

# Safety classification of nuclear power plant systems, structures and components

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

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## Authorization

The Finnish Centre for Radiation and Nuclear Safety (STUK) issues detailed regulations concerning the safety of the nuclear power plants by virtue of Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/87) and Section 29 of the Decision of the Council of State on the General Regulations for the Safety of Nuclear Power Plants (395/91).

The YVL guides are rules any individual licensee or any other organization concerned shall comply with unless some other acceptable procedure or solution is presented to STUK by which the safety level laid down in an YVL guide is achieved.

## 1 General

According to the Decision of the Council of State on the General Regulations for the Safety of Nuclear Power Plants /1/, systems, structures and components important to safety shall be designed, manufactured, installed and operated in such a way that their quality level and the inspections and tests needed to verify their quality level are commensurate with the importance to safety of each item. To facilitate compliance with this principle, the systems, structures and components of a nuclear power plant are assigned to Safety Classes 1, 2 and 3, and to Class EYT (non-nuclear). Items most important to safety are assigned to Safety Class 1.

Safety Class provides a starting point for the definition of the requirements to be set for the quality assurance of nuclear power plant systems, structures and components. The interdependence between Safety Class and quality assurance is defined by the licensee in the quality assurance documents required under Guide YVL 1.4.

Safety classification is the basis also when determining the regulatory control by the Finnish Centre for Radiation and Nuclear Safety (STUK). The interdependence between safety classification and the requirements to be set and presented in detail in the various YVL guides. STUK also provides guidance on the inspection practice case by case.

The seismic classification of nuclear plant components and structures is given in Guide YVL 2.6.

## 2 Scope

The guide pertains to new nuclear power plants and to the safety classification of systems, structures and components designed for the refitting of old nuclear power plants. The guide gives the classification principles and procedures pertaining to the classification document. The guide's Appendix gives

examples clarifying the classification principles of systems which typically belong to the mentioned classes.

When establishing safety classification, attention shall be paid, besides the principles presented in this Guide, to the structure of the nuclear power plant and the tasks determined for its systems. Plant-specific applications always require consideration of the details of classification case by case. During construction and operation each plant shall adhere to the safety classification presented in the classification document approved by STUK for the plant in question.

## 3 Items to be classified

For classification, the nuclear power plant shall be divided into structural or operational units called systems. The division shall be such that every structure and component under STUK's control is included in some system. For example, a system may consist of a part of the primary circuit, an auxiliary process which carries out a certain function or a control circuit, a building or a part thereof, or a number of separate components serving the same purpose. Each system shall be assigned to a Safety Class or Class EYT.

Systems in Safety Classes 1, 2 and 3 shall be further subdivided into structures and components. An item which forms a clearly definable entity as regards manufacture, installation and quality control can be regarded as one structure or component. Each structure and component shall be assigned to a Safety Class or Class EYT.

## 4 General classification criteria

When establishing safety classification, attention shall be paid to the importance of systems, structures and components in ensuring the nuclear power plant's safety functions. The general principle is that the structure or component of a system is in the

same Safety Class as the system itself, if this is necessary for the accomplishment of the system's safety function. Less important parts of the system can be placed in a lower Safety Class or in Class EYT. On the other hand, individual components at points where a system connects with another system in a higher Safety Class, can also be placed in a Safety Class higher than the system itself.

When establishing safety classification, 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 maintenance of a safety function if an item fails during normal operation,
- immediate impact on the continuous maintenance of a safety function if an item fails during a transient or an accident.

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

- available additional 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, isolation possibility during work and 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 the safety classification.

When establishing and applying safety classification, attention shall be paid to the fact that ensuring safety functions sets different requirements on equipment of different types. For instance, as regards pressure vessels and pipes, the most important issue is their mechanical endurance and structural integrity. Also operational reliability is required of pumps and valves. In fuel storage, the central issue is the preservation within safe limits of the storage geometry. With the help of safety classification, the 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.

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 radioactive substances released from the reactor in consequence of the accident inside the reactor containment,
- 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 operate 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 safety functions shall be assigned to Safety Class 3:

- reactor shutdown and maintenance 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.

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

## 5 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. In connection with the construction licence application, the classification document shall be submitted to STUK for approval, in accordance with Section 35 of the Nuclear Energy Decree. Approval of the classification document is

one precondition 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, and
- block and signal diagrams for the instrumentation and control systems.

In the list of systems, the systems shall be consistently arranged in groups and provided with identification marks as well as with Safety Class designations.

System-specific lists of structures and components shall be presented of systems in Safety Classes 1, 2 and 3. The structures and components shall be provided with designations having the system designation as the first part, and their Safety Class is given. For systems classified in Class EYT, lists of pressure vessels included in the systems shall be presented.

Classification of buildings shall be presented in drawings.

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. The modifications and supplements shall be approved by STUK.

## 6 References

- 1 Decision of the Council of State (395/91) on the General Regulations for the Safety of Nuclear Power Plants, 14 Feb. 1991
- 2 IAEA Safety Series No. 50-SG-D1, 1979, Safety Functions and Component Classification for BWR, PWR and PTR.

## 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**  
**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 pressurized or boiling water reactor, such as pressure vessels, piping, pumps, and valves or components which are 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 feedwater 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,

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- 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 may be carried out with a redundant system part, although attempts to close the boundary valve failed,
- a check valve with its flow direction towards the system, and
- a safety or relief valve.

All components defined as a Safety Class boundary are assigned to an upper Safety Class.

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

Small-diameter piping which belongs in a system assigned to Safety Class 2 or 3 and which is not part of the primary circuit may be classified to a lower Safety Class or to Class EYT, pursuant to sub-section 1.1 of Guide YVL 3.3. A system's structures and components which 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 the 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

Primary circuit components whose rupture would result in a leakage of such magnitude that it could not be compensated 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 greater 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 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 classified 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 feedwater systems:
- at a PWR plant, the part inside the reactor containment which is bounded by the outermost isolation valves
  - at a PWR plant, the part of the emergency feedwater system of the steam generators which is bounded by the emergency feedwater pumps and steam generators, and
  - at a BWR plant, those parts of the steam system outside the reactor containment which are bounded by the isolation valves and the subsequent shut-off valves.
- h) The reactor containment and the related systems required to ensure containment integrity in a postulated accident. Such systems may be e.g.
- 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 which are bounded by the valves.
- i) Supporting structures of the primary circuit.
- j) Structures, such as emergency restraints and missile shields, which protect components in Safety Class 1.
- k) Internals of the reactor pressure vessel which support the reactor core and are important to 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 Classes 1 and 2.
- o) Electrical power supply equipment ensuring electricity supply to Class 2 components upon loss of both off-site 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 which are not assigned to a higher Safety Class.
- c) At a PWR plant, those parts of the emergency feedwater system which are not assigned to Safety Class 2. If other systems have been designed to ensure the emergency feedwater system which meets the minimum requirements of

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- Guide YVL 2.7, these may, in their entirety, be placed to Safety Class 3.
- 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 essential for the removal of
- reactor decay heat,
  - decay heat from spent fuel stored outside the reactor,
  - heat generated by Safety Class 2 components, and
  - heat generated by the systems themselves
- into the ultimate heat sink, and which do not belong in a higher Safety Class.
- f) Parts of the sealing water, pressurized 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 which significantly reduce the radiation exposure of employees or releases of radioactive materials into the environment. Below are examples of the functions of these systems.
- maintenance of pressure ratios and filtering of exhaust air in the reactor building (including the containment with its surrounding spaces),
  - ventilation of those rooms in the auxiliary building where radioactive contamination may 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 safety-classified components; 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 into these rooms.

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- j) Those reactor pressure vessel internals not assigned to Safety Class 2.
  - monitoring of reactor power peaking,
  - monitoring and control of the safe shutdown of the plant from the main and standby control rooms,
- k) Nuclear fuel handling and inspection systems whose malfunction may endanger fuel integrity.
  - monitoring of the reactor's condition during fuel loading,
  - monitoring of leaks in the primary circuit,
- l) The following hoisting and transfer equipment:
  - those parts of the control rod drives which are not assigned to Safety Classes 1 or 2,
  - the reactor building main crane, and
  - 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
  - control of hydrogen and oxygen concentrations inside the containment,
  - on-site radiation monitoring during accidents,
  - control of radioactive releases,
  - radiation monitoring of rooms, and
  - an alarm system for alerting people on-site of imminent danger.
- 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:
  - electrical components and electric power distribution systems required to accomplish the safety function of Class 3 systems.
  - 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 which clean the containment air space,
    - systems which prevent the formation of an explosive mixture of gases,
    - systems intended for the monitoring of the condition of the reactor and the containment, and
    - systems and components required for cooling the molten core and for ensuring the integrity of containment penetrations and other openings.

## YVL guides

### General guides

YVL 1.0 Safety criteria for design of nuclear power plants, 1 Dec. 1982

YVL 1.1 The Finnish Centre for Radiation and Nuclear Safety as the regulatory authority in control of the use of nuclear energy, 27 Jan. 1992

YVL 1.2 Documents to be submitted to the Finnish Centre for Radiation and Nuclear Safety concerning the regulation of nuclear facilities, 22 May 1991 (in Finnish)

YVL 1.3 Mechanical components and structures of nuclear power plants. Inspection licenses, 25 March 1983

YVL 1.4 Quality assurance of nuclear power plants, 20 Sep. 1991

YVL 1.5 Reporting nuclear power plant operation to the Finnish Centre for Radiation and Nuclear Safety, 18 Aug. 1989

YVL 1.6 Nuclear power plant operator licensing, 3 March 1989

YVL 1.7 Qualifications of nuclear power plant personnel, 12 Jan. 1978

YVL 1.8 Repairs, modifications and preventive maintenance at nuclear facilities, 2 Oct. 1986

YVL 1.9 Quality assurance of nuclear power plant operation, 13 Nov. 1991 (in Finnish)

YVL 1.13 Regulatory inspections related to shutdowns at nuclear power plants, 9 May 1985

YVL 1.15 Mechanical components and structures in nuclear installations, Construction inspection, 16 April 1984

### Systems

YVL 2.1 Safety classification of nuclear power plant systems, structures and components, 22 May 1992

YVL 2.2 Transient and accident analyses for justification of technical solutions at nuclear power plants, 7 Oct. 1987

YVL 2.3 Preinspection of nuclear power plant systems, 14 Aug. 1975

YVL 2.4 Over-pressure protection and pressure control during disturbances in the primary circuit and steam generators of a PWR plant, 19 Sept. 1984

YVL 2.5 Preoperational and start-up testing of nuclear power plants, 8 Jan. 1991 (in Finnish)

YVL 2.6 Provision against earthquakes affecting nuclear facilities, 19 Dec. 1988

YVL 2.7 Failure criteria for the design of a light-water reactor, 6 April 1983

YVL 2.8 Probabilistic safety analyses (PSA) in the licensing and regulation of nuclear power plants, 18 Nov. 1987

### Pressure vessels

YVL 3.0 Pressure vessels in nuclear facilities. General guidelines on regulation, 21 Jan. 1986

YVL 3.1 Nuclear power plant pressure vessels. Construction plan. Safety classes 1 and 2, 11 May 1981

YVL 3.2 Nuclear power plant pressure vessels. Construction plan. Safety class 3 and class EYT, 21 June 1982

YVL 3.3 Supervision of the piping of nuclear facilities, 21 May 1984

YVL 3.4 Nuclear power plant pressure vessels. Manufacturing license, 15 April 1981

YVL 3.7 Nuclear power plant pressure vessels. Commissioning inspection, 12 Dec. 1991 (in Finnish)

YVL 3.8 Nuclear power plant pressure vessels. Inservice inspections, 9 Sept. 1982

YVL 3.9 Nuclear power plant pressure vessels. Construction and welding filler materials, 6 Nov. 1978

### **Buildings and structures**

YVL 4.1 Nuclear power plant concrete structures, 22 May 1992 (in Finnish)

YVL 4.2 Steel structures for nuclear facilities, 19 Jan. 1987

YVL 4.3 Fire protection at nuclear facilities, 2 Feb. 1987

### **Other structures and components**

YVL 5.3 Valves and their actuators at nuclear facilities, 7 Feb. 1991 (in Finnish)

YVL 5.4 Supervision of safety relief valves in nuclear facilities, 3 June 1985

YVL 5.5 Supervision of electric and instrumentation systems and components at nuclear facilities, 7 June 1985

YVL 5.7 Pumps at nuclear facilities, 27 May 1986

YVL 5.8 Hoisting appliances and fuel handling equipment at nuclear facilities, 5 Jan. 1987

### **Nuclear materials**

YVL 6.1 Nuclear fuel and other nuclear material control at nuclear power plants, 19 June 1991 (in Finnish)

YVL 6.2 Fuel design limits and general design criteria, 15 Feb. 1983

YVL 6.3 Supervision of fuel design and manufacture, 28 Feb. 1983

YVL 6.4 Supervision of nuclear fuel transport packages, 1 March 1984

YVL 6.5 Supervision of nuclear fuel transport, 1 March 1984

YVL 6.6 Surveillance of nuclear fuel performance, 5 Nov. 1990 (in Finnish)

YVL 6.7 Quality assurance of nuclear fuel, 11 Oct. 1983

YVL 6.8 Handling and storage of nuclear fuel, 13 Nov. 1991 (in Finnish)

YVL 6.11 Physical protection of nuclear power plants, 13 July 1992 (in Finnish)

YVL 6.21 Physical protection of nuclear fuel transports, 15 Feb. 1988 (in Finnish)

### **Radiation protection**

YVL 7.1 Limitation of public exposure from nuclear installations, 7 Oct. 1987

YVL 7.2 Evaluation of population doses in the environment of nuclear power plants, 12 May 1983

YVL 7.3 Evaluating the dispersion of radioactive releases from nuclear power plants under operating and in accident conditions, 12 May 1983

YVL 7.4 Nuclear power plant emergency plans, 12 May 1983

YVL 7.5 Meteorological measurements of nuclear power plants, 28 Dec. 1990 (in Finnish)

YVL 7.6 Measuring radioactive releases from nuclear power plants, 13 July, 1992 (in Finnish)

YVL 7.7 Programmes for monitoring radioactivity in the environment of nuclear power plants, 21 May 1982

YVL 7.8 Reporting radiological control of the environs of nuclear power plants to the Institute on Radiation Protection, 21 May 1982

YVL 7.9 Health physics programmes in nuclear power plants, 21 April 1981

YVI 7.10 Individual monitoring and reporting of radiation doses, 1 March 1984

YVI 7.11 Radiation monitoring systems and equipment in nuclear power plants, 1 Feb. 1983

YVL 7.14 Action levels for protection of the public in nuclear power plant accidents, 26 May 1976

YVL 7.18 Radiation protection in design of nuclear power plants, 14 May 1981

### **Radioactive waste management**

YVL 8.1 Disposal of reactor waste, 20 Sept. 1991

YVL 8.2 Exemption from regulatory control of nuclear wastes, 19 March 1992

YVL 8.3 Treatment and storage of radioactive waste at the nuclear power plants, 1 July 1985