European Nuclear Safety Regulators Group
ENSREG

2nd Topical Peer Review – 'Fire Protection'

Country Review Report

Sweden

January 2025

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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	Forsmark 2 Oskarshamn 3 Ringhals 3
Research reactor		-
Fuel reprocessing facility		-
Fuel fabrication facility	1	Westinghouse
Fuel enrichment facility		-
Dedicated spent fuel storage	1 wet	CLAB
Installations under decommissioning		-
On-site radioactive waste storage		-
Total	**5**	

2. Regulatory framework

The NAR mentions that "*The Swedish legal framework consists of the legally binding acts, ordinances and regulations […] With regard to fire safety, the nuclear facilities in Sweden have to comply with specific nuclear regulations as well as conventional (non-nuclear) fire protection regulations.*"
The NAR indicates that these conventional (non-nuclear) fire protection regulations include in particular requirements regarding segregation of items important to safety from fire loads, requirements regarding fire compartments, requirements regarding handling and storage of flammable liquids, general requirements to be considered for worker protection in case of various hazards including fire, requirements regarding prevention and spreading of fire between buildings. Requirements for fire prevention have historically been regulated by other authorities than SSM. These requirements are generic for industrial buildings and not specific for nuclear power plants.
Prior to the new regulations, SSM had limited requirements on fire prevention.
The NAR mentions that "*New SSM regulations were put into force in 2018 and 2022[…]: SSMFS 2021:4,:5 and :6* [related to fire safety] *are specifically for nuclear power plants in operation*."
The NAR indicates the key regulatory requirements related to nuclear safety.
The NAR does not clearly state if the WENRA SRLs SV are binding, however, Sweden has committed to meeting the SRLs. In response to the question of the TPR Team[1], Sweden's answer was "*The result of*

[1] 'The NAR in §1.2 presents the regulatory framework. If not yet clearly mentioned in the NAR, could you indicate whether the WENRA SRLs for NPPs, and RRs (if relevant for your country), which are used as reference for this topical peer review on 'fire protection' (as per the Technical specification) are binding or not in your country? If they are not binding, what is the status of the SRLs (non-binding, guidance, advisory..)?'

the self-assessment made by SSM is that the national regulations comply with all SRLs. The fire requirements used are indicated in the NAR, according to the Tech.Spec."

The NAR states that *"The development of the new regulations in effect from 1 March 2022 included an international comparison in order to make sure that international requirements, guidance and in general state of the art should be considered in the new regulations. This included WENRA Reference Levels 2020 for operating reactors and IAEA Regulations and guidance. Cross reference checks have verified that all WENRA reference levels are covered by the Swedish national regulatory system for operating reactors."*

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

Nuclear power plants

The following **strengths** related to fire protection were reported in the NAR **as generic** for **NPPs**:

- Active fire prevention program that ensures that the fire loads are as low as reasonably achievable (routines to manage and control fire loads and ignition sources at the plant, regular inspections).
- Specific training and a work specific permit for hot work.
- Fire organization with a well-trained onsite fire brigade. The fire brigade performs training in fire safety for all personnel and carries out systematic fire protection work at the facility.
- Close cooperation with the municipal rescue services: the municipal rescue services provide high skilled firefighters stationed on-site safeguarding sufficient staffing in case of an event. The municipal rescue services also perform initial training and refresher fire protection training for operating personnel to support the fire brigade.
- Adherence to fire requirements are checked by not only SSM, but as well by other authorities and insurance companies.
- Implementation of an independent core cooling system (ICCS) in 2020, not credited in FHA, but providing an additional possibility to cool the core and the spent fuel in case of a fire that affects all trains.

The following **lessons learned** related to fire protection were reported in the NAR **as generic** for **NPPs**:

- National forums assessing events and providing information and findings to their members. One forum is the Norderf where all Swedish licensees, and the Finnish utility TVO, and the Swedish company Nuclear Training and Safety Centre (KSU) are members. The Norderf uses information sources such as NRC Bulletin Generic Letter and Information Notice, and IAEA Incident Reporting System, and WANO Reports. There is also a national fire safety forum (NBSG) in Sweden were the regulator and licensees are members.

Forsmark-2

The following **strengths** related to fire protection were reported in the NAR for **Forsmark-2**:

- Establishment of a policy in fire safety to get everyone who works at the power plant to be aware of the importance of their personal role in order to maintaining a strong fire protection. All personnel must have the prerequisites to be able to identify and act on deviations in the fire prevention and in the event of fire. This is done through recurring training and information efforts in fire safety.

- The FHA demonstrates a robust design and a possibility to bring the plant to safe shutdown following a fire. Due to additional regulatory requirements, the analyses have been developed and refined over the years.
- Use of the detailed mapping of plant cable routing, originally performed for the PSA, ensures that safety-important dependencies are accounted for in the safe shutdown analysis.

The following **weakness** related to fire protection was reported in the NAR for **Forsmark-2**:

- Absence of analyses for other operating modes than at-power.

The following **lessons learned** related to fire protection were reported in the NAR for **Forsmark-2**:

- Experience from a fire in an electrical cabinet in 2005 that affected safety related equipment in two safety trains led to several improvements in fire prevention, among others, physical separation of some relay and electrical cabinet rooms, re-construction of venting system, updated instructions and improved pre-fire plans and development of intervention cards for the most important rooms in a reactor safety point of view.
- Some of the actions, based on event experience, fire reviews and information sharing with other organizations) that have been implemented to improve the fire prevention includes:
  - separation of electrical cabinet rooms, some electrical cabinets belonging to different redundancies within a main redundancy that were located in the same fire compartment are now separated and placed in different fire compartments.
  - reinforced fire detection in some electrical cabinets with sampling detectors.
  - installation of alarms of the most important fire compartment doors.
  - fire protection measures on outdoor transformers, new transformers, fire protection metal grating (instead of bedrock) installed over transformer pits for main transformers.
- Events and experiences where the integrity of a fire compartment has been compromised are being tracked and analyzed within the internal system for events and experiences at Forsmark.

The following **improvements** related to fire protection were reported in the NAR for **Forsmark-2**:

- Division of compartments containing SSC's for two redundancies with vital equipment into separated fire cells.
- Reduction of oxygen levels in important areas such as electrical relay rooms, have also been implemented to reduce the risk of spreading fire to redundancies.
- Implementation of an independent core cooling system (ICCS) in 2020, not credited in FHA, but providing an additional possibility to cool the core and the spent fuel in case of a fire that affects all trains.

Some improvements have also been made following recommendations from insurance companies.

Oskarshamn 3

The following **strength** related to fire protection was specifically reported in the NAR for **Oskarshamn 3**:

- High resilience against fire in unit 3: This is a result of the BWR75 design with high redundant safety systems and the rigorously implemented functional and physical separation of redundant trains/electrical subdivisions and the arrangement of fire compartments and fire cells.

No weaknesses related to fire protection were reported in the NAR for Oskarshamn 3.

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

- In year 2009, IAEA conducted an OSART mission at OKG. OKG was encouraged to furthermore decrease the fire load: Efforts to minimize fire loads and arrangements for the management and control of fire loads was given increased attention and is an always ongoing work.
- In recent years the CDF presented has decreased significantly due to plant modifications and less conservative assumptions. This mean that the statement that contribution from fire events can be neglected in comparison with the result of the overall PSA study can be questioned. This is an issue that SSM has to follow up in the future.

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

- Implementation of an independent core cooling system (ICCS) in 2020, not credited in FHA, but providing an additional possibility to cool the core and the spent fuel in case of a fire that affects all trains.
- As a post-Fukushima a design change was conducted to facilitate the refilling of fire water storage tanks directly from the on-site freshwater reservoir using seismically adequate SSCs.

Ringhals 3

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

- High resilience of the plant against fire events resulting from the original plant design along with significant improvements done to the plant configuration, such as the physical separation of safety systems. In the latest versions of the Safe Shutdown analysis, the analysis is performed primarily with the fire compartments as fire barriers. This has shown the strength of the fire compartmentalization since the plant can be safely shut down, in spite of the weakness in the separation of electrical sub divisions (sub:s) mentioned below.
- Use of the detailed mapping of plant cable routing, originally performed for the PSA, ensures that safety-important dependencies are accounted for in the safe shutdown analysis.

The following **weakness** related to fire protection was specifically reported in the NAR for **Ringhals 3**:

- The electrical sub:s in each safety train is not fully separated. Instead the separation of the electrical sub:s in some occasions depend on conditions set in analysis which should be noted as a weakness.

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

- After a larger transformer fire in 2006 on the step-down transformer, several fire protection improvements have been performed on all transformers. This includes improved sealing in penetrations to the adjacent turbine wall, new oil pit separation under transformers to separate any oil spill from stepdown transformers to be able to flow under step-up transformers (and vice versa). Improved Davy's net between oil pit and transformer, possibilities to drain extinguishing water and the installation of a dry-pipe extinguishing system that can be connected to fire-trucks or fire main. Also, the transformers have been replaced to new on all positions and one reason for this is the potential of fire in ageing transformers.
- Implementation of Laydown areas for temporary fire load resulting from a WANO AFI in Fire protection. The updated management and control process has recently been implemented and evaluation will follow in autumn 2023.
- performance of a campaign during the winter of 2022 for ensuring that fire doors are properly closed. The campaign consisted of participation in group meetings by a fire engineer,

informing of the importance of making sure fire doors are properly shut. Effects of this campaign will be evaluated continually in the onsite Fire protection council.

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

- Implementation of an ICCS in 2020, not credited in FHA, but providing an additional possibility to cool the core and the spent fuel in case of a fire that affects all trains.
- Implementation of a container for collecting Reactor coolant pump (RCP) circulation oil after the occurrence of a complete leakage of the circulation oil from one RCP leading to oil ignition below the RCP. Following this measure, the risk associated with this type of fire has been eliminated by encapsuling all oil systems, leading potential oil spill to a metal tank.
- Measures implemented in the compartment housing the pumps used for cooling the spent fuel pool to protect the pumps with a separating wall, in combination with arrangements for smoke extraction.
- Fire protection improvements in MCR in order to fulfil the requirements issued in 2004: The solution applied was to install clean agent extinguishing systems in each of the relay rooms along with improved fire detection capabilities. The effects from this measure is that should a fire occur in one electrical cabinet it cannot spread to the adjacent cabinets.
- Additional improvements were implemented resulting from events or international reviews.

Fuel fabrication facility

Westinghouse fuel fabrication facility

The following **strength** related to fire protection was reported in the NAR for **Westinghouse fuel fabrication facility**:

- Sharing feedback and information up to the highest (international) decision making level. This policy thus guarantees that all operating units can benefit from solutions, mastered at the global level and adapted to local specificities.

The following **weakness** related to fire protection was reported in the NAR for **Westinghouse fuel fabrication facility**:

- Requirements for fire prevention (see also Chapter 2 of CRR).

The following **lessons learned** related to fire protection were specifically reported in the NAR for **Westinghouse fuel fabrication facility**:

- Promotes learning from industry and experience to ensure that safety and quality are held to the highest and most current standards in the performed work. This process is enriched by learning from our operating experience, post-job reviews, self-assessment, benchmarking and much more.
- Inspections carried out by insurance companies to see if Westinghouse complies with applicable insurance conditions are carried out every three years, while internal audits are carried out every two years.

No **improvements** related to fire protection were reported in the NAR for **Westinghouse fuel fabrication facility**.

Dedicated spent fuel storage (wet)

CLAB

The following **strengths** related to fire protection were specifically reported in the NAR for **dedicated spent fuel storage (wet) CLAB**:

- The FHA demonstrates a robust design and an acceptable consequence to the public following a fire. Due to additional regulatory requirements and reviews, the analyses have been developed and refined over the years.
- The facility's routines and safety culture promotes the quick uncovering and remedy of weaknesses. The level of the facility's fire protection safety is considered to be robust both when it comes to radiation safety, personal safety and property protection. If weaknesses are identified, an action plan for these is immediately established.
- The fire load in the facility is generally low and efforts are continuously performed to minimize transient fire load in critical areas.
- The rescue service is trained in knowledge of the facility 8 times yearly.

The following **weaknesses** related to fire protection were specifically reported in the NAR for **dedicated spent fuel storage (wet) CLAB**:

- The required actions to handle the fire and its consequences are still dependent on manual measures (mainly repairs) as a result of not reaching full separation in the construction. This emphasizes the need for education and training of staff that perform these tasks.
- SSM do not have any specific requirements on fire prevention as shown in NAR section 1.2.1 for other nuclear facilities. As such, there have not been any dedicated SSM-inspections of fire safety arrangements and no formal lessons learned with regards to the fire prevention programs for the licensees.

The following **lesson learned** related to fire protection was reported in the NAR for **dedicated spent fuel storage (wet) CLAB**:

- After the WANO peer review in 2013, SKB introduced indicators for fire protection that are measured every six months. SKB also developed fire protection cards placed on the outside of doors to rooms with important equipment. The cards indicate the fire load permitted in the room and the risks. SKB has also reduced the overall fire load in the facility.

The following **improvements** related to fire protection were reported in the NAR for **dedicated spent fuel storage (wet) CLAB:**

- An investigation regarding extinguishing water has been performed at the facility which has resulted in implemented measures. The plan is to build a pond to take care of extinguishing water to prevent it from entering the sea.
- The fire alarm system has been upgraded to a new system during the period 2020-2021.
- Repositioning of redundant components in the cooling system: for example, extension of the safety distance between cables or electrical cabinets. Installation of heat radiation protection between redundant components in the cooling system. Improvement or expansion of the fire cell division.
- After an insurance inspection, fire separation walls were introduced between transformers.
- Following the results of the FHA, vulnerabilities of the plant configuration has been identified and actions to improve the fire protection. CLAB’s electrical systems will be upgraded with two diesel generators and also separated. Furthermore, a new cooling system which is independent from the ordinary seawater cooling system will be installed to ensure that possible fire events will not lead to total loss of cooling. These includes repositioning of redundant components and installation of heat radiation protection between in the cooling system. These improvements have increased CLAB’s ability to withstand a fire.

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 to consider additional facilities (NPP under decommissioning) was not fully addressed in the NAR. The recommendation of the Board (consideration of on-site 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.

Adequate information was provided in reply to the written questions.

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; however, these are addressed by design features or safety analyses, which were acknowledged by the TPR team.

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 of Good Performance		
Nuclear installation: All NPPs		
AGP (1)	**Finding**	The design approach of the fire detection and alarm system is robust regarding the separation of redundant trains.
	Justification	The design of the fire detection and alarm system is robust concerning the separation of redundant trains. In this way, it is ensured that a single failure of a fire alarm centre or the parent system does not lead to the failure of fire detection in more than one safety train.
Nuclear installation: Ringhals 3 NPP		
AGP (2)	**Finding**	Measures to be taken by the operators in the control room are pre-defined in written instructions for every single fire compartment depending on the area affected. For complex spaces, intervention layouts (rooms, detectors and so on) and fire compartment layouts are complemented with specially developed intervention plans.
	Justification	The development of these pre-fire instructions or plans needs a detailed analysis of the effects and consequences of any given fire scenario at every location in the plant and its progression, as well as of the suitability of the actions to be taken by the control room operators on duty to mitigate them.

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.