Fire protection at nuclear power plants

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RADIATION AND NUCLEAR SAFETY AUTHORITY

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 decisions made by STUK before the publication of the guide. It is only after it has heard those concerned that STUK makes a separate decision on how a new or revised YVL guide is applied to operating nuclear power plants, or to those under construction, and to the licence-holders' activities. The guides apply as such to new nuclear facilities.

When it considers how new safety requirements presented in the YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account the principle prescribed in section 27 of the Council of State Decision (395/1991), according to which *for further safety enhancement, actions 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 attained.

Translation. Original text in Finnish.

1 General

Radiation and Nuclear Safety Authority (STUK) is the national authority responsible for the surveillance of the safety of the nuclear power plants. The general guidelines followed by STUK in regulating nuclear facilities are given in Guide YVL 1.1. The regulatory activities include the fire protection arrangements of the nuclear power plants in so far as they affect the nuclear and radiation safety of the power plants.

In Finland the Ministry of Environment gives orders and guides on the technical aspects concerning the construction and the structural fire protection [8]. In each municipality the construction licence authorities supervise that the orders and guides given by the Ministry of Environment are followed in all construction activities. The highest leadership, steering and regulatory control in fire and rescue services is the responsibility of the Ministry of the Interior. In each province the Rescue Department of the Provincial Government is responsible for the activities. The municipalities are responsible for the rescue services in their region. This guide does not describe in detail the regulations and guides given by other authorities, neither the surveillance and inspections carried out by them. In its regulatory work STUK takes into account the activities of other authorities and organisations. The regulatory work of STUK does not replace surveillance actions being the duty of other authorities.

This Guide presents specific requirements for the design and implementation of fire protection arrangements at nuclear power plants and for the documents relating to fire protection that are to be submitted to STUK. Inspections of the fire protection arrangements to be conducted by STUK during the construction and operation of the power plants are also described in this Guide. This Guide can also be followed at other nuclear facilities.

The bases of the quality assurance in the construction and operation of a nuclear power plant are given in the Council of State Decision (395/91) [3] section 5, according to which, *advanced quality assurance programmes shall be employed in all activities which affect safety and relate to the design, construction and operation of a nuclear power plant*. Detailed requirements for the quality assurance are presented in Guides YVL 1.4 and YVL 1.9. These requirements shall be taken into account in the design of fire protection and in the fire protection arrangements during the operation of the nuclear power plants.

2 Design requirements

2.1 General

The starting-point for the design of the fire protection arrangements at nuclear power plants is given in the Council of State Decision (395/91) [3] section 20, paragraph 2, according to which, *structures, systems and components important to safety shall be designed and located, as well as protected by means of structural fire barriers and adequate fire fighting systems so that the likelihood of fire and explosions is small and their effect on plant safety insignificant*. The general requirements for the design of fire protection at nuclear facilities are presented in paragraph 3.7, Fire protection, of Guide YVL 1.0.

The fundamental objective of fire protection at nuclear power plants is that the safety functions of the plant can be reliably accomplished during and after any potential fire accident:

- the reactor can be shut down and maintained subcritical
- the plant can be cooled down to cold shutdown condition
- residual heat can be removed
- the release of radioactive substances into the environment can be prevented.

Besides the requirements presented in this Guide, the Finnish regulations and guides concerning construction as well as fire protection and rescue services also apply for fire protection at nuclear power plants [8]. Foreign regulations and guides can be proposed to be applied when the specific features of a nuclear power plant are to be considered. In this case it shall, however, be demonstrated that they form a feasible com-

plex. The guides and technical standards to be used must be specified. An acceptance from STUK has to be applied for application of foreign regulation and guides.

The all-inclusive design of the fire protection arrangements is important to the overall safety of the power plant. Managing the complexity of the fire protection arrangements puts specific requirements to combining many different design domains together (plant lay-out, building construction, heating/ventilation/air-conditioning systems, electrical systems etc.). In order all the aspects of fire protection were properly taken into account, an expert sufficiently qualified and experienced in both nuclear and fire safety field shall be nominated responsible for the design and construction of the fire protection arrangements.

2.2 Failure criteria

This section presents how the failure criteria are applied to the fire protection arrangements and to the effects of the fires at a nuclear power plant.

According to Guide YVL 1.0, *a single failure means a random failure and its consequent effects which are assumed to occur either during a normal operational condition or in addition to the initiating event and its consequent effects.* According to Guide YVL 2.8, *an initiating event is a single event which requires the starting of the plant safety functions. The initiating event can be an internal or external event e.g. a component failure, a natural phenomenon or a hazard caused by man.*

As for interpretation of the failure criteria the effects of a fire may be considered to be confined to one fire compartment. Then all equipment in the fire compartment shall principally be assumed to fail due to the fire event (see sections 3.8.1 and 3.8.2).

In Guide YVL 2.7 section 3.3, the interpretation of failure criteria is presented in case of fire. According to this

- When a fire in the considered fire compartment can cause an initiating event, but cannot cause failure to safety related redundant subsystems, the failure criteria in Guide YVL 2.7 section 3.2 are applied as such.
- When a fire in the considered fire compartment cannot cause an initiating event but can cause failure to safety related redundant subsystems, the failure is considered as a single failure as determined in Guide YVL 2.7 section 3.2.

The structural fire protection, the separation and lay-out arrangements of systems shall be designed according to the requirements of subsection 2.3 of this Guide in such a way that a fire can not cause an initiating event and can not simultaneously cause a failure to a safety related redundant subsystem. If this could exceptionally be the case in fires of some fire compartments, the failure of safety significant redundant subsystems is not considered as a single failure according to Guide YVL 2.7 section 3.2, but it is a consequence of an initiating event. In this case the criteria in Guide YVL 2.7 section 3.2 are applied as such in addition to the failures caused by the fire.

Requirements for the design of the national grid connections of nuclear power plants are presented in Guide YVL 5.2. The electrical power connections between the power plant and the national grid shall be so arranged that losing all connections simultaneously due to the consequences of a fire deemed possible is very improbable.

A single failure in the fire protection systems shall be taken into account according to Guide YVL 1.0 as follows: *If a fire in some fire compartment may cause a significant release of radioactive substances into the plant rooms or to the environment, fire detection and extinguishing within the compartment shall be ensured by fire protection systems capable of performing their functions even in the event of a single failure.* In this case a single failure means that one or several active components of the fire protection systems have failed.

2.3 Structural fire protection

2.3.1 General

According to Guide YVL 1.0, *fire protection shall be based on room arrangements and fire compartments in the first place. Each parallel subsection of the plant systems performing safety functions shall be placed in a separate fire compartment. No other systems or components shall be placed in these rooms which would essentially increase the fire load or the threat of a fire breaking out. These rooms shall be placed sufficiently far from such other systems and rooms as could endanger the operation of the safety systems.*

The fire classification of buildings containing systems important for nuclear power plant safety shall be fire-resistant. As far as possible, incombustible and heat-resistant materials shall be used everywhere at the plant, particularly in the containment and the control room.

2.3.2 Separation and location of systems

The functional design and lay-out considerations of a nuclear power plant and its buildings create the prerequisites for adequate fire safety of nuclear power plant. The basic design aspect shall be that the portions of the power plant important to nuclear safety, such as the control room and safety related systems, are housed in separate buildings and apart from the conventional parts of the power plant, such as the turbine hall. This facilitates fire protection of plant items important to nuclear safety. The basic design concept of the nuclear power plant should include structural fire protection arrangements, which, as far as possible, alone ensure the safety of the power plant. The fire protection arrangements of the containment and the control room are separately discussed in sections 2.3.5 and 2.3.6.

A nuclear power plant shall be designed to keep fire loads as limited as practically possible. Heavy fire load concentrations or compartments where the risk of a fire is high shall be separated into individual fire compartments. No more than the necessary amounts of combustible liquids, gases or other fire loads shall be housed in those parts of the power plant that contain items important to safety.

The importance of ventilation to fire safety shall be taken into account. Requirements for the design of ventilation systems and smoke extraction are presented in Guide YVL 5.6.

2.3.3 Fire compartmentation

The purpose of the fire compartmentation of a nuclear power plant is to prevent the fire spreading from one compartment to another. The separating structural elements of the fire compartments shall fulfil a minimum fire resistance of EI 60 [8]. The specific requirements deviating from this are presented later. The fire resistance of doors, hatches, fire dampers, and penetrations for cables, ventilation and pipes, piercing the separating structural elements of the fire compartments, shall be at least half of that required for the walls, the floors and the ceiling structures, however, at least EI 60 [8]. Load bearing structures shall at least meet the fire resistance of R 60 [8].

Buildings containing redundant subsystems important to the power plant's nuclear safety shall be separated from other buildings containing heavy fire loads, such as the turbine building, with separating structural elements having the fire resistance of EI-M 120 [8]. In this case the separating doors, hatches, fire dampers and penetrations for cables, ventilation and pipes shall meet the same fire resistance requirement as the separating structural element itself.

Fire compartmentation used in protecting redundant safety-related systems and separating them from each other shall, in general, have a fire resistance of EI-M 120 [8]. In case a fire resistance of EI-M 120 is not deemed necessary because of light fire loads, the use of a lower rating shall be justified on the basis of special fire hazards analyses (see subsection 3.8.1). In case the fire load in a fire compartment is so heavy that a fire resistance of EI-M 120 is deemed insufficient according to RakMK [8], the

fire resistance required for the structural elements shall be determined on the basis of fire hazards analyses taking the real fire loads and fire conditions into account. In the separating structural elements between safety related redundant subsystems any elements reducing the fire safety such as doors, hatches and penetrations for ventilation, pipes and cables should be avoided as long as possible. In case doors, hatches or penetrations are exceptionally installed in these elements, they shall be of the same fire resistance as the separating structural elements.

The separating structural elements shall be manufactured of fire-resistant materials as presented in RakMK [8]. The surface layers of the elements shall belong to class 1 concerning the ignitability properties and to class I concerning the fire spreading properties.

The boundary between the controlled and uncontrolled zones shall also be the boundary between fire compartments. The interconnection space intended for personnel traffic at the boundary between the controlled and uncontrolled zone is an exception. The zoning of the power plant according to the radiation conditions is presented in Guide YVL 7.9.

2.3.4 Access and escape routes

To facilitate a safe escape from the power plant, the nuclear power plant shall be provided with adequate access and escape routes. These routes shall be fire-separated, convenient, spacious and easy to pass through. It shall also be demonstrated that the fire fighting forces are able to perform effectively and the plant personnel is able to move within the power plant to complete all the safety-related actions during and after a fire or other accident.

The requirements set forth due to the physical protection shall also be taken into account in the design of the access and escape routes. The requirements on physical protection are presented in Guide YVL 6.11.

2.3.5 Containment

Fire loads housed inside the containment shall be minimised. The possibility of fires must be taken into account in the design of the containment.

In case safety-related items and equipment of the redundant systems important to safety cannot be housed in separate fire compartments inside the containment and in the (annular) space between the primary and the secondary containment buildings, they shall be protected against fire by means of separation by distance, protective structures, fire-resistant materials and fire insulation. The mentioned compartments shall always be equipped with fire detection and alarm systems and, when necessary, with fire-extinguishing systems. The sufficiency of the designed fire protection arrangements shall be demonstrated with fire hazard analyses according to sub-section 3.8.1.

2.3.6 Control room

The control room shall be housed in the power plant in a location safe from the risk of a fire. In addition, the control room shall be equipped with over-pressure ventilation that is to be designed to prevent smoke from entering the control room when the fire occurs outside the control room.

Cables from the safety related redundant subsystems to the control room shall be routed through separate fire compartments. In case the cables from different redundant systems must exceptionally be situated in the same fire compartment, they shall be separated inside the compartment by means of distance, fire-resistant materials and fire insulation. The fire compartment shall also be equipped with effective and reliable fire detection and alarm systems as well as with fire-extinguishing systems. An example of such an compartment is the cable spreading space under the control desk.

According to Guide YVL 1.0, *the control systems of the emergency control post outside the control*

room shall be separated from the control systems of the control room in such a way that if the equipment in one fire compartment are entirely destroyed by fire this does not harm both control systems so much that the plant safety functions could not be carried out.

2.4 Active fire protection

2.4.1 Fire detection and alarm systems

In order to detect and locate a fire as early as possible, an effective automated fire detection and alarm system of appropriate capacity and reliability is required to cover the whole nuclear power plant. It shall be so designed that the location of a fire can be identified at least to any individual room. In large rooms containing safety-related systems it shall be possible to identify the location of a fire ignition more accurately, even to a single detector within the room if necessary. The fire detection and alarm systems shall annunciate the alarm at least in the unit control room of the power plant.

The selection and placement of fire detection equipment shall take into account the character of the compartment, the fire loads, the ventilation and the significance of the compartment to the power plant's safety. If necessary, the fire detection and alarm systems can also be supplemented with other systems appropriate for fire warning.

The ministry responsible for Rescue Services issues regulations and guides on the design of fire detection and alarm systems [10–11].

2.4.2 Fire-extinguishing systems

According to Guide YVL 1.0, *fire protection systems shall be so designed that their breaking or inadvertent operation does not significantly reduce the capability of structures, systems and components important to safety to carry out their safety functions.*

To facilitate a fast suppression of a fire and to minimise damage and hazards, the nuclear power plant shall be equipped with a fire water system and with effective and reliable fire-extinguishing systems. The power plant's structural fire protection solutions and the amount of fire loads determine the furnishing of the fire compartments with fire-extinguishing systems.

Fixed, sufficiently reliable fire-extinguishing systems shall be provided at least for the following rooms and systems, irrespective of the layout design of the power plant or the amount of the existing fire loads

- cable spaces exceptionally containing cables of more than one safety related redundant subsystems
- rooms and systems from which considerable amounts of radioactive substances can be released into rooms or into the environment due to a fire

and, if necessary, for such compartments and systems as

- diesel generators
- large transformers
- cable spaces
- oil systems.

The removal of extinguishing water shall be arranged from rooms equipped with fixed water-extinguishing systems or from rooms where large quantities of extinguishing water are presumably needed in the event of a fire. In the design and placement of these compartments the effects of the flooding of the extinguishing water shall be taken into account. Compartments with the possibility of oil leakage shall be prepared for oil separation from the extinguishing water.

The ministry responsible for Rescue Services issues regulations and guides of the fire-extinguishing systems [11] (see also [12]).

2.4.3 Operative fire protection

Operative fire protection consists of fire protection performed by the on-site power plant fire brigade, the power plant's personnel and the off-site fire brigades. The operative fire fighting equipment at the power plant is also included.

On the plant site or in the immediate vicinity of the power plant there shall be a full-time fire brigade consisting of at least one fire foreman and two firemen (1 + 2). The on-site fire brigade shall be at a five (5) minute preparedness at all times. The firemen shall be qualified for using breathing apparatus for service in smoke filled areas in terms of education, experience, physical condition, and suitability. They need to be appropriately furnished as well [9]. In addition, there shall be on duty a sufficient number of fire fighting groups put together of the permanent power plant personnel having readiness to participate in fire fighting and rescue operations. Those fire fighting groups shall have the necessary fire fighting and rescue training. The on-site fire brigade and the plant fire fighting groups shall be equipped with a sufficient amount of suitable and efficient equipment.

The co-operation between the on-site fire brigade and the off-site fire brigades shall be planned, guided and trained by drills. In this connection the requirement of the guide A:37 [9] on service with breathing apparatus has to be accounted for, setting the minimum content of this unit as 1 + 5. The management responsibilities have been determined in the Act 561/1999 [5], Decree 857/1999 [6] and the Council of State Decision 397/1991 [4] on Rescue Services.

2.5 Emergency lighting

The power plant shall be designed to be furnished with an emergency lighting system, enabling safe passage inside the power plant and escape from there when the normal lighting is out of order due to a disturbance in the supply of electricity, a fire or some other event.

3 Construction licence

3.1 Application for construction licence

Documents that shall be submitted to STUK together with the application for construction licence are presented in section 35 of the Nuclear Energy Act. These documents shall provide a description of how the requirements presented in section 2 of this guide are met in the design of the fire protection arrangements of the power plant. The documents shall include the aspects presented in the following subsections.

3.2 Designer of fire protection measures

The documents shall present a thorough clarification of the designer responsible for the all-inclusive design of the power plant's fire protection arrangements (see subsection 2.1).

3.3 Separation and placement of systems

The document shall unambiguously show how the systems and components important to safety will be located in the power plant and how the separation of redundant safety-related subsystems is carried out by means of structural fire protection arrangements.

The document shall present the bases for the design of the ventilation and smoke extraction systems as well as their estimated response action with regard to fire safety. The requirements concerning the design of over-pressure ventilation, smoke extraction and other ventilation are presented in Guide YVL 5.6.

3.4 Fire compartmentation

The document shall include the bases for the design of structural fire protection, the preliminary drawings of the fire compartments and other specifications concerning the structural fire protection. The clarifications shall include the preliminary information on the fire loads and the sizes of the fire compartments as well as the fire resistance time of the buildings and the separating structural elements.

Data on any considerable concentrations of combustible materials (solid, liquid, gaseous) at the nuclear power plant shall be presented in a separate description giving the quality, amount and location of the fire loads and the characteristics of smoke and gases released by postulated

fires. In addition, means shall be presented how to collect and restrict the leaking oil or other combustible liquid of spreading.

3.5 Access and escape routes

The document shall include drawings showing

- the access and escape routes
- the routes needed for the measures to safely shut down the power plant (see sub-section 2.3.4).

3.6 Fire detection and alarm systems

The document shall preliminarily present the functional descriptions of the fire detection and alarm systems, the detector types and the principles for their location, as well as the predicted control functions to the detectors.

3.7 Fire extinguishing systems

The document shall present the compartments and rooms foreseen to be equipped with fire-extinguishing systems, and design principles for the planned extinguishing systems. In addition, a description on the arrangements of the reliable fire water supply for both the operational fire fighting and the fire-extinguishing systems shall be given.

3.8 Fire hazard analyses

3.8.1 Fire hazard analyses

Fire hazards analyses shall always be performed for the containment and the control room. By means of the containment fire hazards analysis it shall be demonstrated that the safety functions of the plant can be reliably accomplished during and after any potential fire accident in the containment: the reactor can be shut down and maintained subcritical, the plant can be cooled down to cold shutdown condition and the residual heat can be removed. By means of the fire hazard analysis of the control room it shall be demonstrated that the control of the necessary safety functions can be accomplished in the event of a fire in the control room or in any other fire compartment. In this connection also the influence of fires to the function of safety significant I&C systems shall be demonstrated, including the effects of fire to cables and the reflection of disturbances and failures to those safety functions. When planning use of systems based on programmable technique in the implementation of vital protection and control functions of the power plant, the reliable function of these systems in fire cases shall be demonstrated. Requirements for the automation systems of the nuclear power plant are given in Guide YVL 5.5.

The fire safety shall be demonstrated with fire hazards analyses also in cases referred to in sub-section 2.3.3 when the fire resistance of EI-M 120 [8] is not necessary due to light fire loads. If the fire load of the fire compartment is so heavy that the fire resistance of EI-M 120 is not sufficient according to RakMK [8], the required fire resistance of the structural elements shall be determined on the basis of fire hazards analyses taking the real fire loads and fire conditions into account.

In case there is a well-founded reason, simultaneous fires in more than a single fire compartment shall be assessed and their effects the power plant's safety be analysed (see sub-sections 2.2, 3.8.2 and 6.3).

The preliminary fire hazards analyses and the schedule for the final analyses shall be presented in connection with the preliminary safety analysis report.

3.8.2 Design phase PSA

According to Guide YVL 2.8, *the applicant for a licence has to provide Finnish Centre for Radiation and Nuclear Safety (STUK) with a preliminary probabilistic safety analysis for the application for a construction licence. In the following this analysis is called design phase PSA.* Together with the initiating events analysed in the design phase PSA the fires shall be assessed in order to evaluate the fire protection arrangements and to identify the risks caused by fires.

4 Regulatory control of construction

4.1 General

As stated in Guide YVL 1.1, *according to Section 109 of the Nuclear Energy Decree, STUK exercises detailed control over the construction of the facility. This control aims to ensure that the conditions of the construction licence, the regulations which apply to pressure vessels and the approved plans referred to in point 2.2.2 are complied with and that the nuclear facility is built, also in other respects, in accordance with the regulations issued by virtue of the Nuclear Energy Act. During construction, control is focused on the working methods in particular to guarantee high quality.* The applicant for a license has to provide STUK, as mentioned above, with the detailed plans for the fire protection arrangements of the power plant in the scope specified below. The requirements for the design of the fire protection arrangements of the power plant are presented in section 2.

In order to ensure a licensing time long enough, the plans shall be submitted to STUK in good time before the planned initiation of the construction or installation.

4.2 Fire compartmentation

Detailed drawings of the fire compartmentation of the power plant shall be presented in which each fire compartment is marked with its own symbol. In addition, detailed information on the fire loads of the fire compartments, on the extent of the fire compartments in square meters, and on the fire resistance ratings of the separating structures and elements of the fire barriers of fire compartments shall be presented. Also arrangements for the collection and restriction of leakage of oil and other combustible liquids shall be presented.

The results of the fire hazards analyses discussed in sub-section 3.8.1 shall be available to the extent that the adequacy of the fire resistance of construction elements can be assessed.

Copies of the type acceptance decisions [13] and verified installation instructions for the separating construction elements shall be submitted to STUK for information.

4.3 Emergency lighting

The plan of the emergency lighting shall describe the functional principles of the system and the compartments to be equipped with it.

4.4 Ventilation and smoke extraction for fires

The over-pressure ventilation and the smoke extraction plan shall be presented. This plan shall provide information on how the spreading of hot, possibly corrosive and poisonous gases and smoke released are planned to be prevented and how they are extracted. Measures for preventing the release of radioactive substances into the environment during a fire shall be presented. Detailed plans shall be presented for the over-pressure ventilation of the control room, mentioned in sub-section 2.3.6, and the access and escape routes, mentioned in sub-section 2.3.4.

Requirements set for the ventilation systems are presented in Guide YVL 5.6.

4.5 Fire detection and alarm systems

The fire detection and alarm system plan includes

- design information, functional descriptions and technical specifications
- location of control centres and control units
- list of detector types and functional descriptions of the detectors
- principles of installing different types of detectors for different rooms of the power plant
- description of control functions of the detectors (smoke vents, ventilation, fire doors etc.).

The installation drawings, the schemes of the detector loops and detectors, and a pronouncement on the acceptability of the planned fire detection and alarm system from an inspection agency certified by the Safety Technology Au-

thority, and information on the designer and the supplier of the fire detection and alarm systems shall be submitted to STUK for information.

4.6 Fire-extinguishing systems

The document on the fire-extinguishing systems shall provide the following information

- description of the compartment to be protected
- design data, functional descriptions and technical specifications
- demonstration of the applicability of the selected extinguishing systems and extinguishants.

As for fire-extinguishing systems, it shall be presented how the supply of extinguishing water is ensured.

Detailed drawings of the fire-extinguishing systems and a pronouncement on the acceptability of the planned fire-extinguishing systems from an inspection agency certified by the Safety Technology Authority, and information on the designer and the supplier of the fire-extinguishing systems shall be submitted to STUK for information.

An account shall be given of the removal of fire-extinguishing water from the rooms equipped with fixed fire-extinguishing systems or rooms where large quantities of extinguishing water are presumably needed in the event of a fire.

5 Operating licence

5.1 Operating licence application

Documents that are to be submitted to STUK in connection with the application for an operating licence are presented in section 36 of the Nuclear Energy Act. In addition, accounts of the following items relating to the fire protection arrangements shall be submitted to STUK for information

- description of the operative fire fighting preparedness
- fire-fighting plan
- periodical inspection program.

The Council of State Decision (395/91) [3] section 23 determines that there shall exist appropriate procedures for all transient and accident conditions of the nuclear power plant. Also fire accidents predicted to be serious are among these transient and accident conditions.

5.1.1 Final Safety Analysis Report (FSAR)

The Final Safety Analysis Report shall describe the fire protection arrangements as they are implemented at the nuclear power plant. It shall also contain descriptions of the final analyses mentioned in sub-section 3.8.1 or references to them.

5.1.2 Technical Specifications

The requirements and restrictions for the fire protection arrangements during operation shall be included in the Technical Specifications together with the compensatory safety measures to be applied, in order to maintain a sufficient safety level, e.g. in the event of a component failure or a planned component disconnection from use. For the systems covered by the Technical Specifications the periodical tests shall also be included in the specifications. The tests are needed to demonstrate the operability of systems and components. The Technical Specifications shall include requirements and restrictions for at least the following functions

- structural fire protection measures
- fire water system (water supply, fire water pumps and main pipeline, hydrants and building standpipes etc.)
- fire detection and alarm systems
- fire-extinguishing systems
- equipment for initial extinguishing at the power plant
- operative fire fighting preparedness.

5.1.3 Operative fire fighting preparedness

The applicant for a license shall present clarifications on

- the fire fighting organisation including the duties and tasks of the fire brigade leader and the person responsible for the overall fire protection and fire fighting at the plant

- the administrative arrangements to alarm the on-site fire brigade, the staff of local (municipal) alarm centre and the plant personnel in case of an alarm from the fire detection and alarm systems or any other fire alarm
- leadership responsibilities in case of a fire as well as the procedures for operative fire fighting
- the overall fire-fighting personnel and its competence, including the training given to the permanent and temporary on-site personnel in fire fighting and rescue services
- the communication systems planned to be used in fire-fighting service
- the equipment of the on-site fire brigade and the fire-fighting and protective equipment at the power plant for the fire and rescue purposes
- the special features of the operative fire fighting in compartments belonging to the controlled zone according to radiation circumstances.

The requirements concerning the on-site fire brigade are presented in sub-section 2.4.3.

5.1.4 Fire-fighting scheme

The purpose of the fire-fighting scheme is to serve as a tool for the plant personnel, the on-site fire brigade and the off-site fire brigades during fire-fighting and rescue operations.

The fire-fighting scheme shall describe at least the following

- plant site and its immediate surroundings
- the actual power plant area in detail (buildings, outdoor fire hydrants, entrances to buildings)
- building layouts with markings of fire compartments, fire hydrants, equipment for initial extinguishing, access routes for the fire brigades, escape routes, smoke extraction equipment, overpressure ventilation etc.
- control centres and central units of the fire detection and alarm systems, control areas of detector loops and the manual actuation points of the alarms
- compartments protected by fire-extinguishing systems, valve centres and the manual actuation places of the systems
- protective apparatus.

5.1.5 Periodical inspection program

The applicant shall present a periodical inspection program relating to the overall fire protection arrangements, to be annexed to the periodical inspection program of the whole power plant. The inspections shall pay attention to preventing the outbreaks of fire, to preventing the spreading the fires already ignited and to extinguishing them. Effects of equipment and material ageing phenomena to fire safety features shall be followed-up and surveyed. At least the following items shall be included in the periodical inspection program:

- fire loads
- fire compartments
- access and escape routes and attack routes for the fire brigades
- fire insulation
- fire detection and alarm systems
- fire fighting water system
- fire-extinguishing systems
- fire venting and smoke extraction
- fire dampers
- fire-fighting and rescue equipment
- protective apparatus
- emergency lighting
- communication systems.

The program shall also include detailed procedures, which present the following of each of the inspection subjects mentioned above

- person in charge
- power plant's operational condition for inspecting/testing
- inspection and test intervals
- inspection and test methods and arrangements
- records of the inspections and tests
- criteria for approval.

5.2 Commissioning inspection

STUK performs a commissioning inspection of the fire protection arrangements at the nuclear power plant. In the commissioning inspection it shall be verified that

- the fire compartmentation has been implemented as described in the design documents
- the quality, amount and location of fire loads are as given in the design documents
- the fire detection and alarm system installations are approved by an inspection agency certified by the Safety Technology Authority
- the fire-extinguishing system installations are approved by an inspection agency certified by the Safety Technology Authority
- the equipment for initial fire fighting are located as given in the fire-fighting scheme (subsection 5.1.4)
- the communication system is operable
- the operative fire fighting preparedness is as planned.

The applicant for a license shall present a written commissioning inspection request to STUK not later than one week before the planned inspection. The general prerequisites for the commissioning inspection are presented in Guide YVL 1.1. The inspection can be conducted in several phases. An accepted commissioning inspection is the prerequisite for the commissioning of the power plant.

6 Regulatory control during operation

6.1 General

When operating a nuclear power plant the fire safety requirements and aspects must be taken into account in order to

- prevent the outbreaks of fire
- rapidly detect and extinguish ignited fires
- prevent the fire spreading so that the plant safety functions can be reliably performed also during and after of a fire event.

The licensee is responsible for the development of fire safety and for the maintenance of all the fire protection arrangements. The requirements for fire safety shall be taken into account in every field of plant operation. Both permanent and temporary personnel at the power plant is responsible for attending to the power plant's fire safety.

6.2 Technical Specifications, periodical inspections and maintenance

The licensee is responsible for maintaining the fire protection arrangements in accordance with the valid Technical Specifications and the procedures of the periodical inspection program. STUK has examined the power plant's periodical inspection program relating to the fire protection arrangements while handling the application for the operating licence. In case the licensee performs modifications to the periodical test program, the revisions shall be approved by STUK.

STUK supervises the periodical inspections performed by the licensee to the extent deemed necessary and carries out inspections relating to fire protection arrangements in accordance with its own program. STUK also surveys the results of the periodical inspections performed by the licensee.

If the design basis of the systems, components or constructions relating to fire protection is changed or if new systems or parts of them are built, the plans of the changes shall be submitted to STUK for approval. The plans shall meet the requirements of sections 2 and 4. When purposely disconnecting fire detection or alarm systems, fire water systems or fire extinguishing systems covered by the Technical Specifications, for reparation or modification works, STUK shall always be informed thereof in advance. At the same time also the compensating measures applied to maintain the safety level prescribed in the Technical Specifications shall be presented.

Requirements concerning the modifications, repairs and preventive maintenance during operation are presented in Guide YVL 1.8.

The operative preparedness concerning the fire protection arrangements has been approved together with the operating licence of the power plant. If essential changes are made to the operative preparedness, STUK shall be contacted for approval.

Fire and explosion events at the site or situations containing any risk of them shall all be reported according to Guide YVL 1.5.

6.3 Outages

According to Guide YVL 1.13, *The components, structures and systems required for fire protection must, as a rule, be operable in outage situations. Their operability requirements shall be given in the Technical Specifications. The reliability and adequacy of fire protection arrangements shall be evaluated as part of outage planning. Outage specific special arrangements shall be made if necessary to ensure adequate fire safety.*

Further according to Guide YVL 1.13, a general description of refuelling outages and preplanned extensive reparation outages shall be submitted to STUK for information not later than one month before the start of the outage. The description shall include, e.g., the arrangements during the outage to intensify the emergency preparedness and fire protection arrangements.

The opening of separating penetrations and disconnecting of fire detection and alarm systems as well as the extinguishing systems shall be performed according to clearly defined administrative procedures. The protective measures concerning fire works shall be determined in the work permit. Fire works can be performed only by people with a valid fire work licence card.

The preparedness of the operative fire protection shall be intensified during outages when necessary. During outages a sufficient number of fire guards shall be supervising the fire works and the fire protection arrangements.

Before the power plant is restarted after the annual refuelling outage or some other outage of longer duration, the licensee shall inspect the following concerning the fire protection arrangements

- the yearly inspections required by the Technical Specifications have been performed
- the structural fire protection arrangements meet the requirements of the Technical Specifications
- the fire detection and alarm systems are operable
- the fire-extinguishing systems are operable
- the access routes are open and the power plant house-keeping is on a high level
- the on-site fire brigade is in normal preparedness and its equipment is in order.

The regulatory control of the power plants conducted by STUK during outages and the general arrangements concerning them are clarified in Guide YVL 1.13.

6.4 Development of fire safety

Maintaining and continuously advancing the fire safety of nuclear power plants is a part of the safety culture conducted in the operation of the nuclear power plants.

Maintaining and advancing the fire safety includes updating the PSA, described in Guide YVL 2.8. Also fire hazards analyses and other documents shall be updated if the conditions of the power plant change or modifications of the plant fire protection arrangements are performed. New research results in the fire field, the general progress in the field, accumulated knowledge of the fire events as well as the ageing effects of the components and materials shall be taken into account in the fire hazards analyses and in the operation and inspection activities of the power plant.

7 References

[1] Nuclear Energy Act (990/1987)

[2] Nuclear Energy Decree (161/1988)

[3] The Council of State Decision (395/1991) on General Regulations for the Safety of Nuclear Power Plants

[4] The Council of State Decision (397/1991) on the Emergency Preparedness of Nuclear Power Plants

[5] Act on the Rescue Services (561/1999)

[6] Decree on the Rescue Services (857/1999)

[7] Act on technical requirements of devices of Rescue Services and on fire safety of products (562/1999)

[8] RakMK (Code of Finnish construction regulations)

[9] A:37 (1991) “Fire fighting in Smoke Filled areas”, Guide from the Ministry for Interior

[10] A:41 (1991) “Design and Installation of Fire Detection and Alarm Systems”, Guide from the Ministry of Interior

[11] Other applicable A-series publications of the Ministry of Interior

[12] Sprinkler rules 1990, Central Association of the Insurance Companies in Finland

[13] The Ministry of Environment Decision on type acceptance in the construction field (273/1989).