

FIRE PROTECTION AT A NUCLEAR FACILITY

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continues

With regard to new nuclear facilities, this Guide shall apply as of 1 December 2013 until further notice. With regard to operating nuclear facilities and those under construction, this Guide shall be enforced through a separate decision to be taken by STUK. This Guide replaces Guide YVL 4.3.

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Authorisation

According to Section 7 r of the Nuclear Energy Act (990/1987), *the Radiation and Nuclear Safety Authority (STUK) shall specify detailed safety requirements for the implementation of the safety level in accordance with the Nuclear Energy Act.*

Rules for application

The publication of a YVL Guide shall not, as such, alter any previous decisions made by STUK. After having heard the parties concerned STUK will issue a separate decision as to how a new or revised YVL Guide is to be applied to operating nuclear facilities or those under construction, and to licensees' operational activities. The Guide shall apply as it stands to new nuclear facilities.

When considering how the new safety requirements presented in the YVL Guides shall be applied to the operating nuclear facilities, or to those under construction, STUK will take due account of the principles laid down in Section 7 a of the Nuclear Energy Act (990/1987): *The safety of nuclear energy use shall be maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered justified considering operating experience, safety research and advances in science and technology.*

Under Section 7 r(3) of the Nuclear Energy Act, *the safety requirements of the Radiation and Nuclear Safety Authority (STUK) are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety standards in accordance with this Act, the Radiation and Nuclear Safety Authority (STUK) may approve a procedure or solution by which the safety level set forth is achieved.*

1 Introduction

101. The task of the Radiation and Nuclear Safety Authority (STUK) as the national authority responsible for oversight of the safety of the use of nuclear energy is based on the Nuclear Energy Act (990/1987) [1] and the Nuclear Energy Decree (161/1988) [2]. STUK's general oversight procedures in regulating nuclear facilities are given in Guide YVL A.1. STUK's oversight includes the oversight of the fire protection arrangements of nuclear facilities in so far as they affect the nuclear and radiation safety of the facilities.

102. The Government Decree (717/2013) [3] presents requirements for the safety design of nuclear power plants: Section 12 requires implementation of the defence in depth principles to prevent accidents and to mitigate their consequences; Section 18 requires that the internal events to be considered include at least fire, floods, explosions and component failures; Section 19 presents requirements for the nuclear power plant's control room arrangements; Sections 21-26 present requirements for the nuclear power plant's construction, commissioning, operation, processing of operational experiences, safety research and the Operational Limits and Conditions; Sections 28–30 present requirements for the organisation and personnel of a nuclear power plant.

103. The Government Decree (736/2008) [4] presents requirements for the safety design of the final disposal of nuclear waste: to prevent operational occurrences and accidents, Section 8 requires, among other things, that in a nuclear waste facility, the placement and protection of systems alongside operative methods shall ensure that fire, explosions or other events inside the facility do not pose a threat to safety; Sections 17 and 18 present requirements for the construction, commissioning and operation of a nuclear facility.

104. The Ministry of the Environment issues technical regulations and guidelines on construction and structural fire protection [7]. The building inspection authority in each municipality sees to it that the regulations and guidelines issued by the Ministry are complied with in all construction activities.

105. Leadership and control of fire and rescue services, as well as the availability and quality of its services, rests with the Ministry of the Interior; the Ministry is also responsible for the preparation and arrangement of fire and rescue services at national level; and for co-ordination of the performance of different ministries involved in the fire and rescue services under the Rescue Act (379/2011) [8] and the Government Decree (407/2011) on fire and rescue services [9]. Regional State Administrative Agencies are responsible for the duties of rescue services in their sphere of activity. Municipalities are responsible in co-operation for fire and rescue services in a region determined by the Government (regional fire and rescue services). As regards the requirements, design, installation, maintenance, inspection and demonstration of conformity of the equipment of the rescue services, the Rescue Equipment Act (10/2007) [10] shall be observed.

106. The Government Decree (917/1996) [11] and the Ministry of Trade and Industry Decision (918/1996) [12] present the requirements for equipment and protective systems intended for potentially explosive atmospheres. The Government Decree (576/2003) [13] presents the requirements for prevention of personnel hazards caused by potentially explosive atmospheres. The Finnish Safety and Chemicals Agency (TUKES) and the Ministry of Social Affairs and Health provide guidelines on the application of the ATEX legislation in Finland [14].

107. STUK's activities do not affect any oversight activities required in the Land Use and Building Act (132/1999) [5], the Land Use and Building Decree (895/1999) [6], the Rescue Act (379/2011) [8] and the Government Decree (407/2011) on Rescue Services [9], unless otherwise agreed between the authorities.

2 Scope of application

201. When this Guide sets requirements for nuclear facilities, reference is made, under the Nuclear Energy Act (990/1987), to facilities necessary for producing nuclear energy (nuclear power plants), including research reactors, facilities performing extensive final disposal of nuclear wastes, and fa-

ilities used for extensive fabrication, production, use, handling, storage of nuclear materials or nuclear wastes. Requirements for nuclear facilities always apply to nuclear power plants unless a requirement separately says they only apply to other nuclear facilities.

202. This Guide applies to the planning and implementation of fire protection during the design, construction and operation of the nuclear facility. The Guide shall be applied to the decommissioning of nuclear facilities. This guide shall be complied with at the entire plant area and in all its buildings.

203. As regards fire protection at a nuclear facility construction site, this guide shall apply whenever fire protection is significant for the safety of nearby nuclear facilities and to ensure fulfilment of the design criteria of the nuclear facility under construction.

204. This Guide describes fire protection inspections performed by STUK during the design, construction and operation of the nuclear facility. Furthermore, it presents the requirements for fire protection documents to be submitted to STUK.

205. In addition to the fire protection requirements of this Guide, the following Guides also contain fire protection related requirements to be followed:

- a. Guide YVL A.1, Regulatory oversight of safety in the use of nuclear energy, sets forth requirements for nuclear facility design and oversight.
- b. Guide YVL A.3, Management system for a nuclear facility, sets forth detailed requirements related to the management system and quality management.
- c. Guide YVL A.5, Construction and commissioning of a nuclear facility, sets forth requirements for the management and oversight of the construction project at different stages of a nuclear facility's construction.
- d. Guide YVL A.6, Conduct of operations at a nuclear power plant, sets forth requirements for the operation of a nuclear power plant, such as for outages.
- e. Guide YVL A.7, Probabilistic risk assessment and risk management of a nuclear power plant, sets forth requirements for probabilistic fire risk assessments.
- f. Guide YVL A.11, Security of a nuclear facility, sets forth requirements for physical protection at a nuclear facility and its planning.
- g. Guide YVL B.1, Safety design of a nuclear power plant, sets forth requirements for the nuclear power plant's safety design and the design of systems important to safety.
- h. Guide YVL B.7, Provisions for internal and external hazards at a nuclear facility, sets forth requirements for nuclear facility layout design and the design to protect against internal and external threats.
- i. Guide YVL E.6, Buildings and structures of a nuclear facility, sets forth requirements for the design of civil structures.
- j. Guide YVL E.7, Electrical and I&C equipment of a nuclear facility, sets forth electrical equipment-specific requirements for protection against fire load-induced explosions.

3 Design requirements

3.1 General design requirements

301. Under Section 18 of the Government Decree 717/2013, structures, systems and components important to safety of a nuclear power plant shall be designed and located as well as protected in a way to make the likelihood of internal events (such as fires) small and their effect on facility safety insignificant.

302. A basis for the quality management of the nuclear power plant's construction and operation is provided in Section 29 of the Government Decree (717/2013) on the safety of nuclear power plants; it stipulates that *organisations participating in the design, construction, operation, and decommissioning of a nuclear power plant shall employ a management system for ensuring the management of safety and quality.*

303. The fire protection for the nuclear facility shall be so planned that during and after a potential fire situation the nuclear facility can be brought to a safe state and the release of radioactive substances into the environment can be prevented.

304. The licensee can propose that also foreign regulations and guides be applied in designing the nuclear facility's fire protection arrangements. It shall then be demonstrated, however, that they form a feasible entity. The application of foreign regulations and guides is subject to STUK's approval.

305. An organisation carrying out the fire protection design of buildings shall have an SFS-EN ISO 9001 compliant management system that has been documented and implemented for this purpose.

306. For the inclusion of all aspects of fire protection, an expert responsible for fire protection design shall be nominated for the duration of the nuclear facility's design and construction. The expert shall have sufficient qualifications and experience in nuclear, radiation and fire safety. Management of the entirety of the nuclear facility's fire protection arrangements places specific requirements on the combination of several design areas, such as facility layout, structural, heating/ventilation/air-conditioning, as well as electrical and I&C design.

307. In addition to the design requirements of this Guide, to be complied with in the design of nuclear facilities are

- a. the fire and building legislation in force in Finland
- b. for applicable parts, the practices of risk-informed fire protection planning for nuclear power plants described in the IAEA Guides [15–21] as well as in a technical report [22]
- c. The practices of the WENRA reference requirement area S, "protection against internal fires" [23].

3.2 Defence in depth approach to fire protection

3.2.1 General

308. The nuclear facility's fire protection shall be based on the defence in depth approach to fire protection, which aims to

- a. prevent the ignition of a fire
- b. rapidly detect and extinguish ignited fires
- c. prevent fire growth and spreading of a fire

d. contain a fire so that the facility's safety functions can be reliably performed irrespective of the effects of the fire.

309. Advanced and reliable technical designs and methods shall be used to prevent fire ignition, including e.g.

- a. minimisation of the danger of ignition by the use, in accordance with the National Building Code of Finland RakMK, of construction materials allowable for Class P1 buildings as stated on the classification of buildings in requirement 338
- b. protection and monitoring of equipment causing the risk of a fire, e.g. monitoring of vibration and oil leaks of rotating apparatuses (turbine generators, diesel generators and large pumps), transformer hydrogen analysers and arc barriers of switchgears
- c. ensuring fire protection relating to temporary fire loads and fire-hazardous components, supervision of work and administrative procedures as well as work-related personnel training.

310. A fire shall be detected and promptly extinguished by active fire protection arrangements including e.g.

- a. an automatic fire detection system covering the entire facility
- b. protection of components containing significant fire hazards by fixed extinguishing systems
- c. fire protection during fire-hazardous work
- d. operative fire fighting in accordance with section 3.5.3

311. Fire growth and spread shall be prevented and the effects mitigated by reliable technical means including

- a. fire separation of buildings and safety divisions
- b. fire compartmentation and local fire protection
- c. stopping or rerouting of ventilation to restrict the supply of oxygen and prevent smoke spread
- d. spread prevention and extraction of smoke and combustion gases.

312. Implementation of the defence in depth approach to fire protection shall be assessed by analyses in accordance with section 3.3, which focus at least on the following:

- a. rooms where the fire separation of safety divisions cannot be implemented by means of a fire wall according to standards.
- b. the containment, annulus and control room as well as areas where the zone affected by a design basis fire is contained within the fire compartment smaller than the entire fire compartment.
- c. rooms where the fire load contributing to a fire is, in a design basis fire, assumed to be smaller than the fire load of the entire fire compartment or a single component. Such fire compartments may contain, for example, large cable concentrations, a large transformer and oil systems that do not inherently burn completely due to layout and/or structural protection.

313. The significance of the results of fire hazard analyses used as the basis of risk-informed design shall be assessed by accident modelling methods approved in accordance with the licensing stages described in section 4.

3.2.2. Failure criteria during fire situations

314. In evaluating implementation of the defence in depth approach to fire protection, failures or impairments in the nuclear facility's fire protection shall be assumed. It shall be demonstrated that a single failure or deviation in fire protection does not lead to uncontrolled fire spread and endanger the facility's safety. As impairments of fire compartmentation, situations such as those involving an open fire door, or fire dampers that fail to close, shall be analysed. As common cause failures of active fire protection systems, situations shall be analysed where a fire detection system is inoperational, the fire extinguishing system does not start or the operation of the plant fire brigade is delayed.

315. Nuclear power plant design shall make provision for fire-induced initiating events and safety functions whose actuation is required during fire situations. A fire may cause an initiating event such as a turbine trip or a reactor scram as well

as consequential failures. Even if a fire at the nuclear power plant does not directly lead to an initiating event involving an automatic initiation of safety functions, provision shall always be made for promptly bringing the facility to a safe state during a fire situation in accordance with the operating procedures for anticipated operational occurrences and accidents.

316. All equipment in the fire compartment shall normally be assumed to fail due to a fire. In assessing a common cause failure, the failure of several systems, equipment or structures in consequence of the same single event or cause, either simultaneously or during a brief period of time, is analysed. In interpreting the failure criteria, the effects of fire can be considered to be limited to the area of one fire compartment. A fire can cause the failure of several redundant subsystems of systems in the same safety division within one fire compartment.

317. When a fire in the fire compartment under analysis causes an initiating event at the nuclear power plant but cannot cause the failure of systems associated with safety functions, the failure criteria in Guide YVL B.1 are valid as such.

318. When a fire in the fire compartment under analysis cannot cause an initiating event at the nuclear power plant but causes the failure of a redundant subsystem important to safety, the failure is then considered a single failure/common cause failure as referred to in Guide YVL B.1.

319. In addition to an initiating event possibly caused by a fire, to be taken into account during fire situations are fire-induced consequential failures irrespective of which the accomplishment of safety functions must be possible in accordance with the failure criteria of Guide YVL B.1. In analysing the scope of consequential failures, the effects of smoke and other combustion gases shall be taken into account. It shall be possible to bring the nuclear power plant into a safe state even if a fire causes consequential failures in safety functions, in addition to the initiating event, and even if safety functions are affected by a single failure that is independent of the fire.

320. Fire situations where a transformer fire or a switchgear fire potentially causes the simultaneous loss of all connections to the national grid shall be analysed and the results of the analysis taken into account in the design of grid connections. Guide YVL B.1 presents design requirements for the national grid connections of nuclear power plants.

3.3 Fire hazard analyses

3.3.1 General

321. Fire-induced failure is assessed by deterministic design methods in the first place and its significance for the nuclear power plant's safety is verified by a probabilistic fire risk assessment (Fire PRA) in accordance with Guide YVL A.7.

322. To verify the adequate implementation of the defence in depth approach to fire protection, the following fire hazard analyses shall be conducted:

- a. fire hazard analyses of the nuclear facility by deterministic, generally approved and experimentally verified methods such as
 - structural (FHA) and functional (FFHA, FHFA) fire hazard analyses
 - fire simulation analyses to evaluate fire development and the ambient effects of fire, temperature increase in particular,
 - analyses of heating, load-bearing capacity and integrity of load-bearing and separating structures
 - analyses or calculations of temperature increase in the room or object of study, such as component temperature increase
- b. in addition to the above, for a nuclear power plant, a probabilistic fire risk assessment, a fire PRA (Guide YVL A.7).

323. In risk-informed fire protection planning and assessment, the results of deterministic fire hazard analyses shall be collected on a case-by-case basis and the adequacy of the nuclear facility's defence in depth ensured by accident modelling methods. The methods shall be used to assess the significance of fire protection impairments for fire safety at the nuclear facility.

324. Appendices to Guide YVL A.11 present procedures for providing protection against an airplane crash. Guide YVL B.7 presents requirements for layout design in accidents. In regards to the related fire consequences, the adequacy of fire protection shall be demonstrated by risk-informed design and fire hazard analyses.

3.3.2 Deterministic fire hazard analyses

325. The adequacy of fire protection shall be demonstrated by deterministic fire hazard analyses. It is especially important to demonstrate that the safety functions of the facility can be reliably accomplished during any potential fire situation. Fire hazard analyses shall also examine design basis extension events (common cause failures in systems related to fire protection). The reliable implementation of the safety functions of the facility shall not be endangered by any single failure or deviation in fire protection arrangements. The results of deterministic fire hazards analyses are used as input data in drawing up a fire PRA.

326. It shall be demonstrated by means of the containment fire hazard analysis that, despite containment fires, the reactor can be shut down and cooled, and residual heat can be removed without compromising containment integrity.

327. It shall be demonstrated by a fire hazard analysis of the control room that control of the necessary safety functions can be executed in the event of a fire in the control room or in any other fire compartment.

328. In connection with the design of the I&C systems of the nuclear power plant, the influence of fires on the functioning of safety significant I&C systems shall be analysed, including the effects of fire-induced temperature rise and combustion gases on equipment and the reflection of disturbances and failures thereof on the execution of safety functions.

329. The load-bearing capacity of the building frame R as well as the integrity E and insulation

I of the separating structural elements shall be demonstrated in accordance with the fire resistance class requirements specified in the regulations and guidelines of the E1 National Building Code of Finland (RakMK), or by fire simulation and structural analysis.

3.3.3 Probabilistic fire risk assessment (fire PRA)

330. The PRA shall also analyse fires as initiating events (Guide YVL A.7). Guide YVL A.7 applies to fire risk analyses conducted during design, construction and operation of the nuclear power plant in order to assess the adequacy of fire protection and to identify fire-induced risk factors.

331. To be analysed as internal and external events by the PRA are fires that could induce an initiating event. The analyses shall be conducted in the same way as assessments of facility internal failures, disturbances, human error and loss of off-site power. An initiating event is a single event requiring actuation of the facility's safety functions (Guide YVL A.7).

332. The effects of malfunctioning fire-water and fire extinguishing systems on the reliability of fire protection as well as the flood risk caused by the malfunctions shall be assessed in accordance with Guide YVL A.7.

333. The adequacy of the testing methods of the fire detection and fire extinguishing systems shall be evaluated by using a fire PRA.

334. Guide YVL A.7 prescribes that a design stage Level 1 and Level 2 probabilistic risk assessment including a PRA computer model shall be drawn up for the review of the nuclear power plant's construction licence application. In the plant design stage PRA, fires shall also be analysed as initiating events.

335. Guide YVL A.7 prescribes that the licensee shall supplement and update the Level 1 and Level 2 probabilistic risk assessment compliant with requirement 334, including the PRA computer model, for the review of the nuclear power plant's operating licence application. In the PRA, fires shall also be analysed as initiating events.

3.4 Structural fire protection

3.4.1 General

336. The nuclear facility shall be designed in such a way that structural fire protection together with the facility's functional design and layout design ensure the safety of the facility during fire situations as far as possible without active fire fighting operations.

337. Incombustible construction materials or materials with extremely limited combustion shall be used in structural elements.

3.4.2 Fire resistance classes and separation of buildings

338. Buildings are divided into three fire classes P1, P2 and P3 [7]. Buildings containing systems important to the nuclear power plant's safety shall be designed as Class P1 buildings (see requirement 3.1 in part E1 of the National Building Code of Finland, RakMK).

339. The fire class of buildings containing systems other than those important to safety is determined according to the regulations and guidelines of parts E1 and E2 of RakMK.

340. The minimum fire requirement for the outer walls and roof of safety-classified buildings is the fire resistance class EI-M 120 of RakMK part E1.

341. If two buildings are conjoined, they shall be separated by a fire wall that complies with the fire resistance requirements of RakMK part E1 and has a minimum fire resistance class of EI-M 120.

342. The fire resistance rating of doors and hatches located between buildings shall be at least equal to the fire resistance rating required for the penetrated firewall.

343. The load-bearing structures of the buildings of nuclear power plants shall be constructed in compliance with the regulations of RakMK part E1 in accordance with the fire resistance class and fire load category of the building. Load-bearing structures shall at least meet the fire resistance rating R 60. The fire resistance rating

R of a fire compartment's load-bearing structures shall, however, be at least equal to the fire resistance rating of the walls enclosing the fire compartment, in terms of fire insulation I and integrity E.

3.4.3 Fire separation of safety divisions

344. Requirements for fire separation between safety divisions are given in Guides YVL B.1 and YVL B.7. This Guide sets forth the requirements for the fire separation of safety divisions.

345. Safety divisions shall be separated by structures having a fire resistance rating of at least EI-M 120. If the safety division separation requirement of EI-M 120 is inadequate due to heavy fire loads, the rating of the structures shall fulfil the requirements accordant with fire loads, or their fire resistance rating shall be justified by fire hazard analyses.

346. A safety division shall be divided into fire compartments based on compartmentation by storey and compartmentation by use, as well as based on fire load.

347. In the separating structural elements between safety divisions, any elements reducing fire safety, such as doors, hatches and penetrations for ventilation, pipes and cables, shall be avoided as much as possible. In case these must be installed in structural elements between safety divisions, they shall fulfil the same fire resistance class requirement as the separating structural element.

348. Doors and hatches between safety divisions shall be kept locked during normal operation of the plant and they shall be equipped with continuous position monitoring. Separating fire doors shall be self-closing and self-bolting.

3.4.4 Fire compartmentation

349. Fire compartmentation is based on compartmentation by storey and compartmentation by use. Rooms with varying purposes of use, such as control rooms, computer rooms, electrical and switch rooms, cable spaces, battery rooms and active carbon filter rooms, shall be separated as their own fire compartments.

350. A fire compartment shall not, in terms of radiation protection, have rooms belonging to both the controlled area and the clean area. The interconnecting spaces intended for personnel traffic at the boundary between the controlled and clean area shall be separated into individual fire compartments.

351. Heavy fire load concentrations or compartments where the risk of fire is high shall be separated into individual fire compartments. The amount of combustible liquids, gases and other fire loads placed in the areas and rooms of the plant that are important to safety shall be minimised.

352. The separating structural elements of compartments shall fulfil the fire resistance class requirements of the RakMK part E1. The minimum fire resistance class shall be EI 60.

353. The fire resistance rating of doors and hatches in separating structural elements other than those between safety divisions shall be at least half of that required for the structural element (wall, floor or roof).

- a. The fire resistance class of separating doors and hatches shall be at least equal to EI 60.
- b. Separating fire doors shall be self-closing and self-bolting.

354. Dampers as well as cable, ventilation and piping penetrations shall fulfil the integrity and insulation requirements EI for the penetrated separating structural element.

3.4.5 Protection against fire-load induced explosions

355. Explosions and arcs as well as their consequent effects such as missiles shall be taken into account in designing fire protection arrangements at nuclear power plants. Protection shall be provided against explosions occurring in consequence of fires.

356. The nuclear power plant's design shall provide protection against the risk of explosions and arcs in accordance with the defence in depth approach to fire protection so as to

- a. prevent explosions and arcs by monitoring and protection systems

- b. minimise the risk for plant safety from explosions and arcs
 - c. limit the spread of the effects of an explosion and arc.
- 357.** Combustible liquids or gases, which are not part of the facility's processes and could cause explosions, shall not be permanently or temporarily located in rooms important to plant safety, or in their immediate vicinity. The design of the facility and its fire protection shall take into account the spread of gases, gas mixtures and liquids far from the leak point before they ignite or explode.
- 358.** The generation of conditions prone to explosions and arcs in the tanks, piping and electrical rooms important to safety (switchgears and battery rooms) of the plant's process systems shall be primarily prevented by means of design solutions.
- 359.** Pressure relief along controlled routes (e.g. pressure relief hatches of rooms) to prevent structural failures and collapse of buildings and rooms involving the risk of explosion shall be ensured in the design of buildings and rooms.
- 360.** The possibility of arcing shall be taken into account in the design of rooms containing electrical equipment and in the choice of the equipment (instrumentation, circuit-breakers).
- a. Switch cabinets important to safety shall be provided with arc barriers, which limit the duration of arcs and the amount of total energy generated and released.
 - b. Design shall consider the possibility of smoke causing an arc flash in the switchgear room.
- 361.** In addition to fires, to be taken into account in transformer positioning and protection is the possibility of an arc or a rapid, explosive energy discharge.
- a. During a high energy discharge, the rapid release of gas as well as the mixing and expansion of air and gas could cause a powerful fire and explosion.
 - b. Large oil-cooled transformers shall be equipped with monitoring and protection systems (hydrogen monitors, gas relays) to prevent fires and arcs (arc flashes).
- c. Transformers containing large amounts of oil shall be placed sufficiently far from buildings and protected with structures and fire extinguishing systems.
- 362.** Rooms shall be provided with adequate air-conditioning and ventilation if the risk of explosive concentrations of gas or dust exists.
- a. Hydrogen may form in batteries, which shall be considered in the design of battery room ventilation.
 - b. The risk of a fire and an explosion of dust or gas mixtures in ventilation ducts shall be considered.
- 363.** Hydrogen stations that cool diesel generators, for example, shall be located sufficiently far from buildings important to safety and their design shall consider explosion pressure waves. Other gas cylinders shall be located and stored in rooms specially designed for them.
- 364.** Process systems containing combustible gas mixtures (e.g. the off-gas system) shall be placed far from safety divisions. Provision shall be made for filter and hydrogen fires with regard potential explosions as well.
- 3.4.6 The containment and annulus**
- 365.** Safety divisions (redundant subsystems) inside the containment and in the annulus shall be housed in separate fire compartments whenever possible.
- 366.** Whenever the fire compartmentation between safety divisions is not possible inside the containment of the nuclear power plant, the operability of components important to safety as well as redundant subsystems shall be ensured by protective structures, separation by distance, fire-resistant materials and fire insulation. The design concepts shall be analysed in accordance with the defence in depth approach to fire protection utilising a risk-informed approach and also taking into account the airplane crash resistance requirements of Guide YVL A.11.
- 367.** The fire load inside the containment shall be minimised. Safety system equipment including cables and impulse lines shall be so located and

protected that the effects of a potential fire are limited to one safety division only.

368. Protection and fire protection of the lubrication oil system of the primary circulation pump/motor shall be so designed in accordance with the defence-in-depth approach that a potential fire does not endanger the facility's safety functions. Provision shall be made for oil leaks by means of oil collection and drainage systems whereby leaked oil is extracted to sealed, fire-suppressing collection tanks.

3.4.7 Control room and emergency control room

369. Control rooms shall be placed in plant area locations safe from fire risks. Guidelines and requirements for control rooms are given in Guides YVL B.1 and YVL A.11.

370. Separation of the control room and the emergency control room from the rest of the facility and from each other shall be implemented in compliance with the requirements set for the separation of safety divisions. The control room and the emergency control room shall be their own fire compartments in accordance with RakMK part E1, however their fire resistance shall be not less than EI-M120. The control rooms shall have separate ventilation systems whose structural separation is equivalent to that between safety divisions.

371. Control systems in the emergency control room shall be separated from the control systems of the control room and made into separate fire compartments in such a way that loss of equipment in the control room, or in any single fire compartment, does not prevent the functioning of controls in both the control room and the emergency control room. A corresponding requirement applies to emergency control posts outside the control rooms, which complement the vital functions of the emergency control rooms.

372. Cables important to safety that run from different safety divisions to the control room shall be routed through separate fire compartments. In case cables from different redundant systems must exceptionally be located 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 be equipped with effective and reliable fire detection systems and fire-extinguishing systems. An example of such a compartment is the cable space under the control desk.

373. The control room and the emergency control room shall be provided with overpressure ventilation to prevent smoke from entering the control room or the emergency control room in case of a fire outside the room in question. Overpressure ventilation of the emergency control room can be replaced by locating the supply air centre of the control room and the emergency control room in such a way that their independence as regards smoke risk is reliably ensured. Overpressure ventilation shall be separate from other ventilation systems.

374. In case of a fire situation in a control room, the control room personnel shall be able to quickly and safely move from the control room to the emergency control room.

3.4.8 Access and escape routes

375. The nuclear facility shall feature an adequate number of appropriate, sufficiently spacious and easy-to-use access routes to enable safe exit from the facility. Access and escape route design shall comply with the regulations of RakMK part E1.

376. The fire brigade shall be able to operate effectively at the plant during a fire situation. The design of attack routes for fire brigades shall be in compliance with the regulations of RakMK part E1.

377. The personnel shall be able to move within the plant to ensure the necessary safety functions during a fire or other accident. Emergency response operations shall be ensured by appropriate training.

378. Nuclear security shall be taken into account in the design of access and escape routes. Nuclear security is addressed in Guide YVL A.11. Requirements imposed by passage within the plant area and transport are given in Guide YVL B.7.

3.5 Active fire protection

3.5.1 Automatic fire detection systems

379. To detect and locate a fire as quickly as possible, the nuclear facility buildings shall have extensive, sufficiently effective and reliable automatic fire detection systems. They shall be so designed that the location of a fire can be identified at least to any individual room. In large rooms containing systems important to safety it shall be possible to identify the location of the alarm with sufficient accuracy, even to a single detector within the room, if necessary.

380. The alarms of fire detection systems shall always be relayed to the facility unit's control room and to the plant fire brigade.

381. The selection and placement of fire detection equipment shall take into account the characteristic features of the compartment including ambient conditions, fire loads, ventilation and the significance of the compartment to the safety of the facility. If necessary, the fire detection systems can be supplemented with other appropriate monitoring systems.

3.5.2 Fire extinguishing water systems and fire extinguishing systems

382. There may be several nuclear power plants at the site as well as other nuclear facilities, such as an interim storage for spent nuclear fuel, nuclear waste processing utilities and storages. If the on-site fire extinguishing water system serves several nuclear facilities, its capacity and significance in terms of safety during events threatening the entire facility site shall be assessed.

383. The nuclear power plant and other nuclear facilities at the site shall be equipped with fire water tanks, a fire water pumping station and fire water mains. Fire water volumes and the capacities of the fire water pumping stations shall be designed in accordance with sprinkler rules to supply water to the most extensive area requiring protection and taking into account potential fire spread. Furthermore, an adequate amount of fire water must be available for operative use by fire brigades. Requirements concerning

fire extinguishing systems are set forth in the Ministry of the Interior Decree SM-1999-967/Tu-33 [25] on automatic fire extinguishing equipment. Guidelines regarding fire extinguishing systems are provided in standards [26–30].

384. The fire water systems of the nuclear power plant and other nuclear facilities shall be implemented in such a way that in case of the potential failure of a system part, the leak point can be isolated to limit fire water loss to the vicinity of the failure point.

385. To facilitate fast suppression of fires and to minimise damage and hazards, the nuclear power plant and other nuclear facilities shall be equipped with a fire water system and effective and reliable fire extinguishing systems. Location of the facilities, structural fire protection solutions and the amount of fire loads shall be taken into account in the design of the fire extinguishing systems of different fire compartments.

386. Irrespective of the layout design of the nuclear power plant or the amount of existing fire loads, at least the following rooms and systems shall be provided with fixed, sufficiently reliable and, if necessary, automatic fire extinguishing systems

- a. cable spreading rooms where compartmentation between safety divisions (redundant subsystems important to safety) is not realised
- b. cable rooms containing large cable concentrations with a fire load of $> 1,200 \text{ MJ/m}^2$, unless it can be demonstrated by the defence in depth approach to fire protection that the development of a continuous cable fire in them is highly unlikely.
- c. rooms and systems containing radioactive substances from which considerable amounts of radioactive substances can be released into rooms or the environment due to a fire, unless the risk is otherwise demonstrated to be insignificant
- d. where necessary, components featuring heavy fire loads, such diesel generators, large transformers and other systems containing large amounts of oil.

387. Guide YVL B.7 prescribes that 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.

388. The removal of fire water shall be arranged from rooms equipped with fixed water extinguishing systems or from rooms where large quantities of fire water are presumably needed in a fire situation. The effects of extinguishing water induced flooding shall be taken into account in the design and placement of these rooms. Loose parts shall also be taken into account in the removal of fire water.

389. The seismic resistance of fire water and extinguishing systems is verified in accordance with Guide YVL B.7. Systems and components to be protected by risk-informed assessment are determined in accordance with Guide YVL B.2. This applies to extinguishing water tanks, pumping stations, piping, and protection against pipe breaks in particular.

3.5.3 Operative fire fighting

390. The nuclear power plant shall have an operative fire fighting readiness consisting of fire protection performed by the plant fire brigade, plant personnel and off-site fire brigades. This includes the on-site movable fire fighting equipment.

391. On the nuclear power plant area, or in its immediate vicinity there shall be a plant fire brigade whose adequate manning shall be justified. The brigade shall consist of at least one full-time fire foreman and three full-time fire fighters (1 + 3). The plant fire brigade shall be at a five-minute (5) response preparedness at all times (7/24). The fire fighters shall be qualified in smoke diving in terms of training, experience, physical condition, suitability and equipment [24]. The plant fire brigade shall be equipped with a sufficient amount of suitable and efficient equipment.

392. Operation with the plant fire brigade and the regional fire and rescue services shall be planned, instructions provided and co-operation exercises conducted.

393. The control room and the fire brigade shall be equipped with displays and printers for the fire detection system to speed up and facilitate identification of the fire locations and guidance to the scene of the incident.

394. Where command responsibility is concerned, the provisions of the Rescue Act [8] and the Government Decree on Rescue Services [9] apply.

395. Nuclear facilities shall be provided with equipment facilitating the use of a communication system generally in use by the authorities.

3.5.4 Overpressure ventilation and smoke extraction

396. The use of access routes between the control room and the emergency control room during fires shall be analysed and, where necessary, their reliability assured by special arrangements and taking into account the requirements of Guide YVL A.11.

397. Nuclear facilities shall be equipped with smoke extraction systems that remove the hot, possibly corrosive and toxic combustion gases generated by a fire.

- a. Rooms with heavy fire loads, such as the turbine hall and cable rooms, shall be provided with sufficiently efficient smoke extraction systems.
- b. The personnel carrying out fire extinguishing must be able to safely locate the fire.

3.6 Emergency lighting

398. Emergency lighting shall be designed and installed at the nuclear facility comprising escape lighting as well as stand-by lighting for the control room, emergency control room, control centre and command centre. The emergency lighting shall enable safe passage inside the plant and escape from the buildings when normal lighting is out of order due to a disturbance in electricity supply, a fire or some other event.

3.7 Provision for outages/annual maintenance

399. The nuclear power plant's design shall take into account plant servicing and maintenance. Guide YVL B.7 provides guidelines for the plant layout design.

- a. Fire protection shall make provision for fires occurring during outages by employing the defence in depth approach in accordance with this Guide.
- b. Appropriate storage space, routes and instructions shall be in place for the storage and transport of temporary fire loads.

4 Documents of the design stage and the construction stage

4.1 General

401. Guide YVL B.1 presents the design documents of the nuclear power plant to be submitted to STUK. Regulatory oversight of the nuclear power plant's design and construction comprises four stages: decision-in-principle stage, construction licence stage, construction stage and operating licence stage. Guide YVL A.1 sets forth requirements for the documents to be submitted in the different licensing stages. This section describes the fire protection documents to be submitted during the aforementioned stages and the essential requirements for their contents.

402. Document related source literature not easily accessible, or their copies, shall be submitted to STUK with the documents in question.

4.2 Documents to be submitted during the decision-in-principle stage

403. In the decision-in-principle stage, a document shall be submitted presenting the licensee-determined requirements to assure implementation of the Finnish safety requirements in fire protection. The essential contents of this document include

- a. applicable regulations, guides and technical standards and their scopes of application
- b. defence in depth plan for fire protection and its analysis principles
- c. fire separation of safety divisions
- d. fire resistance classes and separation of buildings
- e. heavy fire loads and their management
- f. fire compartmentation layout of the facility.

4.3 Documents to be submitted during the construction licence stage

4.3.1 General

404. Section 35 of the Nuclear Energy Act (161/1988) presents the documents to be submitted to STUK with the construction licence application for the nuclear facility. Furthermore, all other analyses considered necessary by STUK shall be submitted to STUK.

405. The principles of fire protection for the nuclear facility shall be described in the Preliminary Safety Analysis Report (PSAR) and the topical reports complementing it, as well as in the construction quality assurance plans. The PSAR shall give the safety classification and seismic classification of fire protection systems and the fire class of buildings. Safety classification guidelines are given in Guide YVL B.2.

406. Where fire protection is concerned, to be presented in the PSAR are the design criteria; applicable standards; different fire design areas, such as facility layout, including escape routes, implementation of structural fire protection and active fire protection systems, as well as fire hazard analyses to assure implementation of the defence in depth approach to fire protection; and detailed clarifications of the fire loads, fire compartmentation and layout presented in requirement 403.

407. Furthermore, the following documents shall be submitted in the construction licence stage:

- a. document submission plan and construction site briefing plan
- b. fire protection design plan in accordance with section 4.3.2
- c. qualifications, tasks and responsibilities of responsible fire protection designer
- d. fire compartmentation drawings and fire hazard analyses to verify fire compartmentation, which cover component location and fire load size assessment in the different fire compartments in accordance with section 4.3.3.
- e. system descriptions for fire water systems and fire extinguishing systems in accordance with section 4.3.4
- f. system descriptions for automatic fire detection systems in accordance with section 4.3.5

- g. system description for smoke extraction systems in accordance with section 4.3.6
- h. description of access and escape routes in accordance with section 4.3.7
- i. description of emergency lighting in accordance with section 4.3.8
- j. design solution suitability assessment drawn up by the licensee
- k. conceptual design plan for fire protection inspections during operation.

408. The licensee shall submit for the review of the nuclear power plant's construction licence application to STUK for approval a design Level 1 and Level 2 probabilistic risk assessment including the PRA computer model drawn up in accordance with requirement 334 of Guide YVL B.8.

4.3.2 Design procedure for fire protection

409. A description of the design organisation shall be presented to demonstrate that adequate competence, resources and co-ordination of the different design areas has been reserved to ensure a comprehensive design of the nuclear facility's fire protection arrangements.

410. The design procedure presents the final design bases, applicable design standards as well as the classification and testing standards of systems and components.

4.3.3 Fire compartmentation drawings and verification plans

411. To be presented for buildings are their fire class, fire hazard class, level of protection and density of fire load.

412. Documents shall include the design bases for structural fire protection, fire compartmentation drawings with every fire compartment marked using a unique symbol and outline, as well as other structural fire protection specifications. The specifications shall include preliminary information on the location of components in the fire compartments, the fire loads and sizes of the fire compartments, as well as the fire resistance ratings of separating structural elements and the fire hazard analyses conducted to verify the fire compartmentation.

413. Data on any considerable concentrations of combustible materials at the plant shall be presented in a separate description specifying the quality (solid, liquid, gaseous), amount and location of fire loads and the characteristics of smoke and combustion gases released by fires. Furthermore, conceptual design plans shall present principles of collecting oil leakages and other combustible liquids, as well as the methods of limiting the run-off and dispersion of these substances.

414. Copies of the declarations of performance and CE markings, type approval decisions, verification certificates and manufacturing quality management of separating structural elements pertaining to requirements 342, 347, 353, 354, 366 shall be submitted to STUK for information.

4.3.4 Descriptions of fire water and fire extinguishing systems

415. A system description for the fire water system shall be submitted to STUK for approval. The document shall describe how the supply of fire water to extinguishing systems and fire hydrants has been arranged and ensured.

416. A system description of the fire-extinguishing systems shall be submitted to STUK for approval. The plan for the fire extinguishing systems shall describe the area to be protected, fire loads, system design data, functional description and technical specifications. Furthermore, a demonstration of the suitability of the selected extinguishing systems and substances for their intended use shall be provided.

417. The descriptions of fire extinguishing systems shall present how the supply of fire water from the fire water system is ensured. To be described is the removal of fire water from rooms equipped with fixed water extinguishing systems or rooms where large quantities of fire water may be needed in a fire situation.

4.3.5 System description for the automatic fire detection system

418. A system description for the automatic fire detection system shall be submitted to STUK for approval. Detailed detector installation draw-

ings shall be submitted upon separate request by STUK. A statement on the acceptability of the fire detection systems from an inspection organisation certified by the Finnish Safety and Chemicals Agency (TUKES) and information on the designer and supplier of the systems shall be submitted to STUK for information.

419. The fire detection system plan shall include:

- a. design data, functional descriptions and technical specifications as well as the applicable standards of the system
- b. location of the fire alarm control panel and potential control units
- c. list of detector types and functional descriptions of detectors
- d. principles for installing various types of detectors in different rooms of the plant
- e. specifications of the detectors' control functions (smoke vents, ventilation, fire doors, etc.).

4.3.6 System descriptions for the overpressure ventilation and smoke extraction systems

420. A system description for the smoke extraction systems and overpressure ventilation arrangements shall be submitted to STUK for approval. The system description shall present

- a. design bases for the ventilation and smoke extraction systems, and their impact on fire safety
- b. plans for preventing the dispersion within the plant of hot, possibly corrosive and toxic gases generated in a fire, as well as smoke
- c. method of leading out gases and smoke
- d. method of preventing the release of radioactive substances into the environment in a fire situation.

4.3.7 Plans for access and escape routes as well as attack routes for fire brigades

421. The plans for access and escape routes as well as attack routes for fire brigades shall be submitted to STUK for approval. Drawings and descriptions shall present the access and escape routes, exit route length calculations, routes to carry out measures for safely shutting down the facility (see section 3.4.8) and the attack routes for fire brigades used for extinguishing fires.

4.3.8 System descriptions for the emergency lighting

422. System descriptions for the emergency lighting shall be submitted to STUK for approval. The document shall present the functional principles of the system and subsystems, which fulfil the design criteria, as well as the areas equipped with the systems in question.

4.4 Documents to be submitted during construction

423. During the construction of the nuclear power plant, supplemented and detailed documents covering the construction licence stage shall be submitted to STUK.

- a. The fire hazard analyses required in section 3.3 are updated to correspond to the data of the implementation plans.
- b. The construction plans of structures and components, which are required by the structural fire protection detailed in section 3.4, shall be submitted to STUK in accordance with Guide YVL E.6.
- c. The probabilistic risk assessment submitted in accordance with requirement 408 shall be updated according to Guide YVL A.7 to match the information in the implementation plans, so that STUK can, sufficiently early on during construction, evaluate the significance for fire protection of the changes that are incorporated between the clarifications necessitated by requirements 334 and 335 of this Guide during construction.
- d. Detailed layout drawings for the fire extinguishing systems, as specified in section 4.3.4, shall be submitted if separately requested by STUK,
- e. As regards section 4.3.4, the detailed statements of the inspection body approved by the Finnish Safety and Chemicals Agency on the acceptability of the fire water pumping station, fire water system and the fire extinguishing systems shall be submitted to STUK for information, along with information concerning the parties who designed and implemented the extinguishing systems.

424. To ensure adequate review time, the plan changes of structural fire protection required after the construction licence application shall

be submitted to STUK well in advance of the commencement of construction or installation of the component in question. The nuclear facility's fire compartmentation plans in accordance with section 4.3.3 shall be approved before the construction of equivalent structural framework and the concreting of robust concrete structures is initiated.

4.5 Documents to be submitted during the operating licence stage

4.5.1 Operating licence application

425. Section 36 of the Nuclear Energy Decree (161/1988) lists the documents to be submitted to STUK in connection with the nuclear facility's operating licence application. Furthermore, all other analyses considered necessary by STUK shall be submitted to STUK. The following documents shall be submitted to STUK as regards fire protection arrangements:

- a. The Final Safety Analysis Report (FSAR) with the associated detailed reports and analyses including the fire PRA referred to in requirement 334
- b. Operational Limits and Conditions (OLC)
- c. a description of operative fire fighting preparedness
- d. the fire fighting plan
- e. an in-service inspection programme for fire protection.

4.5.2 Final Safety Analysis Report (FSAR)

426. The FSAR shall describe the fire protection arrangements as they are implemented at the nuclear facility.

4.5.3 Operational Limits and Conditions (OLC)

427. The requirements and restrictions to be set for the fire protection arrangements during operation shall be included in the Operational Limits and Conditions (OLC) together with the compensatory safety measures to be applied to maintain a safety level adequate in the event of e.g. a component failure or a planned component disconnection from use. The OLC shall include periodical tests of fire protection systems covered by the OLC and tests to demonstrate the operability of systems and components. The OLC shall

include requirements and restrictions for at least the following functions

- a. structural fire protection measures, including fire doors and dampers
- b. fire-extinguishing system, water supply, fire water pumps and main pipeline
- c. fire detection systems
- d. fire extinguishing systems
- e. smoke extraction systems
- f. equipment for initial extinguishing at the facility
- g. operative fire fighting preparedness
- h. fire protection during annual outages.

4.5.4 Operative fire fighting preparedness

428. The requirements concerning the plant fire brigade are presented in section 3.5.3. The licensee shall submit specifications on the following to STUK for information:

- a. the duties and tasks of the fire brigade leader and the person responsible for the fire fighting organisation and solutions
- b. administrative arrangements to alert the plant fire brigade, the emergency response centre and nuclear facility personnel in case of an alarm from the fire detection systems or any other fire alarm
- c. command responsibility in a fire situation as well as operative fire fighting procedures
- d. overall fire fighting personnel and its competence, including the fire fighting and rescue training of permanent and temporary on-site personnel
- e. communication systems to be used in fire and rescue events
- f. equipment of the plant fire brigade and the fire fighting and protective equipment at the facility for fire and rescue events
- g. special features of operative fire fighting in spaces belonging to the controlled area based on their radiation conditions
- h. special features of fire protection in energised rooms.

4.5.5 Fire fighting plan

429. A fire fighting plan shall be drawn up and maintained to serve as a tool for the plant personnel, the plant fire brigade and the off-site fire brigades during fire and rescue events. It shall be submitted to STUK for information.

430. The fire fighting plan shall describe at least the following:

- a. plant area and its immediate surroundings
- b. plant area buildings, outdoor fire hydrants and building entrances
- c. building layouts with markings of fire compartments, most significant fire loads, valve control panel of the fire water system, fire hydrants, equipment for initial extinguishing, attack routes for the fire brigades, access routes, escape routes, smoke extraction equipment, overpressure ventilation, and so on
- d. fire alarm system centres, fire detector groups and the locations of manual alarm switches,
- e. spaces protected by fire extinguishing systems, valve control panels and the locations of the manual activation switches of the fire extinguishing systems
- f. personal protective equipment.

4.5.6 Principles of fire protection inspections during operation

431. The plant procedure stating the principles of fire protection inspections during operation shall be submitted to STUK for approval. The document shall present the inspection methods, the grounds for assessment of test results, and the recording arrangements of the results.

4.5.7 Periodic inspection programme

432. The licensee shall draw up an in-service inspection programme for the inspections of fire protection arrangements during operation. This programme shall be annexed to the in-service inspection programme covering the entire facility. The inspections shall pay attention to the prevention of the outbreak of fires, the spreading of fires already ignited and to extinguishing them. Inspection results and potential repair and maintenance measures shall be recorded and the repairs conducted without delay. The effects of the ageing of equipment and materials on fire safety shall be monitored and evaluated. The in-service inspection programme shall be submitted to STUK for information.

433. At least the following items shall be included in the in-service inspection programme:

- a. fire loads

- b. fire compartmentation, including fire doors and structural penetrations
- c. access and escape routes and attack routes for fire brigades
- d. fire insulation
- e. fire detection systems
- f. fire water systems
- g. fire extinguishing systems
- h. overpressure ventilation, smoke extraction ventilation and smoke vents
- i. fire dampers
- j. fire fighting and rescue equipment
- k. personal protective equipment
- l. emergency lighting
- m. communication systems.

434. Detailed procedures shall be drawn up for the above inspection items presenting the following for each inspection and test:

- a. title of inspection
- b. description of inspection
- c. person in charge
- d. operational state of the facility for the inspection/test
- e. inspection and test dates and intervals
- f. inspection and test methods
- g. approval criteria
- h. records to be created
- i. repairs and corrections implemented based on the inspections.

4.6 Commissioning inspection

435. The licensee shall present to STUK the procedures used to assess and approve the fire protection arrangements for commissioning.

436. The commissioning inspection of fire protection arrangements shall be conducted by an inspection organisation certified by TUKES and the licence applicant. The licence applicant shall then submit to STUK a written commissioning inspection request no later than a week before the STUK inspection date.

437. In the commissioning inspection the licensee shall ensure that

- a. fire compartmentation is implemented as described in STUK-approved plans
- b. the quality, amount and location of fire loads is as designed

- c. fire detection system installations have been approved by an inspection body certified by TUKES
- d. fire water system and fire extinguishing system installations have been inspected and approved by an inspection organisation certified by TUKES
- e. initial fire fighting equipment are located as specified in the fire fighting plan (section 4.5.5)
- f. the communication system is operational
- g. operative fire fighting preparedness is as planned.

438. An approved commissioning inspection of the fire protection arrangements is a prerequisite for the commissioning of the nuclear facility.

5 Fire safety during operation

5.1 General

501. In the inspection and operation of nuclear facilities, the licensee shall take into account the fire safety requirements and aspects whose objective is to:

- a. prevent ignition of fire
- b. rapidly detect and extinguish ignited fires
- c. prevent fire spread so that the facility's safety functions can be reliably performed also during a fire situation.

502. The licensee has overall responsibility for the development of the nuclear facility's fire safety and the maintenance of all fire protection arrangements. Fire safety requirements shall be taken into account in every field of operation. Everyone working at the facility is responsible for ensuring fire safety. For this purpose, there shall be training and instructions for both permanent and temporary facility personnel, and they shall be provided with adequate fire protection instructions.

5.2 Operational Limits and Conditions (OLC), in-service inspections and maintenance

503. The licensee is responsible for maintaining fire protection arrangements in accordance with the procedures of a valid OLC and of the in-service inspection programme for fire protec-

tion. Any revisions by the licensee of the OLC's in-service testing programme are subject to approval by STUK.

504. If the original functional principles of fire protection systems, structures or components are changed or new systems or parts thereof are built, the plans for the changes shall be submitted to STUK for approval. The plans shall fulfil the requirements of section 3.

505. In disconnecting fire protection systems (fire detection systems, fire water systems or fire extinguishing systems) covered by the OLC for work carried out at the plant, the procedure shall be carried out in accordance with the OLC as well as approved plans and instructions. Guide YVL A.6 presents OLC-related requirements.

506. STUK shall be informed in advance of any significant/long-term repairs of fire protection systems. At the same time, any compensating measures to maintain the safety level prescribed in the OLC shall be presented.

507. In making essential changes to operative fire fighting preparedness, STUK's approval shall be obtained for the changes.

508. Fires and explosion events at the plant site, or situations involving a risk of them, shall be reported in accordance with Guide YVL A.10.

5.3 Nuclear power plant outages

509. According to the OLC, components, structures and systems required for fire protection shall be operable also during nuclear power plant outages. The functionality and adequacy of fire protection arrangements shall be evaluated as part of outage planning. Outage-specific special arrangements shall be undertaken to ensure adequate fire safety, where necessary.

510. A general description of refuelling outages and preplanned extensive repair and maintenance outages shall be submitted to STUK for information no later than one month before the commencement of the outage. The description shall include arrangements to intensify fire protection arrangements during outages.

511. Operative fire fighting preparedness during outages shall be intensified. During outages, a sufficient number of personnel with fire guard training shall supervise hot work and the fire protection arrangements.

512. The opening of separating penetrations and disconnecting of fire detection systems and extinguishing systems shall be done according to clearly defined procedures. Protective measures concerning hot work shall be determined in the work permit. Hot work can only be performed by those having a valid hot work permit in accordance with the work in question.

513. Hot work and other work presenting a fire hazard shall be provided with unambiguous instructions and supervision. For this purpose, training shall be provided to permanent and temporary power plant personnel and adequate instructions shall be available. If combustible liquids or gases are temporarily needed in rooms important to safety for the purpose of decontamination or hot work, for example, the amounts in question shall be the smallest possible and they shall be appropriately stored and kept, taking fire safety into account.

514. Before the nuclear power plant is restarted after an annual refuelling outage or a maintenance or repair outage of a longer duration, the licensee shall, as regards the fire protection arrangements, ensure that

- a. annual inspections required in the OLC have been performed
- b. the structural fire protection meets the requirements of the OLC
- c. fire detection systems are operable
- d. fire extinguishing systems are operable
- e. access routes are open and housekeeping is on a high level at the facility
- f. temporary fire loads during the outage have been removed or stored safely in accordance with plans
- g. the plant fire brigade is in normal preparedness and its equipment is in order.

5.4 Development of fire safety

515. The maintenance, assessment and continuous enhancement of fire safety shall be part of the

safety culture relating to the operation of nuclear power plants.

516. As part of the maintenance and development of fire safety, the fire PRA described in Guide YVL A.7 shall be kept up-to-date.

517. Fire hazard analyses and other documents shall be updated if conditions at the plant change or plant modifications are made to the plant's fire protection arrangements. New research results in the fire field, general progress in the field, accumulated knowledge of fire events as well as the ageing effects of components and materials shall be taken into account in fire hazard analyses. The aforementioned matters shall also be taken into account in plant operation and inspections as well as in personnel training.

6 Regulatory oversight by the Radiation and Nuclear Safety Authority

601. STUK's inspections of fire protection at nuclear power plants and nuclear facilities are timed in accordance with the stages of the licensing process:

- a. During the decision-in-principle stage, STUK's statement on an application for a decision-in-principle also covers the principles of fire protection.
- b. During the construction licence stage, STUK evaluates the Preliminary Safety Analysis Report (PSAR) and the supplementary topical reports, system descriptions, fire compartmentation drawings as well as the preliminary design and quality assurance procedures. The acceptability and feasibility of implementation of the fire protection principles are verified based on them. During the construction licence phase, STUK also reviews the plant's design phase fire PRA.
- c. During construction STUK ensures that the principles presented in the construction licence stage are implemented in the plant's detailed design and implementation. STUK oversees and inspects the plant construction

- in accordance with the construction inspection programme
- d. During the operating licence stage, STUK inspects the Final Safety Analysis Report, (FSAR) and related system descriptions, the fire PRA and topical reports, including the final analysis reports and commissioning inspection records drawn up by the license applicant and inspection bodies approved by TUKES.
 - e. STUK conducts the commissioning inspections of fire protection systems as part of the commissioning inspections of buildings before the plant's commissioning.
 - f. The above stages may also apply to significant design modifications.
 - g. The licence for dismantling fire protection arrangements in relation to the decommissioning of a nuclear facility is provided by a separate decision.

602. STUK applies, as necessary, nuclear and radiation safety related fire research. For the purposes of document review, STUK may conduct or commission research work and expert assessments, such as:

- a. assessment of the applicability of the whole comprising the design criteria and the applicable regulations and guidelines
- b. comparative risk and fire hazard analyses
- c. fire experiments.

603. STUK oversees and inspects the facility's fire protection, condition monitoring and maintenance in conjunction with the inspections included in its in-service inspection programme and other inspections.

604. At the same time STUK reviews the results of periodic inspections conducted by the licensee and other organisations. Furthermore, STUK oversees on-site as it deems necessary the periodic inspections conducted by the licensee.

605. In the inspection of modification, maintenance and repair work plans, as well as the actual construction, STUK follows the same process as with the approval of the original work, where applicable.

606. Where necessary in the handling of matters related to fire protection, STUK co-operates with other authorities, including the regional rescue services and the municipal building inspection authority. Fire protection is also addressed in connection with emergency preparedness matters, where necessary.

607. STUK exchanges experiences with nuclear facility insurers who comply with Section 23 of the Nuclear Liability Act (493/2005) and arranges joint inspections, where necessary. Organisations that provide insurance cover for nuclear facilities issue international guidelines on fire protection at nuclear power plants [31].

Definitions

Active fire protection

Active fire protection supplements passive fire protection related to the facility's layout design, fire compartmentation and fire-proof structures. Active fire protection includes fire detection systems and fire extinguishing systems, smoke extraction systems, emergency lighting and operative fire fighting.

Initiating event

Initiating event shall refer to an identified event that leads to anticipated operational occurrences or accidents.

ATEX

ATEX, atmosphères explosibles, shall refer to a potentially explosive atmosphere; the abbreviation Ex means explosive; an Ex space is an explosive space; an Ex component is a component or protection system used in an explosive space.

Automatic fire detection system

Automatic fire detection system shall refer to a system that automatically and immediately indicates and locates a starting fire. A fire detection system also provides notification of any failures compromising its functional reliability.

Physical separation in connection with fire protection

Physical separation in connection with fire protection shall refer to the separation of spaces or components by means of distance, fire resistance, fire-proof structures, local fire insulation, or a combination thereof.

Plant area

Plant area shall refer to an area that consists of a fenced area containing buildings related to the operation of the facility, and it shall be located within a zone where movement and sojourn are limited (described in subsection 3.4.2 of Guide YVL A.11).

Plant fire brigade

The plant fire brigade shall refer to a fire brigade maintained by the licensee of a nuclear power plant site. Its purpose is to extinguish fires occurring at the nuclear power plant, as well as the plant site and its immediate vicinity, maintain operative fire fighting preparedness, monitor fire and chemical safety, and provide training to plant personnel on fire protection.

Accident modelling method

Accident modelling methods, in risk informed planning and assessment of fire protection, are used to collect the results of fire hazard analyses on a case-by-case basis and ensure the adequacy of the nuclear facility's defence in depth. The methods are used to assess the significance of any fire protection impairments for fire safety of the nuclear facility.

- A cause-effect diagram can be used to look for the possible consequences of the selected fire situations.
- By applying the failure tree and event tree methods, it is possible to define critical events and sequences of events, and assess their significance with regard to the adequacy of the defence in depth and core damage frequency (CDF) of the plant.
- Fault and effect analyses and consequence analyses (fire and explosion analyses, dispersion analyses) can be used to assess the

sufficiency of the structural and functional layout solutions and other fire protection solutions of the buildings at the plant.

Operative fire fighting

Operative fire fighting comprises, for example, the plant fire brigade as well as the fire fighting measures conducted by the plant personnel and other fire brigades in the nearby areas. It covers the fire fighting equipment of the plant fire brigade, as well as the fire fighting equipment at the plant, such as portable fire extinguishers and fire hydrants. Fire fighting plans, rescue diving instructions, training and instructions on fire fighting as well as fire drills are all encompassed by operative fire fighting.

Fire

Fire shall refer to a chemical reaction that produces heat, smoke, or both. The inherent characteristics of a fire include uncontrolled development and spreading.

Fire load

Fire load shall refer to the total thermal energy released by the materials in a space (fire compartment) when the combustible material in that space is fully burned. Fire load density shall refer to the total thermal energy of the fire load per unit of floor area.

Defence in depth approach to fire protection

The aim of the defence in depth approach to fire protection is to prevent the breakout of fires, detect and extinguish fires quickly, prevent the development and spreading of fires, and limit their effects so that the safety functions can be performed reliably irrespective of the effects.

Fire compartment

Fire compartment shall refer to a section of a building from which the propagation of fires has been prevented by means of separating, fire resistant structural elements.

Fire protection system

Fire protection systems shall refer to fire detection systems, fire-fighting water pumping stations, the fire water mains, extinguishing systems, smoke extraction systems, and emergency lighting.

Fire hazard analysis

- A structural fire hazard analysis (FHA) is conducted to ensure the sufficient fulfilment of the defence in depth approach to fire protection by means of validated deterministic methods.
- A functional fire hazard analysis (FFHA, FHFA) is conducted to ensure the sufficient fulfilment of the defence in depth principle to fire protection in the functional layout solutions for the implementation of the plant's safety functions.
- Analyses of computational fluid dynamics (CFD) simulate the gas flows in fires, as well as fire development and heat transfer.
- The finite element method (FEM) is used to simulate the conduction of fire-induced heat in solid matter and the development of structural responses as a result of the temperature.

Passive fire protection

Passive fire protection shall refer to structural fire protection arrangements, such as fire compartmentation together with the functional design and layout design of the facility, in order to ensure the facility's safety during fire situations as far as possible without active fire fighting operations.

Risk-informed fire protection planning and assessment

Risk-informed fire protection planning and assessment is realised when deterministic planning is combined with risk analysis while utilising demonstrative accident management methods.

Explosion

An explosion can be a fast chemical reaction (detonation) that releases a large amount of thermal and kinetic energy. A vapour explosion occurs when liquefied gas is vaporised extremely rapidly, causing a mechanical explosion.

Consequential failure

Consequential failure shall refer to a failure caused by a failure of another system, component or structure or by an internal or external event at the facility.

Internal events

Internal events shall refer to events occurring inside a nuclear power plant that may have an adverse effect on the safety or operation of the plant.

Suitability assessment

A suitability assessment presents how well a fire protection system meets the requirements placed on it and how the licensee has verified conformity. The suitability assessment also lists changes to the approved documents and their effect on the suitability and acceptability of the system in question.

Design basis fire

Design basis fire shall refer to the worst possible fire situation the probability of which during the design period is not negligible. It is taken into account in the design of fire protection systems, such as fire compartmentation, the fire water mains, and the fire extinguishing systems. A design basis fire must always be determined if the size of a fire load contained by a fire compartment and involved in combustion is assumed to be lower than the fire load of the entire fire compartment. The design basis fire must be justified using hazard, failure and impact analyses.

Ignition

Ignition shall refer to a chemical reaction that can result in a fire. An open flame, sparks, the heating of electrical systems or cables, hot surfaces or static electricity can be sources that cause ignition.

Probabilistic Fire Risk Assessment

Probabilistic fire risk assessment shall refer to a quantitative assessment of the fire-induced hazards, probabilities and negative consequences of sequences of events influencing the safety of a nuclear power plant.

Safety divisions

Safety division shall refer to premises, physically separated from one another, and the components and structures contained therein, where one of the redundant parts of each safety system is placed.

Safety functions

Safety functions shall refer to functions important from the point of view of safety, the purpose of which is to control disturbances or prevent the generation or propagation of accidents or to mitigate the consequences of accidents. (Government Decree 717/2013)

Emergency lighting

Emergency lighting shall refer to back-up lighting and emergency exit lighting, including lighting for exit routes, open areas and hazardous working areas; emergency lighting functions simultaneously with conventional lighting and independent of it.

Fire protection threat

Fire protection threat shall refer to a situation that can result in the outbreak of a fire or an explosion resulting from a fire load.

Arc

Arc shall refer to a physical phenomenon created when the electrical current between two electrodes is discharged through normally non-conducting material, such as air. In the event of an arc, air, which normally insulates electricity becomes conductive due to smoke, for example.

Nuclear facility

Nuclear facility shall refer to facilities used for the generation of nuclear energy, including research reactors, facilities implementing the large-scale final disposal of nuclear waste, and facilities used for the large-scale production, generation, use, processing or storage of nuclear material or nuclear waste. However, nuclear facility shall not refer to: a) mines or milling facilities intended for the production of uranium or thorium, or premises and locations with their areas where nuclear waste from such facilities is stored or located for final disposal; or b) premises finally closed and where nuclear waste has been placed in a manner approved as permanent by the Radiation and Nuclear Safety Authority. (Nuclear Energy Act 990/1987, Section 3)

- The requirements presented in this Guide for nuclear facilities also apply to nuclear power plants unless a requirement separately states they only apply to nuclear facilities.

Nuclear power plant

Nuclear power plant shall refer to a nuclear facility for the purpose of electricity or heat production, equipped with a nuclear reactor, or a complex consisting of nuclear power plant units and other related nuclear facilities located at the same plant site. (Nuclear Energy Act 990/1987)

- The requirements presented in this Guide for nuclear power plants do not apply to nuclear facilities unless otherwise specified in separate application instructions.

Common cause failure

Common cause failure shall refer to a failure of two or more structures, systems and components due to the same single event or cause.

Single failure

Single failure shall refer to a failure due to which a system, component or structure fails to deliver the required performance.

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