Säteilyturvakeskus
Finnish Centre for Radiation and Nuclear Safety

YVL-ohje
YVL Guide

YVL 4.3

2 Feb. 1987 1 (22)

Second, revised edition
Translation

FIRE PROTECTION AT NUCLEAR FACILITIES

TABLE OF CONTENTS

Helsinki 1988
Government Printing Centre

ISBN 951-47-1397-4
ISSN 0783-2389

PL-P.O.BOX 268
SF-00101 HELSINKI
FINLAND

Ydinturvallisuusosasto
Department of Nuclear Safety
Kalevankatu 44
Kumpulantie 7

Puh.-Tel.
(90) 616 71
(90)70821

Telex
122691 STUK-SF

1 INTRODUCTION

1.1 General

The basic design approach to the fire protection of nuclear facilities is presented in the Guide 1.0 /1/. The general guidelines followed by the Finnish Centre for Radiation and Nuclear Safety in regulating nuclear facilities are given in the Guide 1.1 /2/.

This guide presents requirements for the design of fire protection arrangements at nuclear facilities and requirements for the documents relating to fire protection to be submitted to the Finnish Centre for Radiation and Nuclear Safety. Inspections of fire protection arrangements conducted by the Centre during construction and operation of the facilities are also described in the guide.

In place of nuclear facility the term nuclear power plant is used in the guide when the requirements particularly concern nuclear power plants. Also these requirements shall, where applicable, be followed at other nuclear facilities.

1.2 Regulatory body

The Finnish Centre for Radiation and Nuclear Safety (STUK) is the national authority responsible for the surveillance of the safety of the nuclear facilities. The regulatory activities encompass also the fire protection arrangements of the facilities in so far as they affect the nuclear safety of the facilities. In its regulatory work, STUK takes into account the activities of other authorities and organizations.

1.3 Scope

This guide will confine itself to the fire protection arrangements necessary for ensuring that the safety functions of

a nuclear facility are not endangered in the event of a fire. The requirements are, as such, not applied to those nuclear facilities which have been constructed prior to the publication of this guide. The fire protection modifications that may be needed in them will be considered case by case.

As regards additional constructions on-site, the application of this guide will be decided upon the basis of the applicant's presentation.

2 DESIGN REQUIREMENTS

2.1 General

The nuclear facilities shall be designed with a view to the possibility of severe fires. The objective shall be to design such nuclear facilities that the probabilities and effects of fires are minimized and that the safety of the facilities will not be endangered during and after a fire.

Besides the YVL guides, the regulations, standards and guides applied in Finland concerning industrial construction /11/ shall, where applicable, be followed at all design and construction stages. Foreign regulations and guides can be applied when the specific features of a nuclear facility are to be considered.

The fundamental objective of fire protection in nuclear power plants is that the safety functions in the plants can be accomplished during and after any potential fire accident condition, in other words

- 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.

A fire confined to one fire area is regarded as an initiating event as defined in the Guide YVL 2.7 /3/ in case it results in a situation where a plant or its part is no longer in normal operation. In such a case, the rules for the application of the failure criteria are valid as such also in the event of a fire.

In case a fire which is confined to one fire area has no direct effect on the functioning of the plant main processes, the rules for the application of the failure criteria concerning normal operation are valid. In such a case, a fire is not regarded as an initiating event but the failures occurring in the systems important to safety as a consequence of a fire can be regarded as cases of a single failure as defined in the Guide YVL 2.7. In such a situation, it is no more necessary to assume any other single failure that is independent of the fire.

2.2 Structural fire protection

Structural fire protection measures shall be capable of, as far as possible, ensuring alone the safety of a nuclear facility in the event of a fire. Thus, the functional design and lay-out considerations of a nuclear facility and its buildings create the prerequisites for adequate fire prevention and protection. One design aspect shall be the housing of the portions of the facility most important to nuclear safety in separate buildings apart from the conventional parts of the facility, thus facilitating protection against fire of the items important to nuclear safety.

The buildings containing items important to nuclear safety shall be fire resistant.

The electrical power supplies between the facility and the national grid shall be arranged in such a way that the probability of losing all supplies simultaneously due to a fire is minimized.

2.2.1 Fire areas

The purpose of the partitioning of a nuclear facility into individual fire areas is to maintain the operability of the safety functions at the facility irrespective of how well the postulated fire can be brought under control with fire suppression measures. In addition, the purpose of the fire areas is to prevent the fire from spreading in a way that would endanger escape from a dangerous part of the building.

The process, electrical and instrumentation systems at the facility shall be diversified and partitioned into different fire areas in such a way that in case one fire area is destroyed, there are still a sufficient number of systems available to ensure the safety of the facility.

The boundary between the controlled and uncontrolled zones shall also be the boundary between fire areas. The interconnection space intended for personnel traffic at the boundary between the controlled and uncontrolled zone is an exception.

The requirements set forth in the safeguards shall also be taken into account in the design and dimensioning of the fire areas, access and escape routes and fire doors.

The fire areas shall have a minimum fire resistance of A60 (fire resistance in minutes).

Fire areas used in protecting redundant safety-related systems and separating them from each other shall, in geneneral, have a fire resistance of A120 (fire resistance in minutes).

In case a fire resistance of A120 is not deemed necessary because of light fire loads, the use of the lower rating (A60) shall be justified on the basis of special fire hazards analyses (see sub-section 3.8). In case the fire load in a fire area is so heavy that a fire resistance of A120 is deemed insufficient, the required fire resistance shall be determined on the basis of fire hazards analyses taking the real fire loads and fire conditions into account.

The access and escape routes needed for the safe shutdown of the facility, the access routes for the fire brigades and, at least one emergency exit in each building, shall be so designed and constructed that these areas can be used safely at least for two hours under postulated fire conditions. In connection therewith, the shutdown methods of the facility shall be determined in the case of postulated fires in any specific fire area. In addition, it shall be studied whether a higher fire resistance rating should be provided in some area due to the need to utilize certain spaces longer.

No more than the necessary amounts of combustible liquids, gases or other fire loads shall be housed in those parts of the facility that contain items important to safety. Large fire load concentrations or areas where the risk of a fire is great shall be separated into individual fire areas.

The fire resistance of the separating elements of fire boundaries such as doors and hatches, cable and pipe penetrations shall be equal to that required of the walls, the floors and the ceiling structures.

The separating structures and elements, materials and their testing shall, in the first place, comply with the Finnish requirements. Where the Finnish requirements, guides and standards are insufficient, foreign regulations, guides and standards may be submitted for approval by

STUK. Their applicability shall always be verified separately.

Ventilation shall not degrade fire protection of the facility. Fire areas containing redundant systems important to nuclear safety shall not be provided with mutual ventilation systems that could increase fire hazards. In the design of the ventilation systems, it shall be taken into consideration that in the event of a fire they can be switched off quickly and reliably, if neccessary.

2.2.2 Containment

Safety-related items and parts of redundant systems important to safety housed in the nuclear power plant containment and in the space between the primary and secondary containment building shall be protected against fire by means of separation by distance, protective structures, fire-resistant materials and insulation in case they cannot be housed in separate fire areas.

In view of the hazards due to hydrogen and other combustible gases, the containment shall be provided with a system for controlling oxygen and combustible gases, as required in the Guide YVL 1.0, sub-section 8.7.

The oil volume of the main circulation pumps housed inside the containment shall be minimized. Systems containing great quantities of oil shall be housed, if possible, in separate fire areas and shall be provided with an oil leak collecting system and shall be protected against a potential fire by means of a fire-extinguishing system.

2.2.3 Control room

Cables from the redundant safety systems to the control room shall be routed as far as possible inside separate fire areas.

The control equipment and points outside the control room shall be designed and separated from the control room equipment and housed in separate fire areas so that the safety functions can be accomplished in case the control room is totally destroyed (due to a fire).

2.3 Active fire protection

The objective of active fire protection measures is an early detection and effective extinguishment of a fire.

Active fire protection comprises a fire detection and alarm system and fire-extinguishing systems and other fire suppression arrangements as complementary measures to structural fire protection. However, the safety of the facility shall not, in any parts, be dependent on the active fire protection measures alone.

2.3.1 Fire detection and alarm system

In order to detect and localise a fire as early as possible, an effective automated fire detection and alarm system is required. It shall be so designed that a fire can be localised at least to any individual fire area. In large fire areas extending over several rooms and containing safety-related systems it shall be necessary to localise the outbreak of a fire even to the exact room within the fire area concerned. Depending upon the nature of the fire area, the fire detection and alarm system can also be supplemented or replaced with other appropriate fire supervision systems.

The fire detection and alarm system shall be designed in accordance with the resolutions and guides issued by the Ministry of the Interior.

2.3.2 Fire-extinguishing systems

To facilitate a fast suppression of a fire and to minimize damage and hazards, effective fire-extinguishing systems

shall be designed for the facility. Fixed reliable fire-extinguishing systems shall be provided for the following rooms and systems, irrespective of the lay-out design of the facility.

- cable spaces containing redundant cables important to safety not housed in separate fire areas
- large oil systems for the main circulation pumps inside the containment
- diesel generators
- spaces and systems from which considerable amounts of radioactive substances can be released into rooms or into the environment by a fire.

The technical design and installation of the fire-extinguishing systems shall, where applicable, conform to the guidelines for fire protection issued by the Federation of Finnish Insurance Companies.

Removal of extinguishing water shall be arranged from rooms equipped with fixed water-extinguishing systems.

2.3.3 Access and escape routes and emergency lighting

To facilitate the safe shutdown of the facility, the effective operation of the fire brigades and a safe escape from the building during a fire or other emergencies, the building shall be provided with adequate access and escape routes. These routes shall be spacious and easy to pass through.

The plant shall be equipped with an emergency lighting with the purpose of ensuring safety of passage inside the building when the normal lighting is out of order (disturbance in the supply of electricity, fire etc.). Emergency lighting means both signal lights and standby lighting. The signal lights which are used for indicating the escape routes are continuously on and function independently of the normal lighting. The purpose of standby lighting is

to remain on or to be switched on automatically or manually when the normal lighting goes out. Emergency lighting shall also be located near the signs indicating the escape routes and emergency exits.

3 CONSTRUCTION PERMIT

3.1 Application for construction permit

The prerequisite for the issuance of a pronouncement on the construction permit is that the Preliminary Safety Analysis Report (PSAR) and the complementary topical reports are submitted to STUK in accordance with the Guide YVL 1.1. These documents shall provide a description of how the requirements of the section 2 are met in the design of the facility.

The division of items should be as follows:

- description of regulations, guides and standards used in the design
- description of fire loads
- description of fire areas
- description of ventilation in the event of a fire
- preliminary description of the fire detection and alarm system and the fire-extinguishing systems
- description of the escape routes and emergency exits
- description of the fire hazards analyses.

3.2 Regulations, guides and standards used in the design

This sub-section shall provide a list of the regulations, guides and standards used and the comments on their particular application.

3.3 Description of fire loads

Information on any considerable concentrations of combustible materials (solid, liquid, gaseous) at the nuclear

facility shall be presented in a separate description giving the quality, amounts and locations of the fire loads and the characteristics of smoke and gases released by postulated fires. If necessary, plans shall be made for collecting and restricting the leakages of combustible liquids and oil.

3.4 Description of fire areas

In order to assess the fire confinement capability of the boundaries of fire areas, the following documents shall be presented

- drawings of the subdivision of the facility into individual fire areas and other descriptions which unequivocably present the location of the safety-related systems and items at the facility
- description of the fire areas in m^2 and fire resistance ratings of the separating structures and elements of the boundaries of the fire areas.

Each fire area shall be marked with its own symbol in the above-mentioned drawings.

3.5 Preliminary description of fire venting

The functioning of the ventilation systems and smoke extraction in the event of a fire shall be described to give a comprehensive picture of how the spreading of a fire and detrimental gases is to be prevented. The account shall include

- a description of the areas and rooms which, owing to a considerable fire load, personal safety or other arrangements, are to be provided with fire venting and/or smoke extraction
- a preliminary description of smoke extraction
- an account of the fact that smoke extraction will

not essentially degrade the functioning of the fire-extinguishing systems
- arrangements to prevent the release of radioactive substances into the environment out of rooms from which radioactive substances might be released by a fire.

3.6 Preliminary description of the fire detection and alarm system and fire-extinguishing systems

This sub-section shall provide an account of the areas and rooms to be equipped with a fire detection and alarm system and fire-extinguishing systems, as well as functional descriptions of the systems.

In addition, a description of the fire water supply systems for both the fire brigades and the fire-extinguishing systems shall be given.

3.7 Description of the access and escape routes

The description shall include drawings showing

- escape routes and emergency exits
- access routes for the fire brigades
- routes needed in the safe shutdown of the facility.

3.8 Description of fire hazards analyses

In the cases referred to in the sub-section 2.2.1, fire safety shall be verified by means of a special fire hazards analysis. In addition, fire hazards analyses shall always be performed on the containment and the control room.

By means of a containment fire hazards analysis it shall be verified that the safe shutdown, the cooling of the reactor or the removal of residual heat from the reactor will not be threatened by any fire in the containment.

By means of a control room fire hazards analysis it shall be verified that the necessary control room functions can be accomplished in the event of a fire in the control room or in any other fire area.

The Preliminary Safety Analysis Report shall include a short description of the fire hazards analyses to be performed, the analysis methods to be used and the time schedule to be followed in performing the analyses.

In accordance with the principles of the Guide YVL 2.8 /4/, a probabilistic safety analysis concerning fire hazards (the Fire-PSA) specific of the facility shall be performed as well. Its purpose is to assess the probability of a core damage caused by fire. The Fire-PSA is performed in parallel to or together with the analyses required by the Guide YVL 2.8 so that the results of the analyses are available at the same time.

4 SUPERVISION OF CONSTRUCTION

After the issuance of the construction permit, STUK supervises the construction of the plant. In order to get a sufficiently detailed picture of the implementation of the fire protection arrangements at the nuclear facility, the applicant shall furnish STUK with accounts of the following items:

- wall, floor and ceiling structures of the fire boundaries as far as they are not described in the other documents submitted to STUK
- fire doors and hatches and their fire resistance
- types and fire resistance of fire stops used in cable and pipe penetrations
- fire detection and alarm system
- fire-extinguishing systems
- fire venting and smoke extraction
- removal of extinguishing water
- emergency lighting.

The results of the fire hazards analyses of the sub-section 3.8 shall be reported comprehensively to facilitate the assessment of the fire resistance of the structures.

4.1 Structures and elements of fire boundaries

The structures and elements by which a fire area is separated from the other areas include walls, ceilings and floors with their fire doors and hatches and the penetrations for cables, pipes and ventilation ducts.

The separating structures and elements are acceptable when they comply with the requirements of the construction regulations and instructions issued by the Ministry of the Interior. An adequate fire resistance can be verified by a type acceptance resolution issued in accordance with the above-mentioned regulations and instructions or a pronouncement issued by the fire laboratory of the Technical Research Centre of Finland.

4.2 Fire detection and alarm system

The document shall provide the following information on the fire detection and alarm system

- list of detector types and functional descriptions of the detectors
- transfer of alarms from the control unit onwards
- potential control functions connected to the detectors (smoke vents, ventilation, fire doors etc.)
- schematic wiring diagram of system
- company responsible for the design of the fire detection and alarm system.

A pronouncement of the Finnish Fire Protection Association on the acceptability of the planned fire detection and alarm system shall be submitted to STUK.

4.3 Fire-extinguishing

The document shall provide at least the following information on the automated and manual fire-extinguishing systems

- area to be protected
- demonstration of the applicability of the selected extinguishing systems and extinguishants
- design bases
- functional descriptions of the extinguishing systems
- names of the companies responsible for the design and implementation of the designed systems
- drawings of the extinguishing systems showing i.a.
  - manual actuation points of the extinguishing systems
  - location of tanks containing extinguishants and locations of valve centres.

A pronouncement of the Finnish Atomic Energy Insurance Pool on the acceptability of the planned fire-extinguishing systems shall be submitted to STUK.

4.4 Ventilation and smoke extraction in the event of a fire

Detailed requirements for the ventilation systems are given in the Guide YVL 5.6 /5/.

The description of the smoke extraction systems shall provide information on how the spreading of hot, possibly corrosive and poisonous gases and smoke released by a fire is prevented and how they are extracted.

The document shall provide at least the following information on smoke extraction

- areas and rooms to be provided with smoke extraction

- design bases
- design data on smoke extraction
- flow charts and data on extraction channels
- functional descriptions
- structural drawings of smoke vents and fire dampers and account of their acceptability
- location diagrams of smoke extractors (see Resolutions of the Ministry of the Interior on smoke extractors).

4.5 Removal of extinguishing water

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.

4.6 Emergency lighting

The applicant shall submit to STUK a description of the function and locations of the emergency lighting.

5 OPERATING PERMIT

5.1 Operating permit

The prerequisite for the issuance of a pronouncement on the operating permit is that the Final Safety Analysis Report (FSAR) is submitted to STUK in accordance with the Guide YVL 1.1. In addition, accounts of the following items relating to the planned fire protection arrangements shall be submitted to STUK:

- fire-fighting organization and training
- fire-fighting plan
- inservice inspection program

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 facility.

It contains the final descriptions of the items required to be described in the Preliminary Safety Analysis Report (PSAR) or its supplementary documents and the final analyses according to sub-section 3.8.

5.1.2 Technical Specifications

The requirements for and restrictions of the fire protection arrangements during operation shall be included in the Technical Specifications.

5.1.3 Fire-fighting organization, training and equipment

The description shall provide an account of the on-site fire-fighting organization, its competence, and training given for the on-site personnel in fire protection. The account of training shall include the special features concerning the operational fire-fighting in the controlled zone.

The description shall also provide information on the communication systems used in fire-fighting work, fire-fighting and rescue equipment, protective equipment and radiation monitoring equipment.

5.1.4 Fire-fighting scheme

The purpose of the fire-fighting scheme is to serve as a tool for the personnel at the facility and the fire brigades during fire-fighting operations. The fire-fighting scheme shall describe

- plant site and its immediate surroundings

- site of the facility in detail (buildings, storage areas, outdoor fire hydrants, entrances to buildings)
- building layouts with markings of fire areas, fire hydrants, equipment for initial extinguishment, valve centres, emergency phones, access routes for the fire brigades etc.
- protective apparatus
- areas protected by fire-extinguishing systems and the manual actuation points of the systems.

5.1.5 Inservice inspection program

The applicant shall present an inservice inspection program for the inservice supervisory measures relating to fire protection to be annexed to the inservice inspection program of the whole facility. At least the following items shall be included in the program:

- fire loads
- fire areas
- fire insulations
- fire venting and smoke extraction
- fire detection and alarm systems
- fire-extinguishing systems
- fire-fighting equipment
- protective apparatus
- equipment for radiation monitoring
- emergency lighting
- communication systems
- removal of extinguishing water.

The program shall also describe

- inspection and test intervals
- inspection and test methods
- documentation of the inspections and tests.

5.2 Commissioning inspection

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

- the partitioning of the facility into fire areas has been implemented as described in the preliminary inspection 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 of by the Finnish Fire Protection Association
- the fire-extinguishing system installations are approved of by the Finnish Atomic Energy Insurance Pool
- the equipment for initial extinguishment are located as given in the fire-fighting scheme (subsection 5.1.4).

The owner of the nuclear facility 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 given in the Guide YVL 1.1. The inspection can be conducted at several stages.

The fire protection arrangements at a nuclear power plant shall be accepted in the commissioning inspection in the extent required by each commissioning stage of the facility.

6 SUPERVISION DURING OPERATION

6.1 Inservice inspections

STUK supervises the inservice inspections performed by the owner of the nuclear power plant to the extent deemed

necessary and carries out inspections relating to fire protection in accordance with its own program.

6.2 Modifications, repairs and preventive maintenance

Modifications, repairs and preventive maintenance during operation shall be performed in accordance with the Guide YVL 1.8 /6/.

6.3 Outages

Supervision conducted by STUK during outages and the related general arrangements are described in the Guide YVL 1.13 /7/.

7 BIBLIOGRAPHY

1 STUK Guide YVL 1.0, Safety criteria for the design of nuclear power plants

2 STUK Guide YVL 1.1, the Institute of Radiation Protection as the supervisory authority to nuclear power plants

3 STUK Guide YVL 2.7, Failure criteria for the design of a light-water reactor

4 STUK Guide YVL 2.8, Probabilistic safety analyses (PSA) in the licensing and regulation of nuclear power plants

5 STUK Guide YVL 5.6, Inspection of ventilation systems of nuclear power plants, a draft

6 STUK Guide YVL 1.8, Repairs, modifications and preventive maintenance in nuclear facilities,

7 STUK Guide YVL 1.13, Regulatory inspections related to shutdowns at nuclear power plants

8 STUK Guide YVL 2.1, Safety classification of nuclear power plant systems, structures and components

9 STUK Guide YVL 5.5, Supervision of electric and instrumentation systems and components at nuclear facilities

10 KTA 2101.1 Brandschutz in Kernkraftwerken, Teil 1: Grundsätze des Brandschutzes

11 The Ministry of the Interior, the code of Finnish construction regulations

In the event of any differences in interpretation of this guide, the Finnish version shall take precedence over this translation.