Radiation and Nuclear Safety Authority 109/0002/2016
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Guide YVL B.8, Fire protection at a nuclear facility

1 Scope of application

Guide YVL B.8 applies to the planning and implementation of fire protection during the design, construction and operation of the nuclear facility. The Guide shall also be applied to the decommissioning of nuclear facilities. This Guide shall be complied with at the entire plant area and in all its buildings.

When this Guide presents 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 facilities 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.

2 Justifications of the requirements

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 and author of the YVL Guides is based on the Nuclear Energy Act and the Nuclear Energy Decree (161/1988).

The Radiation and Nuclear Safety Authority Regulation on the Safety of a Nuclear Power Plant (STUK Y/1/2018) presents higher-level requirements on the safety design of a nuclear power plant, including the following key sections with regard to fire protection:

Section 9 Defence-in-depth

1. In order to prevent anticipated operational occurrences and accidents, and to mitigate the consequences thereof, the functional defence-in-depth principle shall be implemented in the design, construction and operation of a nuclear facility.

2. In accordance with the functional defence-in-depth safety principle, the design of a nuclear facility must include the following levels of defence:

1) prevention to ensure that the operation of the nuclear facility is reliable and deviations from normal operating conditions are rare;

2) control of deviations from the nuclear facility's normal operating conditions so that the facility is equipped with systems which are able to limit the development of operational occurrences into accidents and if required can bring the facility into a controlled state;

3) control of accident situations so that the nuclear facility is equipped with systems that function automatically and reliably to prevent severe fuel damage in postulated accidents and in design extension conditions; manually actuated *systems can be used to manage accident situations if it can be justified from a safety perspective;*

4) confinement of a release of radioactive substances in severe reactor accidents by equipping the nuclear power plant with systems which ensure the leaktightness of the containment in severe reactor accidents so that the limits for releases in severe reactor accidents are not exceeded;

5) mitigation of the consequences by means of emergency arrangements to limit the public's exposure to radiation in situations where radioactive substances are released from the nuclear facility into the environment.

3. The levels of defence required under the defence-in-depth principle shall be as independent of one another as is reasonably achievable.

4. High quality proven technology is to be used for the different defence levels.

5. The necessary measures to bring a situation under control or to prevent harmful effects of radiation must be planned in advance. When organising licensee's operations, it must be ensured that operational occurrences and accidents are reliably prevented. There shall be effective technical and administrative provisions to ensure staff's ability to operate in these situations.

Section 9 of Regulation STUK Y/1/2018 requires implementation of the defence in depth principles to prevent accidents and to mitigate their consequences. With respect to fire protection, this refers to structural fire protection arrangements responsible for a significant part of the fire risk management. Structural and active actions for the implementation of the defence in depth approach to fire protection include minimisation of fire loads, prevention of ignitions, rapid detection of ignitions and fire, extinguishing of fires and containment of the spreading of fire. To ensure the fulfilment of this requirement, the Guide requires risk-informed design assessed by means of accident modelling methods and fire hazard analyses. In connection with this, plant design shall include the defence in depth approach to system failure management as set forth in Guides YVL B.1 "Safety design of a nuclear power plant" and YVL B.7 "Provisions for internal and external hazards at a nuclear facility".

Section 15 Protection against internal hazards affecting safety

1. The design of a nuclear power plant shall take account of any internal hazards that may endanger safety functions. Systems, structures and components shall be designed, located and protected so that the probability of internal hazards remains low and impacts on nuclear facility safety minor. The operability of systems, structures and components shall be demonstrated in the room specific environmental conditions used as their design bases.

2. Internal events to be considered shall include fire, flood, explosion, electromagnetic radiation, pipe breaks, container breakages, falling of heavy objects, missiles resulting from explosions and component failures, and other possible internal events. The design shall also consider unlawful and other unauthorised activities compromising nuclear safety.

Section 15 of Regulation STUK Y/1/2018 requires protection against internal events. With respect to fire protection, this refers to risk-informed design based on which it can be demonstrated that the probability of consequential effects of fires to nuclear and radiation safety remain sufficiently low. In connection with this, plant design shall include corresponding fire PRA management as set forth in Guide YVL A.7 “Probabilistic risk assessment and risk management of a nuclear power plant”.

Section 16 Safety of monitoring and control

4. The nuclear power plant shall have a supplementary control room independent of the main control room and the necessary local control systems for shutting down the nuclear reactor and for removing decay heat from the nuclear fuel in the reactor and the spent nuclear fuel stored.

Sections 9 and 16 of Regulation STUK Y/1/2018 require that the control room operations of a nuclear facility shall be ensured using the defence in depth approach in the form of a control room, emergency control room and necessary control systems. With respect to fire protection, this refers to the protection of the corresponding phases of defence in depth using structural fire protection measures.

Section 17 Taking the safety of the decommissioning into consideration in the design and the safety of decommissioning

1. The design of a nuclear facility and its operation shall take account of the decommissioning of plant units so that it is possible to limit the volume of nuclear waste for disposal accumulating during the dismantling of units, and radiation exposure to workers due to the dismantling of the facility, and to prevent radioactive materials from spreading into the environment during decommissioning.

The Guide does not include detailed fire protection instructions for the decommissioning stage of a nuclear facility’s life cycle. In this regard, however, item g of requirement 601 of regulatory oversight by the Radiation and Nuclear Safety Authority states that the licence for dismantling fire protection arrangements in relation to the decommissioning of a nuclear facility is provided by a separate decision based on Section 17 of Regulation STUK Y/1/2018 so that, as a rule, the dismantling of a nuclear facility’s fire protection arrangements shall take place at a significantly later stage than the removal of the corresponding protected plant components and significant fire loads.

Section 18 Safety of construction

1. The holder of the nuclear facility unit’s construction license shall ensure during construction that the nuclear facility is constructed and implemented in conformity with the safety requirements and using approved plans and procedures.

Section 18 of Regulation STUK Y/1/2018 requires that the construction and construction functions are carried out in a responsible manner. As regards fire protection, the starting point for the oversight and inspections by STUK is that the Guide presents corresponding requirements for documents to be submitted to STUK during the various stages of construction to demonstrate that the construction meets the design requirements for the nuclear and radiation safety required by fire protection.

Section 19 Safety of commissioning

1. In connection with the commissioning of a nuclear facility or its modifications, the licensee shall ensure that the systems, structures and components and the nuclear facility as a whole operate as designed. The procedures of the commissioning of the nuclear facility or its modifications shall be planned, and instructions shall be provided.

2. At the commissioning stage, the licensee shall ensure that appropriate procedures are in place for the future operation of the nuclear facility.

As regards commissioning of a nuclear facility, Section 19 of Regulation STUK Y/1/2019 requires ensuring the previous design and implementation stages as well as the organisational readiness to operate the facility. As regards the fire protection systems, this means that the quality of the corresponding design work, as well as technical design and implementation, shall be ensured. Requirements for the construction and organisational performance are given in the Series A YVL Guides.

Section 20 Safety of operation

3. For operational occurrences and accidents, appropriate procedures for the identification and control of incidents shall be available.

Section 21 Taking operating experience and safety research into consideration in order to improve safety

1. Safety-significant operational events shall be investigated for the purpose of identifying the root causes as well as defining and implementing the corrective measures.

2. For further safety enhancement, operating experience from the facility and from other nuclear facilities, the results of safety research and technical developments shall be regularly monitored and assessed.

3. Opportunities for improvements in technical and organisational safety, identified from operating experience, safety research and technical developments shall be assessed and implemented to the extent regarded as justified on the basis of the principles laid down in Section 7 a of the Nuclear Energy Act.

Section 22 Operational Limits and Conditions

1. The Operational Limit and Conditions of a nuclear facility shall include the technical and administrative requirements for ensuring the nuclear facility's operation in compliance with the design bases and the assumptions of safety analyses. The requirements for ensuring the availability of systems, structures and components important to safety, as well as the limitations that are to be complied with when they are unavailable, shall also be included in the Operational Limits and Conditions.

2. The plant shall be operated in compliance with the requirements and restrictions set in the Operational Limits and Conditions, and compliance with them shall be monitored and any deviations reported.

Section 23 Condition monitoring and maintenance to ensure the safety of the facility

1. Systems, structures and components important to the safety of a nuclear facility shall be available as detailed in the design basis requirements.

2. Operability and the effects of the operating environment shall be monitored by means of inspections, tests, measurements and analyses. Operability shall be checked in advance by regular maintenance, and provisions shall be made for maintenance and repairs in the event of any deterioration in operability. Condition monitoring and maintenance shall be planned, supervised and implemented so that the integrity and operability of systems, structures and components are reliably preserved throughout their service life.

Sections 20–23 of Regulation STUK Y/1/2019 require that the operation and maintenance shall be instructed and controlled in relation to operational safety and that the corresponding global operational events, trends and research at nuclear facilities shall be monitored. As regards fire protection, this means that the fire protection of an operating facility shall be managed in a holistic manner.

Section 25 Ensuring safety by management, organisation and personnel

1. When designing, constructing, operating and decommissioning a nuclear facility, a good safety culture shall be maintained. Safety shall take priority in all operations. The decisions and activities of the management of each organisation participating in the abovementioned activities shall reflect its commitment to operational practices and solutions that promote safety. Personnel shall be encouraged to perform responsible work, and to identify, report, and eliminate factors endangering safety. Personnel shall be given the opportunity to contribute to the continuous improvement of safety.

2. Organisations participating in the design, construction, operation and decommissioning of a nuclear facility shall employ a management system for ensuring safety and the management of quality. The objective of such a management system shall be to ensure that safety is prioritised without exception, and that quality management requirements correspond to the safety significance of the activity and function. The management system shall be systematically assessed and further developed.

Section 25(1–2) of Regulation STUK Y/1/2019 requires that the organisations involved in the design, construction, commissioning and decommissioning of a nuclear facility shall maintain a sound safety culture and management system for ensuring the quality management in radiation and nuclear safety. This Section also applies to organisations responsible for fire protection.

As regards underground nuclear waste facilities, the starting point is the Radiation and Nuclear Safety Authority's Regulation on the Safety of Disposal of Nuclear Waste (STUK Y/4/2018). Key sections with regard to fire protection are as follows:

Section 13 Defence-in-depth

1. In order to prevent anticipated operational occurrences and accidents, and to mitigate the consequences thereof, the functional defence-in-depth principle shall be implemented in the design, construction and operation of a nuclear facility taking into account its significance in terms of safety.

2. In accordance with the functional defence-in-depth safety principle, the design shall include the following levels of defence:

1) prevention to ensure that the operation of the facility is reliable and deviations from normal operating conditions are rare;

2) control of deviations from the plant's normal operating conditions so that the plant is equipped with systems which are able to limit the development of operational occurrences into accidents;

3) control of accident situations so that the nuclear facility is equipped with systems that function automatically and reliably to limit the release of radioactive substances in postulated accidents and in design extension conditions; manually actuated systems can be used to manage accident situations if it can be justified from a safety perspective;

4) mitigation of the consequences, when necessary, by means of emergency arrangements to limit the public's exposure to radiation in situations where radioactive substances are released from the facility into the environment.

3. The levels of defence implementing the defence-in-depth principle shall be as independent of one another as is reasonably achievable.

4. High quality proven technology is to be used for the different levels of the defence-in-depth.

5. The necessary measures to bring a situation under control or to prevent harmful effects of radiation must be planned in advance. When planning the licensee's operations, it must be ensured that operational occurrences and accidents are reliably prevented. There shall be effective technical and administrative provisions to ensure staff's ability to operate in these situations.

Section 18 Protection against internal hazards affecting safety

1. The design of a nuclear facility shall take account of internal hazards that may endanger safety. Systems, structures and components shall be designed, located and protected so that the probability of internal hazards remains low and impacts on plant safety minor The operability of systems, structures and components shall be demonstrated in the environmental conditions used as their design bases.

2. Internal hazards to be considered shall include fire, flood, explosion, electromagnetic radiation, drop of heavy objects, different types of rock slides, and other possible internal events. The design shall also consider unlawful and other unauthorised activities compromising nuclear safety.

Section 22 Safety of construction of a nuclear waste facility

1. The holder of the nuclear facility’s construction license shall ensure during construction that the facility is constructed and implemented in conformity with the safety requirements and using approved plans and procedures.

2. At the construction stage, the licensee shall ensure that an expedient organisation is in place for the construction of the nuclear facility, alongside a sufficient number of qualified personnel and appropriate procedures.

Section 23 Safety of commissioning of a nuclear facility

1. In connection with the commissioning of the nuclear facility or its modifications, the licensee shall ensure that the systems, structures and components and the facility as a whole operate as designed and that the disposal system can be implemented. The procedures of the commissioning of the nuclear facility or its modifications shall be planned, and instructions shall be provided.

2. At the commissioning stage, the licensee shall ensure that appropriate procedures are in place for the future operation of the nuclear facility.

Section 24 Safety of operation

2. The control and supervision of a nuclear facility shall utilise written procedures that correspond to the existing structure and state of the facility. Written orders and related procedures shall be provided for the maintenance and repair of components.

3. Procedures shall be made available for the identification and control of operational occurrences and accidents.

4. Significant events influencing safety shall be documented so as to facilitate their later analysis.

5. The holder of the nuclear facility’s operating license shall ensure that the modifications to the nuclear facility are designed and implemented in conformity with the safety requirements and using approved plans and procedures.

Section 38 Ensuring safety by management, organisation and personnel of a nuclear facility

1. When designing, constructing, operating and decommissioning a nuclear facility or permanently closing a disposal facility, a good safety culture shall be maintained. Safety shall take priority in all operations. The decisions and activities of the management of each organisation participating in the abovementioned activities shall reflect its commitment to operational practices and solutions that *promote safety. Personnel shall be encouraged to perform responsible work, and to identify, report, and eliminate factors endangering safety. Personnel shall be given the opportunity to contribute to the continuous improvement of safety.*

2. Organisations participating in the design, construction, operation and decommissioning of a nuclear facility shall employ a management system for ensuring safety and the management of quality. The objective of such a management system shall be to ensure that safety is prioritised without exception, and that quality management requirements correspond to the safety significance of the activity and function. The management system shall be systematically assessed and further developed.

Similar to the above items in Regulation STUK Y/1/2018, items in Regulation STUK Y/4/2018 require that the safety of nuclear waste facilities as regards fires and explosions shall be considered in all phases of the design, construction and operation.

2.1 Connection of the Guide with the other YVL Guides, the fire and building legislation and the ATEX legislation

Guide YVL B.8 complements Guide YVL B.1 “Safety design of a nuclear power plant” by setting out detailed requirements for fire protection at a nuclear facility. There is a clear connection between Guide YVL B.8 and Guides YVL A.7 “Probabilistic risk assessment and risk management of a nuclear power plant”, YVL A.11 “Security of a nuclear facility” (fire fighting and rescue operations, protection against hazards), YVL B.7 “Provisions for internal and external hazards at a nuclear facility” (internal hazards, external hazards, plant technology, plant layout design) and YVL E.6 “Buildings and structures of a nuclear facility” (passive fire protection arrangements such as structures and layout). Item 205 of this Guide includes an extensive presentation of the connections with the other YVL Guides.

As regards requirements for the buildings of a nuclear facility, the provisions and regulations stipulated in the Land Use and Building Act (132/1999) and the Land Use and Building Decree (895/1999) shall be complied with. The Ministry of the Environment issues detailed regulations and guidelines on the technical aspects concerning the construction and the structural fire protection. As regards fire safety, this means that the Decree of the Ministry of the Environment on Fire Safety of Buildings (848/2017) shall be complied with. Decree 848/2017 has replaced guidelines E1 and E2 of the Finnish Building Code. The change has caused needs for updates in the structural fire protection arrangements section of this Guide. As regards operative fire fighting, key legislation is presented in the Rescue Act (379/2011) and the Government Decree on Rescue Services (407/2011). 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.

This Guide sets forth equivalent requirements on the interpretation of the fire and building legislation as regards fire safety for the nuclear facilities. In addition, the requirements take into account the internationally agreed level in nuclear and radiation safety as well as associated guidelines and recommendations on good practices.

The Government Decree on Equipment and Protection Systems Intended for Use in Potentially Explosive Atmospheres (1439/2016) and the Ministry of Trade and Industry Decision (918/1996) present the requirements for equipment and protective systems intended for potentially explosive atmospheres. The Government Decree (576/2003) presents the requirements for prevention of personnel hazards caused by potentially explosive atmospheres. The Ministry of Social Affairs and Health and the Finnish Safety and Chemicals Agency (Tukes) provide guidelines on the application of the ATEX legislation.

This Guide sets forth equivalent requirements on the interpretation of the ATEX legislation concerning the protection against fire-load induced explosions in a nuclear facility.

In addition, the Guide presents STUK's own fire protection inspection and oversight activities. STUK's activities do not affect any regulatory oversight required in the fire and building legislation unless otherwise agreed between the authorities.

Guide YVL B.8 does not contain requirements for the fire protection arrangements in relation to the decommissioning of a nuclear facility. This restriction is conservative in that the fire protection requirements for a facility in operation or under annual maintenance may be observed until the dismantling of the facility and fire protection systems thereof may begin according to methods approved by a separate decision by STUK. Thus, separate instructions shall be provided later for the decommissioning of a nuclear facility and fire protection thereof under the principle that any protection needs and protected items shall be removed first before the dismantling of the fire protection arrangements.

3 Justifications of the requirements by topic

3.1 Section 3 Design requirements

The design of fire safety of the buildings of nuclear power plants and nuclear facilities is based on the application of the Decree of the Ministry of the Environment (848/2017) in accordance with the fire and building legislation. In addition, understanding of the systems essential to nuclear safety and safe layout thereof is required in fire safety design. The key points presented in section 3 of the Guide are as follows:

- The design of fire safety shall be based on the defence in depth approach to fire protection.
- It must be possible to demonstrate by means of analyses that the safety functions of the facility can be reliably accomplished during any fire situation.
- The design basis of the buildings shall be based on the fire rating determined by the significance of the rooms inside the buildings on the design of safety divisions of the nuclear facility.
- In case of a fire, the load-bearing structures of a building must be capable of withstanding the minimum specified time.

- The growth, development and propagation of fire and smoke in the buildings must be restricted.
- Propagation of fire and smoke to other buildings in the vicinity must be prevented.
- People inside the building must be provided with an opportunity to exit the building in case of a fire or to be rescued by some other means.
- It must be possible to detect a fire by means of a fire detection system covering the entire plant.
- Important locations must have automatic fire extinguishing systems.
- Fire fighting and rescue activities must be taken into account in the design of the buildings and plant area.
- Rescue activities after an earthquake shall be ensured.

3.1.1 Section 3.1 General design requirements

The requirement for the certification of organisations carrying out fire protection design of buildings has been clarified to be consistent with the other YVL Guides. The level of qualification required by STUK from the responsible fire protection designer differs from that required by the building legislation. The reason for this is that STUK requires that the designer shall also have qualification and experience in nuclear and radiation safety. Plant design is essential in designing the fire safety of a nuclear facility. STUK evaluates the comprehensive competence of the person responsible.

3.1.2 Section 3.2 Defence in depth approach to fire protection

The Guide presents more detailed requirements on the implementation of the defence in depth approach in fire protection at a nuclear facility. In this respect, the Guide is based on the Finnish fire and building legislation in that it sets requirements on measures with the aim of fire load minimisation, fire ignition prevention, fire detection and rapid extinguishing as well as fire development and propagation prevention. This makes it possible to ward off fire risk and limit fire effects in phases by means of defence in depth barriers, thus ensuring reliable implementation of the plant's safety functions also during fire situations.

Defence in depth approach shall be verified by risk-informed design, including assessment of the design concepts by means of fire hazards analyses which, as a whole, are evaluated by accident modelling methods. The methods are used to assess the significance of fire protection deviations and impairments for fire safety at the nuclear facility and in bringing the nuclear facility in a safe state. The objective is to assess the adequacy of the defence in depth approach to fire protection in view of the facility's safety functions and the facility's safe shutdown in particular.

- A cause-effect diagram can be used to look for the possible consequences of the selected fire events.
- By applying the fault 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.
- Failure mode 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.

The analyses verifying the defence in depth principle and solutions based thereof are based on technical design specifications and any material property test results conducted as necessary. Locations, where verifying analyses are needed to assess the design concepts, include, for example, the following:

- Containment, containment annulus and control room and the cable space below it with cables of different safety divisions, as well as locations where the zone affected by a design basis fire is contained within a fire cell smaller than the fire compartment as a whole or the fire compartment contains systems of more than one safety division, for example cables.
- As regards the fire compartmentation, fire dampers differ from other doors and hatches between the safety divisions in that they are normally open and should close when required. Therefore, fire dampers between the safety divisions must be duplicated, and the need to use different types of motor-driven fire dampers to avoid common cause failures must be assessed.
- Locations with heavy fire loads, such as the primary circulation pumps in the containment and cable rooms and tunnels, where the fire load exceeds 1,200 MJ/m^2. Other heavy fire loads include, for example, fuel systems of the diesel generators, lubrication oil systems of the turbine generators, and large oil-cooled transformers. These locations shall be analysed depending on the layout design of the facility and overall level of protection. In case the fire load in a fire compartment is so heavy that a fire resistance of EI-M 120 is deemed insufficient, the fire resistance required for the structural elements must be determined on the basis of fire hazards analyses taking the real fire loads and fire conditions into account.
- Rooms designed for storage of low-level radioactivity waste. Ignition of a fire shall be demonstrated unlikely on the basis of the storage method and fire load properties to allow justified replacement of traditional type-approved fire detectors with some other monitoring system to ensure detection of a smouldering fire with sufficient reliability.
- As regards the cables, in particular, the materials of the cables selected shall be of the fire-retardant type, such as halogen-free (EN50267) cables (FRNC) that meet the requirements of the bunched cable test F4B (EN-50266-2-3 cat. A or cat. B).

Depending on the interpretation, the fire itself may be considered to be an initiating event or the fire may be considered to cause, directly or indirectly, an initiating event (e.g. loss of instrumentation room ventilation, loss of coolant due to main coolant pump sealing failure, failed reactor scram). The Guide includes the application of failure criteria during fire situations when related to initiating events that initiate the facility's safety functions. The starting point is that the fire is limited to a single fire compartment and the safety divisions are designed such that loss of any safety division and equipment therein due to the fire does not cause a loss of any of the safety functions. In accordance with requirement 315, fire situations must be taken into account in the design phase, and procedures must be provided in case of fire situations. In case of a fire situation, provisions must be made to bring the facility into a controlled state even if not immediately called for by the initial fire. The operational restrictions of the facility must be defined in the OLC. Requirement 319 sets forth that consequential failures caused by fire shall be taken into account in the design. This includes, for example, the following protections:

- A transformer fire may cause a loss of external grid connection at the facility's switchyard. Provision for such an event shall be made by providing emergency supply backup by means of, for example, diesel generators and protecting such backup from the fire event.
- A fire may cause a reactor scram or turbine trip, so the safety systems must be protected to ensure that they remain in operating condition under such a fire situation.
- A fire may damage only one subsystem of the safety system. In such a case, the remaining subsystems of the safety systems must remain in operating condition for the reliable accomplishment of safety functions in accordance with the failure criteria (see Guide YVL B.1).

3.1.3 Section 3.3 Fire hazard analyses

Fire hazards analyses are divided into deterministic and probabilistic analyses. The analyses model actual fire conditions and study the significance of deviations to the fire protection design bases. Deviations may include, for example, fire protection system failures. The analyses are related to the verification of the adequacy of the defence in depth principles. Objects of study for assumed deviations include the fire detection and fire extinguishing systems, fire doors and fire dampers. Uncertainties and delays in relation to the operative fire protection are also studied. Impairments in the fixed structures of structural fire protection need not be assumed. That said, provisions must be made for, for example, a temporary penetration opening in a compartment structure in accordance with requirement 512.

The Guide requires that the results of the deterministic fire hazard analyses shall be available to the extent allowing the assessment of fire compartmentation and fire resistance of construction elements in fire compartments that contain heavy fire loads, such as cables, lubricants, fuel, filters or transformers.

Requirement 329 now includes a reference to standard ISO 18195 that specifies methodology to demonstrate the fire resistance rating of the separating structural elements when it cannot be demonstrated directly based on fire tests and table values. When analysed according to the standard, separate fire curves are calculated for the rooms, and separate fire resistance curves are calculated for the separating structural elements, and these are then compared with each other. The method is based on the application of calculation formulae, fire simulation and fire tests.

Appendix A to the Guide sets forth more detailed requirements on the evaluation of the implementation of the defence in depth approach to fire protection.

Probabilistic fire hazard analyses shall utilise fire scenarios to analyse any potential initiating events caused by fires (YVL A.7, PIE) as well as safety system failures and reliability of the safety functions during and after the fire. The analyses may justify demands to improve fire protection if

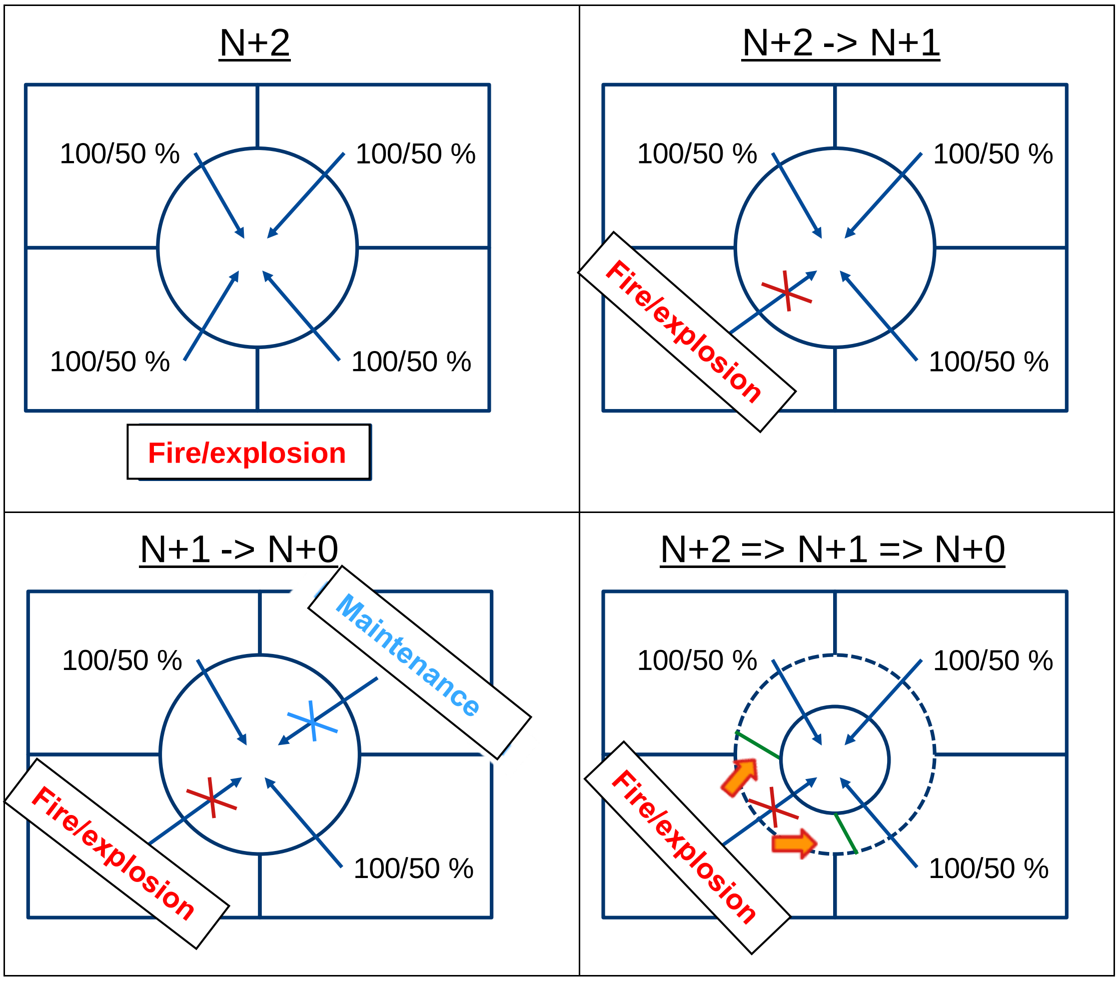
- the maintenance of safety functions is jeopardised due to, for example, the following reasons: failure to demonstrate a fire compartment or structural separation in an unambiguously deterministic manner, such as the separation of safety divisions in the containment and control rooms and in case of heavy fire loads

- there is a possibility of a significant release of radioactive substances into the plant facilities or the environment in case of a fire situation, such as a fire in waste storage or one involving large filters
- an analysis by means of fire scenarios reveals that the risk due to initiating events caused by fire (PIE) and safety systems failures (CDF or CCDP) is proportionally too high compared to the total risk.

If necessary, the PRA must also analyse a simultaneously occurring fire in multiple fire compartments if, for example, the spreading of the fire through an open fire door or due to a failure of the fire dampers causes a significant increase in the risk.

The risk due to flooding of the fire water system is discussed in Guide YVL B.7.

3.1.4 Example of needs for fire hazard analyses



The figures above demonstrate the verification of the fulfilment of the requirements in accordance with the designed nuclear power plant failure criteria. Basic situations in accordance with the failure criteria must be verified by plant design according to the requirements of Guide YVL B.1, and initiating event and fault condition analyses associated with the fire situations must be conducted by PRA according to the requirements of Guide YVL A.7.

Failure criterion N+2 is described by a fire or explosion situation occurring in a space outside the safety divisions. If the event causes an initiating event, such as a loss of the external grid, the plant must be brought into the appropriate safe state. Since the N+2 situation has been verified by plant design and PRA according to the requirements of Guide YVL B.1, normal structural fire hazard analyses (FHA) suffice to verify the fire safety. As regards structural fire protection, it is essential that fire from outside must not destroy two or more safety divisions at the same time. This is ensured by the requirement for fire resistance class EI-M 120 set forth in requirement 340.

If the fire breaks out inside a safety division, the plant state failure criterion may change from N+2 to N+1 due to safety system failures caused by the fire. If the event causes an initiating event, such as a reactor scram or forced shutdown of the plant (probably unavoidable in most cases in a safety division fire situation), the plant must be brought into a safe state. In an N+1 situation like this, plant safety in case of a single-failure must be ensured by plant design according to the requirements of Guide YVL B.1, and sufficient safety must be demonstrated by analyses utilising the PRA. Normal structural fire hazard analyses (FHA) suffice for the verification of the structural fire safety, such as fire separation of the safety divisions and fire compartments.

If one safety division is unavailable due to planned preventive maintenance or repair of a fault, and fire breaks out in another safety division at the same time, the failure criterion of the plant changes from N+1 to N+0. In such a case, the plant must always be brought into as safe a state as possible considering the risk. Failure criterion N+1 for single-failure shall be verified by plant design according to the requirements of Guide YVL B.1. In this case, verification of fire safety also requires functional fire hazard analyses (FFHA/FHFA). PRA analysis must be utilised in preparing the operating procedures for operational occurrences and emergencies to be applied in the situation in question. There may be fault situations where hot plant shutdown provides a safer option than bringing the plant into cold shutdown.

If the fire breaks out inside a safety division in an area where the safety divisions are not structurally separated from each other by means of structural fire compartmentation, like in the containment annulus (PWR), the fault criterion of the plant situation may change from N+2 to N+1 or N+0. In such a case, the OLC must require that the plant shall be brought into a controlled state in a fire situation as quickly as possible. As a rule, the fire safety shall be ensured by verification of the fault criterion N+1 for single-failure through plant design according to the requirements of Guide YVL B.1 and functional fire hazard analyses (FFHA/FHFA). The adequacy of the design concepts must also be demonstrated by PRA. The design must take into account any flood risk due to fire water.

3.1.5 Section 3.4 Structural fire protection

The design basis for the structural fire protection is as follows:

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.

As regards structural fire protection, the requirements presented include fire resistance classes and separation of building, fire separation of safety divisions, fire compartmentation and protection against explosions. More detailed site-specific instructions are provided for the containment, annulus, control room and emergency control room as well as access and escape routes. Based on the stringiest requirements in the Decree of the Ministry of the Environment (848/2017), the starting point is that buildings containing systems important to the safety of a nuclear facility are in fire class P1 where the load-bearing structures are expected to withstand fire without collapsing. Systems important to safety include systems in classes SC1–SC3 and EYT/STUK. In practice, this means that all buildings located in the plant area belong to fire class P1. There is no limitation on the size of the buildings or the number of people, and functions in fire hazard classes 1 and 2 may be located in the buildings. The buildings may also be designed as Class P0 buildings in compliance with the conditions in items a–c of requirement 338. The conditions on the use of fire class P0 are there to ensure that a design based on postulated fire development does not result in an under-dimensioned structural strength in case of a fire situation. In practice, requirements related to the fire resistance of fire class P1 structures in concrete buildings are usually met due to other structural requirements.

Requirement 337 requires the use of incombustible construction materials or materials with extremely limited combustion. The omission of reference to classification according to standard SFS EN 13501-1 from the requirement is intentional, allowing some latitude for the use of certain materials used in negligible quantities without the need for deviation from the YVL Guide. Fire class P1 in itself sets out stringent requirements for the materials used.

Guide YVL B.8 sets forth new requirements for the use of firewalls in the design. The requirements apply to the walls between the safety divisions (345) and buildings (341) as well as the outer walls (340).

Buildings containing subsystems important to the plant's technical safety must be separated from other buildings, such as the turbine building, by means of a firewall with a minimum fire resistance class of EI-M 120 in accordance with Table 9 in the Decree of the Ministry of the Environment (848/2017). Firewalls shall be made of Class A1 construction materials. Similar application examples include:

- In case an exterior wall of a building or a wall between safety divisions is load-bearing and also required to meet requirement EI-M 120 in terms of integrity, insulation and impact resistance, the load-bearing must be in compliance with requirement R 120.
- If the fire load in a compartment consisting of a safety division exceeds 1,200 MJ/m^2 and the height of the building exceeds 56 metres, the load-bearing structures must meet class requirement R 180 as specified in Table 3 of the Decree (848/2017). It is then required that the building must be equipped with an automatic fire extinguishing system. If the separating wall of a safety division is

load-bearing, it must meet class requirement R 180 in terms of load-bearing in addition to the separation requirement EI-M 120.

As for the class requirements for the outer walls, roof and inner building surfaces, reference is made to the requirements of the Decree (848/2017).

Safety divisions are divided into fire compartments based on compartmentation by storey and compartmentation by use. No other systems or components shall be placed in rooms with heavy fire loads if they increase the fire load or the threat of a fire breaking out in a significant manner. In addition, these rooms shall primarily be placed sufficiently far from such other systems and rooms that could, if exposed to effects of fire, endanger the operation of the safety systems. The development of the heat release rate and equivalent structural responses are evaluated by necessary analyses. It shall be presented unambiguously how the systems and components important to safety will be located in the facility and how the separation of redundant safety-related subsystems is carried out by means of structural fire protection arrangements.

Guide YVL B.1 sets forth a requirement of separate safety division ventilation systems as well as specific controlled area deviations the acceptability of which can be assessed in the manners presented in this Guide.

The Decree of the Ministry of the Environment (848/2017) allows relaxations in the fire resistance classification of doors and hatches between fire compartments, defined in more detail in requirement 353.

Requirement 354 concerning fire dampers and cable, ventilation and piping penetrations does not allow a similar relaxation.

As part of the structural fire protection, section 3.4.5 of the Guide presents new requirements on protection against fire-load induced explosions and consequences thereof. The corresponding defence in depth approach is presented in the following requirement:

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.*

The objectives of the compartmentation of the containment and annulus safety divisions are supplemented by means of the defence in depth approach with the requirements in section 3.4.6 concerning the objectives of the fire-compartmentation, fire loads and analyses to ensure fire safety.

These requirements lead to an assessment of the requirements of Guides YVL A.11, YVL B.7 and this Guide as a whole to determine the significance of fire compartmentation between the safety divisions and insulation of the effects of vibration between the internal and external containment to the overall safety of the plant.

The separation of the control room and emergency control room also includes the separation of the routing of the plant controls:

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.

The requirement does not take a stand on a loss of location where control is lost irrespective of cable route and control room protections due to, for example, a disturbance or malfunction related to programmable digital systems. The requirement conforms with the principles of Sections 9 and 16 of Regulation STUK Y/1/2019 in requiring fire compartmentation to ensure the defence in depth approach to control room activities.

As regards control room pressurisation, the requirements are as follows:

373. The control room and the emergency control room shall be provided with pressurised ventilation to prevent smoke from entering the control room or the emergency control room in case of a fire outside the room in question. Pressurisation 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. Pressurisation shall be separate from other ventilation and air conditioning systems.

Ventilation and air-conditioning terminology used in the Guide has been specified in accordance with the Decree of the Ministry of the Environment (1009/2017). The control room shall always be provided with separate pressurised ventilation to prevent smoke from entering the control room in case of a fire outside the control room. The ventilation and air-conditioning of the emergency control room are independent and separate from the control room ventilation and air-conditioning. There is no need to require pressurised ventilation in the emergency control room if the smoke risk to the control room is prevented by appropriately dimensioned ventilation and air-conditioning or appropriately located emergency control room supply air intake, etc. It is also possible to have the emergency control room pressurised, which may also be the most practical solution.

Section 3.4.8 presents the requirements concerning the access routes and escape routes. As a rule, the design shall comply with the requirements of the Ministry of the Environment's decrees 848/2017 and 1007/2017. Exit arrangements may draw upon design based on postulated fire development according to fire class P0. This set of requirements is challenging because the design is expected to take into account exiting from the plant, rescue operations and security of the facility. The access opening operating procedures are not discussed here. If necessary, basic diagrams on the opening of the hatches/doors are included in the normal access and escape route signs. Such signs shall be placed appropriately on the access and escape routes.

Doors are covered by the following general principles that can be derived from this Guide and Guide YVL B.7:

- There must be double doors between safety divisions where possible.
- Doors on access routes, escape routes and attack routes should open in the direction of traffic flow or, at minimum, consistently in the same direction along the entire route. As a rule, the doors must be designed to open in the direction of the room with the higher pressure.
- As regards pressure differences, the opening/closing of the doors shall be supported by mechanical means.

3.1.6 Section 3.5 Active fire protection

Active fire protection consists of automatic fire detection systems, fire extinguishing systems, operative fire fighting, pressurisation of the rooms and smoke ventilation as well as emergency lighting.

The fire detection system must cover the entire nuclear facility.

As for the adequacy of fire water at the plant site, the requirements are as follows:

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 on automatic fire extinguishing equipment. Guidelines regarding fire extinguishing systems are provided in standards.

Dimensioning rules for the fire water pumping station and fire water mains shall be according to the sprinkler regulations and industry standards. Fire water pumps are independent of the plant’s electrical power systems. Typically, the design basis for a fire water pumping station are as follows:

- Equipped with three diesel engine-powered fire water pumps with a capacity of 3 x 100%. Single pump failure as a design basis.
- One pump, or a maximum of two pumps, shall be sufficient to protect the most extensive area requiring protection. Sufficient amount of fire water must remain to accommodate the needs of operative fire fighting regardless of the consumption

in the most extensive area requiring protection even if one pump is assumed to be unavailable.

Rooms to be protected by automatic fire extinguishing systems are presented in requirement 386.

The fire water system is also intended to be used in severe accident management in accordance with Guide YVL B.1.

The seismic resistance of fire water and extinguishing systems is described as follows:

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.

Supply connections may be located outside the buildings to enable pumping of water using a fire engine. In addition, the suitability of the necessary active equipment, such as trigger valves, must be demonstrated.

The requirement is further supplemented by the following fire PRA requirement:

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.

Fire protection systems designed to protect safety-classified components pursuant to Guide YVL B.2 must be designed in seismic category S1, meaning that also loads due to vibrations caused by a large commercial airliner crash and explosion pressure wave must be addressed within the applicable failure criteria.

As regards operative fire fighting, Guide YVL B.8 presents the requirements on the strength, response preparedness and competence of the plant fire brigade. The operation of the plant fire brigade must be coordinated and practised with the regional fire and rescue services. The guide does not give specific technical requirements concerning the operation of the fire brigade. The licensee/license applicant must design the principles and operation of operative fire fighting and present them in the design procedure for fire protection (fire protection concept), documents in accordance with requirement 428 and the fire fighting plan. As a rule, fire safety must be ensured by means of structural fire protection measures. Protection against fire risks cannot be based on the plant fire brigade. In cases where quick extinguishing of the fire is impossible, the task of the fire brigade may be, for example, to ensure structural fire protection measures to prevent the propagation of the fire.

The updated Guide further specifies requirement 395 to provide nuclear facilities with equipment enabling the use of a communication system for public officials. In 2019, the network in use by the officials is VIRVE.

General requirement to justify equivalent solutions for overpressure ventilation and smoke extraction is presented as follows:

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

Emergency lighting is covered in requirement 398.

Provision for annual maintenance and outages shall also take place in accordance with the defence in depth approach to fire protection. The primary focus shall be on temporary fire loads.

3.2 Section 4 Documents of the design stage and the construction stage

Requirements concerning the documents to be submitted to STUK are presented in section 4 of the Guide. The sets of document and content requirements are described in the sub-headings of the section. As a rule, design requirements in section 3 and document requirements in section 4 of the Guide with respective sub-headings provide between them sufficient information on the focus of the requirements presented in the different licensing stages.

The plant's fire protection documents to be submitted to STUK shall be presented by licensing stages as follows:

- in the decision-in-principle stage, description of the requirements applied to the licensee to ensure prerequisites for the fulfilment of the Finnish safety requirements in fire protection (403)
- in the construction licence stage, the preliminary safety analysis report by the plant supplier completed with system descriptions for fire protection and topical reports as well as design and quality assurance procedures required to verify the acceptability and feasibility of implementation of the fire protection principles (404–422)
- during construction, information concerning the designer of the extinguishing systems, updates corresponding with the implementation design as regards fire analyses, and statements on the acceptability of the extinguishing systems from inspection bodies accepted by the Finnish Safety and Chemicals Agency (TUKES) (423–424)
- in the operating licence stage, the final safety analysis report and related topical reports (425).

The Guide requires the design information to be submitted to STUK earlier so that it will become consistently more specific within the different licensing stages. This will improve the processing of new matters and questions and make the processing of documents in the level of detail required in the licensing stage more efficient. In principle, structural fire protection systems should be accepted based on master plans and system descriptions in accordance with the construction licence application. However, new fire loads and new cable route requirements between the safety divisions are identified as the design progresses. In such cases, it is necessary to assess structural fire protection even during construction. Concreting work provides a clear final deadline for the acceptance of structural fire protection systems. This is covered by the following requirement:

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.

The Guide requires a suitability assessment in the construction licence stage, where the licensee 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.

Requirement 436 on the commissioning inspections has been specified to describe the role of the inspection bodies and license applicant in the commissioning of fire protection systems.

3.3 Section 5 Fire safety during operation

Section 5 of the Guide presents the fire safety requirements for nuclear facilities and nuclear power plants during operation. The Guide continues to ensure implementation of the defence in depth approach by means of Operational Limits and Conditions, planned periodic inspections and maintenance.

The Operational Limits and Conditions (OLC) present requirements to ensure adequate fire safety. This section includes requirements for systems governed by the OLC.

The Guide clarifies fire protection requirements during nuclear power plant outages and brings forward development requirements for fire safety together with Guide YVL A.7.

Requirement 504 of the Guide presents requirements for modifications. In decision 2/0010/2012, STUK accepts the interpretation according to which only extensive modifications to fire protection systems, spare part changes to components that are significant in terms of the operation of the systems and products of a new type shall be submitted to STUK for approval. Other documentation shall be submitted to STUK for information or reviewed at the plant site. The above interpretation shall also apply to the updated Guide YVL B.8. This means that routine repairs involving known components need not be approved by STUK.

3.4 Section 6 Regulatory oversight by the Radiation and Nuclear Safety Authority

Section 6 of the Guide describes STUK's regulatory oversight during the various licensing stages. This section does not include new requirements in addition to the ones presented in the previous sections.

Inspections performed by STUK in the different licensing stages focus on the equivalent documentation detail level, with emphasis on the system description level. The inspection body approved by TUKES plays a key role in the technical inspection. As regards fire protection, STUK focuses on the fire, flood and earthquake risk management. The Guide further specifies the commissioning inspection practices. STUK conducts the commissioning inspections of fire protection arrangements in new facilities as part of the building commissioning inspections. Active fire protection systems shall be inspected as part of these inspections. STUK conducts separate commissioning inspections of active fire protection systems only when the systems undergo significant modifications or if an entirely new system is commissioned during the operation of the facility.

This section also presents the points of departure for the fire protection-related cooperation between authorities. In connection with the design of the Olkiluoto 3 and Hanhikivi 1 nuclear power plant units and Posiva disposal facility, good experience has been gained on cooperation between authorities like STUK, the rescue authorities and the municipal building inspection authority when discussing the design work under the responsibility of various authorities. Practical issues have included, for example, the designed access and escape routes and attack routes in combination with the separation of safety divisions in cases where the overall concept has required a combination of competencies of several authorities.

The Nuclear Liability Act requires cooperation with nuclear facility insurers:

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.

3.5 Appendix A Evaluation of the implementation of the defence in depth approach to fire protection

In the previous YVL Guide update in 2013, the requirement to apply the defence in depth approach to fire protection was added to Guide YVL B.8. After the update, it was deemed necessary to clarify the relation of the defence in depth approach to the fire hazard analyses. Appendix A further specifies what is required of the analyses, and provides examples on the implementation of the analyses.

The appendix first discusses the selection of the objects of study. The objects of study are presented in requirement 312, but objects of risk that are not covered by the aforementioned requirement may also be identified. Risks may be caused, for example, by heavy fire loads, connections between safety divisions and location of the safety systems. A 3D model is a good tool for identifying objects. The appendix also lists special objects where the defence in depth shall be assessed.

The defence in depth approach to fire protection is built of consecutive levels ensuring the nuclear facility’s fire safety. The system description level should describe the fire protection arrangements designed for each object. As regards the separately reviewed objects of risk, fire protection arrangements shall be assessed by the defence in depth levels with a description of their respective role in fire protection.

Sections 3.2 and 3.3 of the Guide describe the requirements for fire hazard analyses. Section A.3 of the Appendix incorporates the objects reviewed in section A.2 as part of the fire hazard analyses. Depending on the object, it may be justified to include the review in the building's structural or functional fire hazard analysis or perform a separate analysis on the reviewed object (e.g. separate analyses on objects inside the containment). The section presents content requirements for fire hazard analyses in general and requirements concerning the review of special objects. Analyses based on postulated fire development are described in the Decree of the Ministry of the Environment (848/2017) and the associated explanatory memorandum. In practice, structural fire hazard analyses shall include the equivalent information unless the fire resistance rating of the structures is based on class values. Design based on postulated fire development may also be applied in, for example, the design of the exiting safety. In this case, the analyses supporting the design must also be presented.

Requirements A305–A308 describe the determination of any fire scenarios in the object of study. Fire scenarios are used to identify possible types of fire, magnitudes of initial fires and propagation of fire in the object. Fire scenarios are used as means to coordinate the required analyses. Fire scenario determination is an iterative process studying a fire event based on certain initial assumptions and possible fire development. The analysis can be used to determine the development of the fire and whether it will spread within the fire compartment. Modelling the fire development may require several simulation rounds to iteratively determine the development of the fire under certain initial assumptions. The simulation and calculation tools shall be based on tested procedures and validated by the parameters under analyses.

The fire scenario shall include all possible fire trends. One way to manage any variations in a fire scenario, and assess fire protection impairments as part of the fire scenario, is to use the fire event tree. A fire event tree allows the identification of the so-called worst-case that, if found to be safe, means that it may not be necessary to simulate the other cases. This cannot, however, be done unless it is obvious which event tree branch leads to the worst outcome with consideration to the safety system layout in the fire compartment. In such a case, all fire event tree branches that have not been found safe must be analysed for consequential effects.

The design basis fire in requirement A305 is the worst-case fire according to the fire scenario. There is no need to define it separately if the assumption is that all the fire load in the fire compartment will burn and all equipment there will fail.

There is no need to determine the fire compartment conditions according to requirement A307 if

- the compartment's compartmentation structures are dimensioned based on the table (< 1,200 MJ/m^2);
- it is expected that all the fire load will be included in the fire; and
- the separation of safety divisions takes place in the required manner.

The content of the consequential effect analysis is determined by the type of fire hazard analysis. Consequential effect analysis of a structural fire hazard analysis may be considerably more concise than that of a functional fire hazard analysis. In a deterministic fire hazard analysis, open doors shall be considered as impairment. The results of the review must be such that they can be incorporated in the fire PRA.

4 International provisions concerning the scope of the Guide

International instructions and requirements essential for the Guide are presented in the references of the Guide.

The IAEA presents general radiation and nuclear safety principles in the following publications: IAEA SSR-2/1, “Safety of Nuclear Power Plants: Design” and IAEA SSR-2/2, “Safety of Nuclear Power Plants: Commissioning and Operation”. The principles apply to the establishment of responsibilities, legality, leadership, acceptability of facilities and functions, the establishment of protection levels, individual safety, present and future protection of the population and environment, prevention of accidents, preparedness for emergencies as well as continuous reduction of identified and postulated risks. Guide YVL B.8 and the content of the requirements therein have been prepared in compliance with said principles also as regards fire protection at a nuclear facility in establishing requirements for the design of the defence in depth and verification thereof as well as for the organisations responsible for the design and verification, including the plant fire brigade and the person responsible for the design of fire protection.

The IAEA presents general requirements for the preparedness for technical nuclear and radiological emergencies and response in case of said emergencies in the following publication: IAEA GSR Part 7, “Preparedness and Response for a Nuclear or Radiological Emergency”. As regards fire protection, general requirements are presented for the fire compartmentation, exit routes and fire alarms in nuclear facilities as well as requirements for the personnel performing fire protection at nuclear facilities, verification of cooperation capabilities in emergency response activities and extensive procedures for emergency situations. Sections 3 and 5 of Guide YVL B.8 present the corresponding requirements in detail, and section 6 presents the corresponding descriptions concerning the activities of the Radiation and Nuclear Safety Authority.

The IAEA presents general requirements for radiation protection in the following publication: GSR Part 3, “Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards”. As regards fire protection, the requirements address emergency management and the associated establishment of responsibilities. Sections 3 and 5 of Guide YVL B.8 present the corresponding requirements in detail, and section 6 presents the corresponding descriptions concerning the activities of the Radiation and Nuclear Safety Authority.

The IAEA present general requirements for safety assessments in the following publication: GSR Part 4, “Safety Assessment for Facilities and Activities”. The instructions present general requirements for progressively developed safety assessments and associated responsibilities. Guide YVL B.8 complies with corresponding general requirements: sections 3.1, 3.2 and 3.3 of the Guide set forth requirements for the application of deterministic and probabilistic methods such that the final acceptability of the safety level shall be verified by fire PRA. Section 4 of

Guide YVL B.8 sets forth the corresponding requirements for the submitting of documents in the different stages of the licencing process.

The IAEA presents a more detailed reference level for fire protection in the following instructions: NS-G-1.7, "Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants" and NS-G-2.1, "Fire Safety in the Operation of Nuclear Power Plants". The instructions are applied in accordance with requirement 307 with the first priority given to the Finnish fire and building legislation. The following parts of said IAEA instructions are discussed in other YVL Guides:

- Safety classification instructions presented in Section 7 of Guide NS-G-1.7 are discussed in Guide YVL B.2.
- Instructions concerning the periodic inspections presented in section 4 of Guide NS-G-2.1 are discussed in Guide YVL A.7.
- Instructions concerning the quality management in Guides NS-G-1.7 and NS-G-2.1 are discussed in Guide YVL B.1.

Practices presented in the IAEA safety report SRS 10, "Treatment of Internal Fires in Probabilistic Safety Assessment for Nuclear Power Plants" are applied in the analysis requirements of Guide YVL B.8. The fire event tree analysis presented in said report was expanded in the spirit of Section 9 of Regulation STUK Y/1/2019 into requirements 322 and 323 on the accident situation analyses to consider the needs resulting from the Fukushima accident in addition to the practices presented in the IAEA Guides NS-G-1.7 and NS-G-2.1.

Guide YVL B.8 covers the WENRA reference requirement area S, protection against internal fires.

5 Impacts of the Tepco Fukushima Dai-ichi accident

As regards Guide YVL B.8, the areas for improvement identified and already taken into account in the version published in 2013 are as follows:

- Qualification of the fire-extinguishing systems shall be taken into account if the function is necessary for the management of accident situations.
- Personnel resources shall be taken into account if the use of fire-extinguishing systems or mobile fire fighting equipment is necessary for the management of accident situations.

This means that the supply of fire water immediately after an earthquake shall be ensured. In such a case, as regards earthquake resistance, the Guide requires concepts to ensure availability of fire water with consideration also to other use of fire water than those related to extinguishing a fire.

Guide YVL B.2 presents the following requirements for seismic classification:

325. Seismic category S1 shall comprise [...]

10. the fire detection and alarm systems and fire extinguishing systems with extinguishing agents in rooms containing safety-classified components, unless *the consequences of a fire can be demonstrated as highly insignificant by analyses.*

326. Seismic category S2A shall comprise systems, structures and components the maintenance of whose operability and integrity is not essential for the accomplishment of safety functions but which may have effects depending on their system connection or location (e.g. collapse, falling) or due to other reasons (release of a hazardous substance, fire, flooding) on the safety-related operation or integrity or automated safety functions of seismic category S1 systems.

327. All seismic category S1 and S2A components shall be assigned the characteristics (e.g. functionality, integrity) that they must maintain after a loading situation caused by a design basis earthquake.

As regards structural fire protection, fire separation requirements between the safety divisions were tightened such that the highest requirement level in the Decree (848/2017) is applied in the Guides. Examples of the above include separation of safety divisions in contact with each other and separation between building (firewall requirement). The Decree (Section 2, 848/2017) states that firewall *refers to a wall that prevents the spread of fire to the other side of the wall for a stated period of time and withstands the collapse of adjoining buildings or parts thereof and impacts caused by the collapse.*

Traditional type approval of firewalls stipulates that, at the end of the fire resistance test, the structure still has to withstand an impact of a sack filled with 200 kg of lead weights hung on a rope and swung against the wall at the height of 1.5 meters. In practice, traditional nuclear facility structures withstand this with ease. Prevention of progressive structural collapse is a more relevant resistance requirement requiring the assessment of the characteristics of the firewall in view of stopping the progress of collapse in equivalent robust structural framework typical to nuclear facilities. Also this requirement is met inherently by the traditional nuclear facility structures.

6 Needs for changes taken into account in the update

The needs for changes due to the changes made to international and national laws/regulations and the change proposals made in connection with the preparation of the YVL Guide implementation decisions (SYLVI) together with others recorded in STUK's database have been considered when updating the requirements. In addition, the possibilities to reduce the so-called administrative burden have been considered.

The Guide makes several references to the fire and building legislation. The new Decree of the Ministry of the Environment on the Fire Safety of Buildings (848/2017) has replaced parts E1 and E2 of the National Building Code of Finland, RakMK. The most significant change resulting from this is the addition in requirement 338 that allows the use of fire class P0 (design by postulated fire development) under certain conditions. The change allows for more flexibility in design, but deviations from the fire class P1 requirement level must be justified by analyses. The new Decree also has indirect effects on many requirements.

From the perspective of nuclear safety, the design basis for fire protection changed in connection with the update such that, in case of a fire, it shall be possible to bring the facility to a controlled state according to requirement 453 of Guide YVL B.1. There has been a conflict between the Guides as Guide YVL B.8 previously required that the facility must immediately be brought to a safe state. The change lowers the requirement level.

Based on Regulation STUK Y/4/2018, some requirements have been extended to cover nuclear waste facilities in addition to nuclear power plants.