall be updated during the nuclear facility's operation.

4 Regulatory oversight by the Radiation and Nuclear Safety Authority

401. Based on their safety class, STUK determines the scope of the regulatory oversight of systems, structures and components.

402. During the application for a construction licence, STUK assesses the appropriateness of the preliminary system-level safety classification document required under Section 35 of the Nuclear Energy Decree (161/1988) and approves the preliminary classification document.

403. During the construction licence phase, STUK reviews and, based on the review, approves the final classification document.

404. During the nuclear facility's operation, STUK reviews and, based on the review, approves modifications and additions to the classification document. STUK also assesses any needs to modify the classification document based on operating experience and the results of PRA, for example.

Definitions

Diversity principle

Diversity principle shall refer to the backing up of functions through systems or components having different operating principles or differing from each other in some other manner, with all systems or components able to implement a function separately. (Government Decree 717/2013)

Controlled state

Controlled state shall refer to a state where a reactor has been shut down and the removal of its decay heat has been secured. (Government Decree 717/2013)

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.

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.

System

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

Seismically classified system/structure/component

Seismically classified system, structure or component shall refer to a system, structure or component which has been classified in different seismic categories based on the earthquake resistance requirements set for them.

Normal power supply systems

Normal power supply systems shall refer to power supply systems whose operation is not secured by safety-classified auxiliary power supply systems located within the plant site.

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. accident caused by a rare external event and which the facility is required to withstand without severe fuel failure (DEC C).

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 ($1 \times 10^{-5}/a$) at median confidence level. A design basis earthquakes are represented using peak ground acceleration and ground response spectra.

Probabilistic risk assessment (PRA)

Probabilistic fire risk assessment shall refer to a quantitative assessment of the fire-induced hazards, probabilities and negative consequences of sequences of events influencing the safety of a nuclear power plant. (Government Decree 717/2013)

Safe state

Safe state shall refer to a state where the reactor has been shut down and is non-pressurised, and removal of its decay heat has been secured. (Government Decree 717/2013)

Safety system

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

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.

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)

References

1. Nuclear Energy Act (990/1987)
2. Nuclear Energy Decree (161/1988)
3. Government Decree on the Safety of Nuclear Power Plants (717/2013)
4. Government Decree on the Safety of Disposal of Nuclear Waste (736/2008)
5. Government Decree on Emergency Response Arrangements at Nuclear Power Plants (716/2013).
6. Safety of Nuclear Power Plants: Design. IAEA Safety Standards Series, Requirements, No. SSR 1/2. IAEA 20.2.2012.
7. WENRA reference requirements, Issue G.
8. Safety Classification of Structures, Systems and Components in Nuclear Power Plants, DS367, 4th April 2013, IAEA