European Nuclear Safety Regulators Group
ENSREG

2nd Topical Peer Review – 'Fire Protection'

Country Review Report

Finland

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CONTENTS

1. Brief overview of the candidate installations

The following installations were finally selected and included in the national assessment report (NAR).

Installation category	Number of installations	Name of candidate installations
Nuclear power plant	3	Olkiluoto 1, 2 Olkiluoto 3 Loviisa 1, 2
Research reactor		-
Fuel reprocessing facility		-
Fuel fabrication facility		-
Fuel enrichment facility		-
Dedicated spent fuel storage	1 (wet)	Olkiluoto KPA
Installations under decommissioning		-
On-site radioactive waste storage		-
Total	**4**	

2. Regulatory framework

The NAR explains that "*Below the constitution there are laws regulating the use of nuclear energy. The most essential laws are Nuclear Energy Act and Radiation Act*". The continuous safety assessment and enhancement approach applied in Finland is based on the Nuclear Energy Act Section 7 a. Besides, the "*Nuclear Energy Decree (161/1988) describes the license requirements and regulatory oversight. In addition to nuclear specific requirements, there are also laws that set fire safety requirements for all buildings.*"

Furthermore, the NAR indicates that "*STUK Regulation on the Safety of a Nuclear Power Plant is used to issue the provisions concerning the safety of a nuclear power plant that specify the provisions of the Nuclear Energy Act. [This] regulation section 9 states general functional defence in depth safety principle to be implemented in the design, construction, and operation of a nuclear facility. In section 15 is stated, that the design of nuclear facilities shall take internal hazards, such as fires, into account. According to regulation, systems, structures, and components (SSC) shall be designed, located, and protected so that the probability of internal hazards is low and impacts on nuclear safety minor.*

The NAR indicates as well that *"STUK has issued regulatory guide (YVL B.8) on Fire protection at a nuclear facility which introduces more in-depth requirements on fire protection arrangements [and that] requires that fire protection at a nuclear facility be designed following the defence in depth principle for fire protection.*" The guide also sets requirements for fire hazard analyses. Additional descriptions are provided of the verification of the fulfilment of the fire safety requirements in accordance with the designed nuclear power plant failure criteria.

In response to the question of the TPR Team about whether or not the SRLs are binding, Finland's answer was "*The WENRA regulations are not legally binding, but Finland has agreed to fulfill the safety reference levels or achieve similar level of safety with different measures in the national regulatory framework*".

The NAR indicates that during the renewal process of the regulatory guides that was finished in 2013, WENRA SRLs (2008) were implemented in the new YVL guides. However, the "[WENRA] *SRLs published in 2021 were accounted for in Finnish regulations".*
The NAR states that *"the Finnish nuclear safety regulations are at least as stringent as the existing IAEA requirements. Guide YVL B.8 requires licensees or applicants to comply with IAEA guides and technical reports that pertain to fire protection where applicable."*

3. Findings and significant improvements of approaches on the installations from the national self-assessment

Nuclear power plants

Olkiluoto 1, 2

The following **strengths** related to fire protection were reported in the NAR for **Olkiluoto 1, 2:**

- Control of fire load and ignition sources: For all storing (temporary / permanent) at nuclear power plant permit is required. Temporary storage permit is implemented in the work management system. Permanent storage places are processed in the plant change process.
- Temporary storage of combustibles is subject to permits - the storage area is marked with marking tape and the permit is affixed to the site.
- 24/7 professional plant fire brigade on site: Plant fire brigade is trained and capable to perform fire and rescue operations. Training with regional emergency services is done regularly.
- Work related to fire safety, such as hot works, dust-causing works, opening fire compartment structures, working in an explosive area and temporary storing. For example, all hot works are inspected before the work starts, and post-inspections are also carried out. Provision of additional manual fire extinguishers at hot work sites.
- Fire PRA is a full scope analysis of the units. It covers all plant operation modes, as well as PRA Level 1 and Level 2 analyses.

The following **weaknesses** related to fire protection were reported in the NAR for **Olkiluoto 1, 2**:

- There is a large amount of fire load, especially PVC/PE cables, and turbine lubricant oil.
- Human factors are seen as a major contributor to possible ignition events, especially during maintenance outages.
- Some old CO2-gas systems, whose design basis do not comply with today's industrial standards, are still operational. Replacement of some of the systems is ongoing and planned for the rest.
- Fire PRA is mainly based on conservative assumptions in the scope of fire induced damages inside the compartment. Use of expert judgement to estimate limited fire spreading sequences contains some uncertainty.

The following **lessons learned** related to fire protection were reported in the NAR for **Olkiluoto 1, 2**:

- Fixed extinguishing systems are important to reduce fire risk.
- Noticed during fire safety self-assessment that doors/hatches in between divisions is not monitored in a systematic way. This weakness was improved identifying the doors/hatches in between divisions and defining the closed position check measures. It was important thing to be assessed, securing that the fire containing principle is valid all the time, if not then

compensatory measures come in force: “Fire compartments are completely surrounded by fire resistant walls and ceilings with fire resistant sealing devices for openings and penetrations”.

- In WANO's peer review in 2020, an AFI was published regarding fire-opening penetrations. A procedure has been published and implemented to improve the situation.
- A recent event, which led to corrective actions, was discovered regarding the activities of plant fire brigade. Shortcomings had been observed at all Olkiluoto nuclear power plants in adherence to compensatory fire protection practices during the isolation of fire protection systems in 2022. Shortcomings in fire safety rounds constitute a deviation from both procedures and Technical Specifications. Corrective and development activities were implemented.

The following **improvements** related to fire protection were reported in the NAR for **Olkiluoto 1, 2**:

- Sprinkler system changes in the cable rooms of two subsystem pairs.
- Passive fire protection was improved in the rooms of the auxiliary building containing safety-critical systems pumps.
- Door locking changes in the rooms below the main control rooms and other doors between subsystems.
- Second start-up transformer was installed (two per unit), based on the experience gained from the fire of the electric supply unit in 1991, to improve the failure tolerance of plant’s external grid connections. Furthermore, the main transformers, in-house transformers and start-up transformers are protected with a sprinkler extinguishing system, which reduces essentially the risks arising from transformer fires.
- Halon extinguishing systems at the Olkiluoto 1 and 2 were replaced with other extinguishing systems by the year 2000. New Novec 1230 gas extinguishing system has been also added to replace a sprinkler system in the control building cable rooms in 2014.
- Fire protection of cables, that are crucial to safety, have been improved by renewing fire detectors and improving fire extinguishing systems in cable tunnels. Cable tunnels may contain two redundancies of cables one on each side of the tunnel. The modernized system is designed against fire spread from one cable redundancy to the other. Also, some cable trays have been protected with casings and fire insulation boards.
- The extinguishing capabilities in the turbine hall have been improved with water cannons (new installations).
- Aging of fire doors and penetrations have been evaluated and renewals have been planned and completed based on the evaluations.

Olkiluoto 3

The following **strengths** related to fire protection were reported in the NAR for **Olkiluoto 3:**

- Scope and thoroughness of fire analyses: the extensive deterministic fire hazard analyses (structural and functional) are used to verify fire safety of plant design. Functional Analyses have been carried out to demonstrate that even in the event of losing one entire safety fire compartment by a fire, the reactor can safely shut down.
- Fire PRA is a full scope analysis of the unit Olkiluoto 3. It covers all plant operation modes, as well as PRA Level 1 and Level 2 analyses.
- Exemplary separation of safety divisions.
- Extensive structural fire protection.
- The fire alarm system covers the entire plant.
- Large concentrations of fire load and other important areas such as MCR are protected with active fire suppression systems.

- Fire prevention - use of permit system for temporary and permanent storage. Hot work permitting etc. inspected before works starts and post-inspections. Provision of additional manual fire extinguishers at hot work sites.
- PCP motors are protected with casing to reduce the effects from potential oil leaks.
- The cabling has been mainly done with FRNC-cables that do not ignite easily and reduce the fire spread. The smoke from the burning cables is non-corrosive.
- Olkiluoto 3 plant is situated at the same site as Olkiluoto 1 and 2 and is serviced by the same plant fire brigade.

The following **weaknesses** related to fire protection were reported in the NAR for **Olkiluoto 3**:

- There are deviations of cable laying concept, power / I&C supply of the component needs to be routed through same division associated rooms. These cable laying deviations were justified.
- Authority communications network (TETRA) does not exist at plant.
- Basic position of firefighting water supply system containment isolation valves is closed position to eliminate certain flood hazards. In the event of fire, the building isolation valves are opened from MCR to allow active firefighting.

The following **lessons learned** related to fire protection were reported in the NAR for **Olkiluoto 3**:

- Internal flooding risks related to firefighting water systems were identified in the inspections and document review during the construction phase of OL3. This led to some changes in the design.
- Changing the characteristics of some fire detectors due to room conditions.
- Sprinkler systems in EDG/SBO diesels have been modified due to several unnecessary fire alarms. Fire pump tests caused pressure hammers to the fire water network. After the modification, the unnecessary fire alarms have ended.
- Noticed during fire safety self-assessment that doors/hatches in between divisions were not monitored in a systematic way. This weakness was improved identifying the doors/hatches in between divisions and defining the closed position check measures.
- Additional casing was designed on PCP motors to contain oil leaks and improve fire safety.

The following **improvements** related to fire protection were reported in the NAR for **Olkiluoto 3**:

- Cable replacement of the smoke extraction system 30SAG. Original cables with a 30-minute fire resistance had to be replaced with cables with a 90-minute fire resistance according to regulations.

Loviisa 1, 2

The following **strengths** related to fire protection were reported in the NAR for **Loviisa 1, 2:**

- Availability of batteries that ensure the autonomous operation of the central units and the control panel of the fire alarm system for 72 hours without an external power supply source.
- The plant has highly trained and experienced full time professional fire brigade with wide responsibilities related to plant´s fire protection and fire safety activities.
- The power plant has established in cooperation with the authorities (Radiation and Nuclear Safety Authority, Rescue Authority, Police Department) offsite muster point in the area of the nearest city.
- Fire PRA is a full scope analysis of the units Loviisa 1 and Loviisa 2. It covers all plant operation modes, as well as PRA Level 1 and Level 2 analyses.
- The plant has developed comprehensive plant level risk analysis for identification of risk areas and combustible materials/fire loads to be used in relation to fire load permit

management. The analysis has also been integrated to be as part of fire load management, storage area managements, area approval procedures, etc.

The following **weaknesses** related to fire protection were reported in the NAR for **Loviisa 1, 2**:

- The possibility of fires and consequential nuclear accident caused by them were not adequately taken into account initially in the functional design and the lay-out design of the Loviisa plant. The original design of Loviisa NPP was vulnerable to fires due to shortcomings in functional plant layout design and many improvements (see below) have been done to mitigate the following deficiencies:
    - the plant has unprotected steel structures to some extent which increase the risk of collapse in case of fire, if active fire protection fails;
    - current requirements regarding the structural separation of control room and emergency control room are not fulfilled;
    - Fire compartmentation and cable routings do not meet the standards of today.
- Plant units still contain much fire load in the form of PE- and PVC-cables, diesel generator fuel and turbine lubricants etc.
- Original piping of firefighting water distribution system has had some leakages, which have been repaired.
- Fire PRA is based on conservative assumptions especially considering consequences of instrumentation and control circuit failures (possibility for spurious signals is included). This ensures scope of possible initiating events but simultaneously increases the quantified fire induced core damage frequency.

The following **lessons learned** related to fire protection were reported in the NAR for **Loviisa 1, 2**:

- Different operating experiences, peer reviews, other missions and inspections have played an important part of continuously improving and evaluating the performance and practices within the plant.
- STUK required that Fortum assess fire doors and hatches also taking into account the risk of flooding. This assessment led to renewal program of fire doors that did not meet the current standards.
- PRA has helped identify needs for safety improvements in fire protection arrangements and plant systems that have lowered the risks related to internal fires.
- Fixed extinguishing systems are very important to reduce fire risk.
- Fires are not significant in the PRA of spent fuel pools or interim spent fuel storages. Fires may affect the cooling function of the spent fuel pools causing minor risk sequence.
- When fire detection systems are disconnected, compensatory measures will be put in place. The hourly inspection rounds carried out by the fire and security organization is one of the many compensatory measures. The rounds are triggered when a room is without a functioning fire detector or when half of the detectors of a fire group are disabled or faulty. The onsite fire brigade has enhanced the recording of inspection rounds procedures. Now the measures are accurately recorded in the fire brigade station logbook at the exact times. If necessary, the entries are reviewed at the daily fire brigade´s operational meeting, and they can also be verified later.

The following **improvements** related to fire protection were reported in the NAR for **Loviisa 1, 2**:

- With regard to passive fire protection, there have been new walls built, some doors closed permanently, protection of load-bearing steel structures, and moving of fire loads to different fire compartments.
- Firewall was constructed between turbine hall and feedwater tank compartment.
- The generator excitation system transformers of both plants no longer contain oil. They were changed to dry transformers in 2015.

- Provision against oil fires in the turbine hall. Fire insulators of the load-bearing steel structures of the turbine building were installed. Turbine hall has been equipped with an automatic sprinkler system and the significant areas of the turbines have been protected by dedicated sprinkler systems. The turbine bypass valve hydraulics changed from oil-based to water-based to eliminate the possibility of hydraulic oil fire.
- The main transformers have been protected with a sprinkler system, which essentially reduces the risk of fire spreading into the surrounding buildings, especially into the turbine hall.
- The original fire water pumps are supplied from the off-site and onsite electrical network. The additional fire water pump station has been constructed at the plant and equipped with diesel-driven fire water pumps and with a separate fire water tank. The fire water piping and fire extinguishing systems, as well as their coverage have been improved.
- A new addressable fire alarm system was completed in 1999 at Loviisa 1 and in 2001 at Loviisa 2.
- Improving the fire safety of generator excitation system rooms in 2018.
- New hot work building outside the protected area in 2020.
- Procurement of spare parts for the main and sub-centers of the fire alarm system in 2019.
- Replacement of cargo pallets with non-combustible ones 2020-2022.
- Reforming the fire load permit procedure based on fire safety assessments 2020-2022.
- Concerning fire doors:
    - Development of aging management of fire doors (identification of doors and places of use);
    - Renovation project for fire doors 2018-2022, renewal of doors according to fire risk significance;
    - Expanding the condition monitoring of fire doors in accordance with the Fire PRA;
    - Closing, locking or walling up of some fire doors in accordance with the fire PRA.
- Development of the fire protection organization 2019-2022.
- Regular renewal of fire equipment (every 4 years).

Spent fuel storage

Dedicated spent fuel storage (wet) Olkiluoto KPA (ISFS)

The following **strengths** related to fire protection were reported in the NAR for **Olkiluoto KPA:**

- Regardless of the fire load, cables, switchgear, instruments and devices of different redundancies (A- and C-sub) are placed in different fire compartments.
- Fire PRA is based on conservative assumptions in the fire induced damages.
- Possible extra fire load is monitored via fire safety inspection rounds and continuing observation is performed by fire safety department. Safety observations are requested to be made by plant workers.
- Fire safety permit process (hot works, storing, opening of penetrations) and the alternative measures for maintaining required fire safety level defined in Technical specifications (TTKE).
- Existing guidance for storing materials and hot works.
- The task of active fire protection systems is to ensure good operating conditions for the operational activities of the fire brigade and to extinguish fires in locations with large fire loads or an obvious risk of ignition.
- The Olkiluoto ISFS facility is situated at the same site as Olkiluoto NPP and is serviced by the same on-site fire brigade.

The following **weakness** related to fire protection was reported in the NAR for **Olkiluoto KPA**:

- The original fire protection concept/philosophy has mainly been found to be good, even though it does not meet the current regulations regarding passive fire protection in all respects.

The following **lessons learned** related to fire protection were reported in the NAR for **Olkiluoto KPA**:

- Fires are not meaningful in the PRA of the ISFS.
- The systems have been kept in good working order by testing them regularly and modernizing them, e.g., a 25-year health assessment has been made for the sprinkler system, as a result of which the nozzles were changed to fast-acting ones.
- It was noticed during fire safety self-assessment that doors/hatches in between divisions are not monitored in a systematic way. This weakness was improved identifying the doors/hatches between divisions and defining the closed position check measures.
  Closed position check of doors/hatches between divisions is made in daily bases by nuclear security.

The following **improvement** related to fire protection was reported in the NAR for **dedicated spent fuel storage (wet) Olkiluoto KPA**:

- Modernization of smoke ventilation hatches was done in 2023.

4. Peer-review conclusions

4.1 Attributes of the NAR and the information provided

The candidate installations are the ones which were the subject of the Board's review prior to the national self-assessment. The recommendation of the Board (consideration of on-site NPP waste storage) was addressed in the NAR.

The information provided in the NAR allowed a meaningful peer review in particular, for the identification of peer review findings.

The document was reader-friendly and facilitated the finding of relevant information.

The outcomes of the self-assessment appropriately mentioned the findings, which were well-illustrated and clearly described.

In general, replies to the written questions allowed to clarify the identified issues.

Additional information and updates provided in reply to written questions and in the national presentation in the country review workshop were taken into account in the definition of the findings below in section 4.2.

4.2 Peer review findings

The self-assessment revealed some weaknesses in the fire protection of the nuclear installations. The finding in the table below was acknowledged as an area for improvement by the TPR Team.

Areas For Improvement mentioned in the NAR as weaknesses and acknowledged as such by the TPR Team	
Nuclear installation: Olkiluoto 1, 2	
AFI (1)	A need to complete the replacement of old CO2-gas extinguishing systems, whose design basis does not comply with today's industrial standards.

The TPR team recommends that Finland addresses this area for improvement in the National Action plan.

During the country review workshop, the findings identified during the peer review phase have been discussed. Based on these discussions, the TPR team concluded on the following findings:

Areas For Improvement		
Nuclear installation: Olkiluoto 1, 2 and Loviisa 1, 2		
AFI (2)	**Finding**	FSA should consider seismically induced fire.
	Justification	The fire protection system is not qualified against seismic hazards. The acceptability of this approach should be justified by the fire safety analysis.

The TPR team recommends that Finland addresses this area for improvement in the National Action plan.

Areas of Good Performance		
Nuclear installation: Olkiluoto 3 NPP		
AGP (1)	**Finding**	Use of a battery for powering fire valves and smoke removal valves for a period of at least 10 minutes as a compensatory measure.
	Justification	In case of loss of normal power supply in one division the corresponding local central units of the Fire Alarm System will be supplied from emergency (diesel) power distribution boards. Even the diesel bus bars may be interrupted for a short time during diesel start, so a small separate UPS system (battery buffered) with at least 10 minutes' capacity is installed for the power supply of the fire dampers and for the smoke exhaust dampers. This compensatory measure will increase the reliability of the fire protection system operability, will reduce the probability of spurious actuation of dampers in case of the grid fluctuations and will allow the control system (automatic) or operator to perform relevant actions in urgent cases or blackout (if diesel would fail to start/run).
Nuclear installation: Loviisa 1, 2		
AGP (2)	**Finding**	Gas detectors are installed in premises where diesel generators are located which signal the leakage of combustible gases from fuel tanks.

	Justification	Such an approach significantly increases the operators' fire prevention capabilities in response to a possible emergency situation (in case of combustible gases and/or fuel leakage). It serves as a fire prevention measure; it alerts maintenance personnel of a potential leak; it potentially reduces the response time of fire services, and it increases reliability of safety equipment by reducing failures to start/run because of fuel supply or other dependent failure (like fire/exploding impact).

Definition of the types of findings

According to the TPR II Terms of Reference, the country group workshop discussions should lead to conclude on the findings categorised as an 'area of good performance' or 'area for improvement'. These are defined therein as follows:

A National area of good performance which should be understood as an arrangement, practice, policy or programme related to fire protection that is recognized by the TPR Review Team as a significant accomplishment for the country and has been undertaken and implemented effectively in the country and is worthwhile to commend.

A National area for improvement which should be understood as an aspect of fire protection identified by the TPR Peer Review Team where improvement is expected, considering the arrangement, practice, policy or programme generally observed in other participating countries. It may also be self-identified by the country itself (i.e. self-assessment) where improvement is appropriate.