

Nuclear power plant systems, structures and components and their safety classification

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Authorisation

By virtue of the below acts and regulations, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Council of State Decision (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Council of State Decision (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Council of State Decision (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Council of State Decision (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Council of State Decision (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or to those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account section 27 of the Council of State Decision (395/1991), which prescribes that *for further safety enhancement, action shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.*

If deviations are made from the requirements of the YVL guides, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the YVL guides is achieved.

1 General

The assurance of a nuclear power plant's safety is based on the reliable functioning of the plant as well as on its appropriate maintenance and operation. To ensure the reliability of operation, special attention shall be paid to the design, manufacturing, commissioning and operation of the plant and its components. To control these functions the nuclear power plant is divided into structural and functional entities, i.e. systems.

A system's safety class is determined by its safety significance. Safety class specifies the procedures to be employed in plant design, construction, monitoring and operation. The classification document contains all documentation related to the classification of the nuclear power plant.

The principles of safety classification and the procedures pertaining to the classification document are presented in this guide. In the Appendix to this guide, examples of systems most typical of each safety class are given to clarify the safety classification principles.

2 Safety classes

In accordance with the Council of State Decision on the safety of nuclear power plants [1]:

The functions important to the safety of the systems, structures and components of a nuclear power plant shall be defined and the systems, structures and components classified according to their safety significance.

The systems, structures and components important to safety shall be designed, manufactured, installed and operated so that their quality level and the inspections and tests required to verify their quality level are adequate considering any item's safety significance.

To comply with the above principles, the systems, structures and components of the nuclear power plant are grouped into Safety Classes 1, 2, 3, 4 and Class EYT (classified non-nuclear).

The items with the highest safety significance belong to Safety Class 1.

Safety class determines what quality requirements apply to the nuclear power plant's systems, structures and components and to their quality assurance. The applicant for a construction or operating licence shall define how safety class and quality requirements on the one hand and safety class and quality assurance on the other hand are interrelated.

The scope of the regulatory control of systems, structures and components is determined by safety class. The regulatory control of systems based on safety classification is described in Guide YVL 2.0, among others. The inspection and control practices for structures and components in Safety Classes 1, 2, 3, 4 and Class EYT are described in the respective YVL guides.

Safety classified pressure equipment are *nuclear pressure equipment* and those in Class EYT are *conventional pressure equipment*.

When a system of safety classification is drawn up, in addition to the principles presented in this guide, the construction and layout of the nuclear power plant and the functions assigned to its systems are considered. Plant-specific applications always require a case-specific consideration of the classification details.

Systems, structures and components pertaining to physical protection are controlled according to Guide YVL 6.11; this guide thus does not apply to their classification.

Requirements for the seismic classification of nuclear power plant components and structures are given in Guide YVL 2.6.

3 Classification criteria

For the purpose of classification, the nuclear power plant shall be divided into structural or operational units called systems. Every structure and component shall belong to a system. A system is, for example, a part of the primary circuit, an auxiliary process carrying out a spe-

cific function, a control circuit, a building or part thereof, or a number of individual components serving the same purpose. Every system that is a structural or operational entity shall be assigned to a safety class or to Class EYT.

Systems in Safety Classes 1, 2, 3 and 4 shall be subdivided, in sufficient detail, to structures and components. An item that forms a clearly definable entity as regards manufacture, installation and quality control may be regarded as one structure or component. Every structure and component shall be assigned to a safety class or to Class EYT. When a structure or component essentially affects a system's safety significance, or when the structure or component is needed to accomplish the system's safety function, the structure or component is assigned to the same safety class as the system itself. Less important system parts may be in a lower safety class or in Class EYT. On the other hand, individual components may be assigned to a safety class higher than the system itself, for example at points where the system connects to a system in a higher safety class.

When safety classification is established attention shall be paid, in the first place, to the following points:

- safety functions in the accomplishment of which the item to be classified takes part or which it ensures
- immediate impact on the continuous maintaining of a safety function if an item fails during normal operation
- immediate impact on the continuous maintaining of a safety function if an item fails during a transient or an accident
- the possible emergence of an initiating event that could endanger nuclear or radiation safety and prevention of the initiating event's progression.

In addition, the following points may be taken into account:

- available compensatory systems and their classification
- possibilities for fault detection if the fault does not immediately affect normal plant operation

- the time available for repair before the fault would lead into a partial or complete loss of a safety function
- repair possibilities taking into account i.a. accessibility, how demanding the repair work is, availability of spare parts and materials, and isolation possibility during work
- necessary process actions such as cooling, pressure relief and decontamination before repair work
- increase in the reliability of the item concerned through requirements based on safety classification.

When safety classification is established and applied attention shall be paid to the fact that the ensuring of safety functions sets different requirements on equipment of different types. The most important feature of pressure vessels and pipes, for example, is their mechanical endurance and structural integrity. Of pumps and valves, also operational reliability is required. In fuel storage, the central issue is the preservation within safe limits of the storage geometry. With the help of safety classification, requirement levels are graded among equipment of the same type. The requirements to be set for equipment of different types need not be mutually identical even if the equipment belonged to the same safety class.

4 Assigning systems to safety classes

Systems, structures and components shall be assigned to Safety Class 1, if their

- fault or failure would cause an accident immediately threatening the shutdown or cooling of the reactor and would require prompt starting of the safety systems.

Systems, structures and components shall be assigned to Safety Class 2, if their

- well-timed or continuous operation is necessary in design basis accidents to ensure reactor subcriticality and cooling, or to confine inside the reactor containment radioactive substances released from the reactor in consequence of an accident

- fault or failure would prevent continued operation, and would, at the same time, prevent cooling of reactor and removal of decay heat with the systems by which cooling and decay heat removal are normally carried out
- failure to function would cause a considerable risk of uncontrolled criticality, or
- fault or failure during an outage would prevent reactor decay heat removal with systems by which decay heat is normally removed in that particular state.

Systems, structures and components having an essential effect on the reliability of the below safety functions shall be assigned to Safety Class 3:

- reactor shutdown and maintaining of subcritical condition
- reactor cooling and decay heat removal from the reactor
- decay heat removal from spent fuel which is stored outside the reactor
- prevention of the dispersal of radioactive material, and
- mitigation of the consequences of severe accidents.

Systems by which the accomplishment of the safety functions mentioned above are monitored shall also be classified in Safety Class 3.

In addition, Safety Class 3 shall include systems whose function is to reliably prevent the progression of initiating events into situations during which a system maintaining or actuating a safety function is needed.

Safety Class 4 shall include systems that do not belong to a higher safety class and whose failure could

- cause an initiating event that could significantly endanger nuclear or radiation safety
- due to the high level of kinetic, pressure or thermal energy they contain, significantly endanger the plant environment or cause the loss of essential safety functions
- hinder safe plant operation or its management in transient and accident situations, for example computer systems.

Safety Class 4 shall include systems that

- during internal or external initiating events protect systems carrying out safety functions, for example the fire and flooding protection systems.

Safety Class 4 shall include also such structures and components of Class EYT systems whose failure could

- cause an initiating event that could significantly endanger nuclear or radiation safety
- due to the high level of kinetic, pressure or thermal energy they contain, significantly endanger the plant environment or cause the loss of essential safety functions.

An example of the systems safety classification of a nuclear power plant equipped with a light water reactor is given in the Appendix to this guide.

5 Classification document

The classification of the nuclear power plant's systems, structures and components is described in the classification document. Compilation of the classification document shall begin as early as possible during the plant design stage and the document shall be supplemented along with the progress of the plant design. The classification document shall be submitted to STUK for approval in connection with the construction licence application in accordance with section 35 of the Nuclear Energy Decree. The approval of the classification document is one of the preconditions for STUK's endorsement of the construction licence.

The classification document shall present

- a marking system for nuclear power plant systems and components
- a list of systems
- system-specific lists of structures and components
- main drawings of buildings, or other drawings appropriate for the presentation of the classification of buildings

- flow diagrams for process systems and air conditioning
- main diagrams for electrical systems
- conceptual design diagrams of I & C systems
- software and their recording equipment
- physical location of systems, structures and components at the plant.

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

System-specific lists shall be presented of structures or components in Safety Classes 1, 2, 3 and 4. In Class EYT systems, lists shall be presented of pressure equipment as well as of safety-classified components and structures. The structures and components are provided with designations beginning with system designations. The safety classes of buildings, structures and components shall be indicated in drawings.

The boundaries of safety classes shall be unambiguously presented in the main diagrams of electrical systems and in the conceptual design diagrams of I & C systems contained in the classification document.

The flow diagrams of process systems shall show system boundaries and the process-technical location of classified components in the system. The classification of piping is presented in the flow diagrams of the process systems.

Seismic classification in accordance with Guide YVL 2.6 is presented in the same classification document.

As the design of the plant proceeds, and in connection with modifications made during operation, the classification document shall be supplemented and updated accordingly. It is therefore recommended that the document be compiled in such a format that it can be easily updated. Any revisions of and supplements to the document shall be approved by STUK.

6 References

- 1 Decision of the Council of State (395/1991) on the General Regulations for the Safety of Nuclear Power Plants, 14 February 1991.

APPENDIX

An example of the systems safety classification of a nuclear power plant equipped with a light water reactor

1 Boundaries of systems containing liquid or gas

Primary circuit boundaries
Other safety class boundaries

2 Systems classification

Safety Class 1
Safety Class 2
Safety Class 3
Safety Class 4
Class EYT

1 Boundaries of systems containing liquid or gas

Primary circuit boundaries

The primary circuit means all pressure-retaining components included in the reactor cooling water system of nuclear power plants equipped with a pressurised or boiling water reactor, such as pressure equipment, piping, pumps and valves or components connected to the reactor cooling water system. The following are considered a primary circuit boundary:

- the outermost containment isolation valve in a pipeline that penetrates the reactor containment
- the outer of two valves which are kept closed during normal reactor operation in a pipeline that does not penetrate the reactor containment, and
- a safety or relief valve in the reactor cooling system.

In a nuclear power plant equipped with a boiling water reactor, the reactor cooling water system and the primary circuit referred to in this guide

are considered to extend to the outer isolation valves of the main steam and feed water pipelines.

The boundary valves of the primary circuit are included in the primary circuit.

Other safety class boundaries

In case a system in Safety Class 2 or 3 containing liquid or gas is connected to a system in a lower safety class, the safety class boundary may be defined to be:

- a passive device which reduces the flow so much that the system will remain operable even if a failure occurred in a lower safety class system; examples of flow limiters are a small pipe fitting, a throttle or a shaft gasket
- a valve which is normally kept closed
- the outer of two shut-off valves normally kept open, either of which can be closed so quickly that the system will remain operable even if a failure occurred in a lower safety class system
- a shut-off valve normally kept open in a system the safety function of which can be

carried out with a redundant system part even if attempts to close the boundary valve failed

- a check valve with its flow direction towards a higher safety class system
- a safety or relief valve.

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

Heat exchangers with one side connected to piping classified to a higher safety class and the other side to piping classified to a lower safety class are, as an entity, classified to the higher safety class. The steam generators of a pressurised water reactor plant are an exception to the general classification of heat exchangers; the primary side is classified to Safety Class 1 and the secondary side to Safety Class 2.

Small-diameter piping that belongs in a system assigned to Safety Class 2 or 3 and is not part of the primary circuit may be classified to a lower safety class or to Class EYT pursuant to Guide 3.3. A system's structures and components that are irrelevant in view of the main function of the system may be assigned to a lower safety class or to Class EYT on the same grounds as small-diameter piping.

The above boundaries do not apply to primary circuit components classified to Safety Class 2. Their boundaries have been defined in connection with the primary circuit.

2 Systems classification

Safety Class 1

- a) Reactor fuel.
- b) Primary circuit components whose rupture would result in a leakage of such magnitude that it could not be compensated for by the make-up water systems of the nuclear power plant. In conformity with this principle, the following primary circuit components remain outside Safety Class 1:
 - small-diameter pipes (inner diameter not more than 20 mm)
 - components connected to the reactor coolant system through a passive flow-limiting device and which, if ruptured, do not cause a leak larger than that caused by the rupture of a 20 mm pipe, as well as
 - components which, in the event of their failure, can be isolated from the reactor coolant system by two successive, automatically closing valves whose closing time is short enough to allow for normal reactor shutdown and cooldown.

Safety Class 2

- a) Primary circuit components not assigned to Safety Class 1.
- b) Systems and components required for a reactor trip.
- c) Emergency core cooling systems intended for loss-of-coolant accidents.
- d) The boron supply system required to shut down the reactor or to maintain it in a sub-critical condition during a postulated accident.
- e) A decay heat removal system for circulating the water of the reactor coolant system.
- f) At a PWR plant, the part of the make-up water system which is bounded by make-up water pumps and the primary circuit.
- g) The following parts of the steam and feed water systems
 - at a PWR plant, the part inside the reactor containment that is bounded by the outermost isolation valves
 - at a PWR plant, the part of the emergency feed water system of the steam generators that is bounded by the emergency feed water pumps and steam generators, and
 - at a BWR plant, those parts of the steam system outside the reactor containment

that are bounded by the isolation valves and the subsequent shut-off valves.

- h) The reactor containment and related systems required to ensure containment integrity in a postulated accident. Such systems may be for example:
- the containment spray system
 - other systems intended for the reduction of pressure and temperature within the containment
 - systems to prevent the formation of an explosive mixture of gases
 - personnel and material locks, penetrations and other equivalent structures, and
 - isolation valves of the reactor containment other than those included in the primary circuit, and parts of the piping penetrating the containment that are bounded by the valves.
- i) Supporting structures of the primary circuit
- j) Structures, such as emergency restraints and missile barriers, which protect components in Safety Class 1.
- k) Internals of the reactor pressure vessel that support the reactor core and are important for its coolability.
- l) Storage racks for fresh and spent fuel.
- m) A protective instrumentation and automation system for starting a reactor trip, reactor emergency cooling, isolation of reactor containment or other safety function necessary in a postulated accident.
- n) Electrical components and distribution systems necessary for the accomplishment of safety functions of systems in Safety Class 1 and 2.
- o) Electrical power supply equipment ensuring electricity supply to Safety Class 2 components upon loss of both offsite power and power supplied by the main generators.

Safety Class 3

- a) The boron supply system bounded by the borated water storage tank in so far as the system or parts thereof are not classified to a higher safety class.
- b) At a PWR plant, those parts of the reactor volume control system that are not assigned to a higher safety class.
- c) At a PWR plant, those parts of the emergency feed water system that are not assigned to Safety Class 2.
- d) Systems needed for the cooling and pressure relief of the primary circuit, if they are not classified to a higher safety class.
- e) Cooling systems, including their cooling water channels and tunnels, essential for the removal of
- reactor decay heat
 - decay heat from spent fuel stored outside the reactor
 - heat generated by Safety Class 2 components
 - heat generated by the above-mentioned systems themselves
- into the ultimate heat sink, and which do not belong to a higher safety class.
- f) Parts of the sealing water, pressurised air, lubricating, fuel, etc systems necessary for the start-up or operation of systems in Safety Classes 2 and 3.
- g) Systems for treating liquids or gases containing radioactive substances the failure of which could, compared to normal conditions, result in a significant dose increase to a plant employee or a member of the public.

Examples of such systems are:

- reactor cooling water cleanup system
- sampling systems of the primary circuit
- treatment and storage systems for liquid wastes, and
- radioactive gas treatment systems.

- h) Ventilation systems that reduce the radiation exposure of employees or the releases of radioactive materials into the environment. Below are examples of the functions of these systems:
- maintaining of pressure differences in the reactor building and filtering of its exhaust air (including the containment with its surrounding spaces)
 - ventilation of those rooms in the auxiliary building where radioactive contamination could occur
 - ventilation of the spent fuel storage
 - ventilation of quarters containing radioactive waste
 - ventilation of laboratories where considerable amounts of radioactive materials are handled, and
 - securing of working conditions in the control room and other rooms requiring continued stay during accidents, in case the air on-site contains radioactive or other hazardous materials.
- i) Air cooling and heating systems in rooms containing components classified to Safety Classes 1, 2 and 3; the systems are needed to maintain the temperature required for ensuring reliable functioning of the equipment, taking into account extreme outdoor air temperatures and the waste heat released in these rooms.
- j) Those reactor pressure vessel internals not assigned to Safety Class 2.
- k) Nuclear fuel handling and inspection systems whose malfunction could endanger fuel integrity.
- l) The following hoisting and transfer equipment:
- those parts of the control rod drives that are not assigned to Safety Class 1 or 2
 - the reactor building main crane
 - equipment needed for the lifting and transfer of nuclear fuel.
- m) Storages of spent fuel and liquid wastes, including pools and tanks.
- n) Buildings and structures designed to
- protect or support equipment in Safety Classes 2 or 3 and the failure of which could endanger the integrity of the equipment
 - protect workers to assure their ability to maintain functions important to safety in accident conditions.
- o) Concrete structures inside the reactor containment other than those assigned to Safety Class 2.
- p) Instrumentation and automation systems and components required for the following functions and not classified to a higher safety class:
- reactor power limitation systems
 - control of reactor main parameters (power, pressure, coolant volume)
 - monitoring and control of safety functions during accidents
 - monitoring and control of reactor power peaking
 - monitoring and control of safe plant shutdown from the main and standby control rooms
 - monitoring of reactor criticality during fuel loading
 - monitoring of primary circuit leaks
 - monitoring of hydrogen and oxygen concentrations inside the containment
 - monitoring of primary circuit water chemistry
 - on-site radiation monitoring during accidents
 - monitoring of radioactive releases
 - monitoring for radiation in rooms.
- q) Electrical components and electric power distribution systems required to accomplish the safety functions of Safety Class 3 systems.
- r) Systems designed to ensure the integrity of the reactor containment or to limit releases especially in a severe accident. Examples thereof are:
- systems limiting the containment pressure

- systems intended for the control and filtering of releases out of the containment
 - air circulating and filtering systems that clean the containment air space
 - systems that prevent the formation of an explosive gas mixture
 - systems intended for the monitoring of the condition of the reactor and the containment, and
 - systems and components required for cooling a molten core and for ensuring the integrity of containment penetrations and other openings.
- I & C and computer systems contributing to safe plant control and operation
 - safety-significant information management systems relating to plant operation and maintenance.

Safety Class 4

- a) Fire protection systems:
 - fire alarm systems
 - fire extinguisher systems.
- b) Of systems and components connected to turbine and generator, those that could significantly contribute to their failure, for example:
 - bearings
 - rotor
 - turbine and generator protection systems
 - turbine trip valves
 - oil systems
 - generator hydrogen cooling system
 - vibration monitoring system
 - generator circuit-breaker and field breaker.
- c) The below I&C and computer systems:
 - PWR secondary side main controls
 - monitoring of secondary circuit water chemistry
 - monitoring for radioactivity in laboratories
- d) Systems safeguarding electrical and I&C systems against external impacts:
 - protection against climatic overvoltages.
- e) Plant communication systems to assure normal operation and for use in accident management.
- f) Environmental radiation monitoring and meteorological measurements.
- g) Systems for monitoring external threats, for example:
 - a flood monitoring system
 - a system for monitoring the ultimate heat sink (i.e. the sea)
 - a frazil ice monitoring system.
- h) An alarm system for giving warning of imminent danger onsite.
- i) The thermal insulation of piping and structures inside the containment.
- j) The feed water system of a boiling water reactor plant.
- k) The main electrical power systems.

Class EYT

Includes all systems, structures and components not assigned to Safety Classes 1, 2, 3 or 4.