ENSREG
European Nuclear Safety Regulators Group

European Nuclear Safety Regulators Group
ENSREG

2nd Topical Peer Review – ‘Fire Protection’

Country Review Report

Germany

January 2025

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[1]	1	Encompasses NPPs' 3 units that were in operation until 15 April 2023 and further 4 units under decommissioning that are not yet free of fuel elements.
Research reactor	2	Triga Mark-II at Mainz site (hereafter – FR MZ) FRM II at Technical University of Munich (hereafter – FRM II)
Fuel reprocessing facility		-
Fuel fabrication facility	1	BFL fuel fabrication facility
Fuel enrichment facility	1	UAG uranium enrichment facility
Dedicated spent fuel storage	2 (dry type)	BZB , Biblis spent fuel storage (dry type) facility at the Biblis NPP site, BZB ZLN, spent fuel storage (dry type) facility Rubenow, ZLN
On-site radioactive waste storage	2	Biblis storage facility AZB 1 and AZB 2 Waste storage facility North ZLN
Installations under decommissioning	1	Karlsruhe reprocessing plant (WAK) with VEK
Total	**10**	

2. Regulatory framework

The NAR reports that the requirements for fire protection can be found in different nuclear regulations, in particular in the "Safety Requirements for Nuclear Power Plants" issued by BMU, guidelines of the BMUV, recommendations of the Reactor Safety Commission, Nuclear Waste Management Commission, and the Commission on Radiological Protection, as well as the nuclear safety standards of the Nuclear Safety Standards Commission (KTA) on fire protection in nuclear power plants.

[1] All German NPPs would formally come under the installations under decommissioning in the TPR II. At the time of the peer review, seven nuclear power plants still had nuclear fuel in their respective spent fuel pools. However, Germany reported on these installations in the chapters related to the NPPs.

The NAR indicates that "*the German nuclear regulations, in particular safety standard KTA 2101.1, require a fire protection concept and a fire hazard analysis for nuclear power plants[…] The fire protection concept for German nuclear installations follows the principles of the defence-in-depth concept with regard to fire safety*."

The NAR indicates the key regulatory requirements related to fire protection of NPPs. The report informs that *"Essential elements of fire protection were already practised at an early stage in all German nuclear installations and have been continuously improved. The fire protection at nuclear power plants of all generations as well as of research reactors has been continuously reviewed and adapted to the state of the art and to the applicable nuclear regulations as long as they have been or are being commercially operated, taking into account valuable findings from the feedback from operating experience."* Furthermore, general requirements from the safety related requirements regarding fire protection are provided in the KTA safety standards, and while these basically apply to nuclear power plants and research reactors, they can also be applied to nuclear fuel cycle and storage facilities.

The NAR indicates that "*for research reactors, legal design principles from the conventional area are primarily applied. These are supplemented by the fire protection regulation for nuclear power plants, which is graded according to the hazard potential*".

The NAR indicates that "*fire protection for storage facilities for spent fuel or radioactive waste is essentially based on the conventional (non-nuclear) building law*".

The NAR does not mention if the WENRA SRLs are transposed in the regulatory framework. In response to the question of the TPR Team[2], Germany's answer was "*In Germany, the WENRA Safety Reference Level (SRLs) are not directly binding; they have the status of sub-statutory guidance documents. However, their respective specifications are incorporated in the regulatory framework, e.g. in the "Safety Requirements for Nuclear Power Plants", the KTA nuclear safety standards and others. Thus, as part of the sub-statutory legal framework, the SRLs are made binding vis-à-vis the operator by virtue of their integration into the operating licences or orders by the nuclear supervisory authority*."

The NAR mentions that the German nuclear regulatory framework complies to a high degree with the latest IAEA guides related to fire protection and probabilistic fire risk analyses.

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 for **NPPs**:

- In accordance with the regulatory requirements, deterministic fire hazard analyses and probabilistic fire risk assessments (Fire PSA) were carried out within the scope of PSRs related to power operation. The insights regarding possible fire protection improvements were implemented in a timely manner. Due to the different times at which the individual installations were designed, optimisations were carried out to varying degrees over time. This

[2] '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..)?'

always ensured a high fire protection level, taking into account the state of the art in science and technology.

- The fire protection concept is always kept up to date. It contains an overall assessment of structural, equipment-related, operational and administrative as well as defensive fire protection, oriented toward nuclear and conventional protection goals, and their combined effects.
- The already conceptual minimisation of permanent fire loads is a significant strength in fire prevention.
- Administrative requirements for dealing with temporary fire loads (e.g. use of non-combustible containers) and potential ignition sources (e.g. provision of fire watches) contribute additionally to fire prevention.

No **weaknesses** related to fire protection were reported in the NAR for **NPPs**.

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

- Challenges arise from decommissioning and dismantling. Additional temporary fire loads and potential ignition sources, e.g. machines, are introduced into the plant. Work with a fire risk potential needs to be identified and suitable measures specified. The same applies to temporary storage areas in rooms of nuclear power plants.
- The following example fire events having occurred during NPP decommissioning were reported in the NAR:
  - Smouldering fire of residues in a waste container inside the drying facility. Modification of the process parameters, additional demonstration of a non-spontaneous ignition of the material to be dried, adjustment of reporting criteria, etc, lead to reduce the probability of a recurrence of the event;
  - Self-extinguishing fire of the steam generator dismantling enclosure. In order to further minimise the risk of a fire, additional measures have been taken (Cutting adaptation to ensure the distribution and/or removal of the heat energy introduced by the wire, recurring thermal control of the cuttings).
- The following example fire events were reported for NPPs in operation in the NAR:
  - Transformer fire: As a consequence, the ventilation modes in the German nuclear power plants were checked for building-external fire events and, if necessary, adjusted to minimise the entry of fire gases in such events. In addition, monitoring equipment was implemented at the transformers to detect transformer damage in advance in order to make a transformer fire significantly less probable;
  - Consequential damage due to a fire after oil leakage from a main coolant pump. The event shows that despite preventive measures, oil leakages and their ignition cannot be completely excluded.
- The following example events with failure or deterioration of fire protection features were reported in the NAR:
  - Findings on fire doors of older design. Comparable doors were analysed regarding their construction, checked for defects and, if necessary, replaced or refurbished;
  - Findings on cable and pipe penetration seals. Penetration seals in safety-related buildings were checked for similar defects and, in the event of deviations from the required state, improved in accordance with their design certification.

The following **improvements** related to fire protection were reported for the **NPPs**:

- The deterministic fire hazard analyses and probabilistic fire risk analyses revealed a number of weak points in the frame of fire protection assessments and the first PSR for each facility. Leading events were identified and measures for optimisation derived, as the following examples show:

- The reduction of fire loads in the enhancements of the individual model lines of nuclear power plants;
- The modification of the oil supply to the reactor coolant pump to reduce the fire load;
- The use of self-medium-operated (steam/water) instead of oil-hydraulically controlled valves;
- The cabling of the feedwater tank level measurements in one plant were routed via the same cable run. A fire in this area of the turbine hall would have caused a failure of the measurements with subsequent protective shutdown of all feedwater pumps and subsequently to a "failure of the complete feedwater supply". After splitting up the cabling into two redundant trains, the risk of simultaneous failure of both measurements in the event of fire and thus the dominant PSA contribution with regard to the calculated damage frequency was significantly reduced.

Research reactors

The following **strengths** related to fire protection were reported in the NAR for the **FR MZ research reactor**:

- Increasingly strict requirements for structural fire protection over the last decades. Fire protection is continuously adapted to the state of the art in science and technology, in coordination with the competent authority (supervisory building authority).
- Even in a design extension event, no significant releases from the FR MZ are anticipated.

No **weaknesses** related to fire protection were reported in the NAR for **FR MZ research reactor**.

The following **lessons learned** related to fire protection were reported in the NAR for **FR MZ research reactor**:

- In 1977, there was a technical note from the manufacturer of the TRIGA reactor General Atomic recommending that licensees retrofit smoke detectors. This was triggered by a cable fire in the company's headquarters. This prompted the FR MZ to retrofit smoke detectors, which resulted in the planning and installation of a new fire detection and alarm system in 1984. Finally, this system was continuously extended and adapted to the state of the art in science and technology.
- As part of the robustness analysis for research reactors, in 2012 the techn.ical safety organisation carried out a study on the effects of an aircraft crash on the FR MZ with consequential kerosine fire. The study comes to the conclusion that under the worst and highly unlikely conditions, such as the complete loss of reactor water and temperatures of 110 °C at the fuel elements, a subsequent release of radionuclides due to fuel element cladding damage is to be expected.
- The majority of the interventions were due to false alarms by the fire detection and alarm system, actuated by dust-generating work conducted by external companies.
- Due to the different years of construction of the various building parts of the FR MZ, they are equipped with fire protection features that widely differ in concept. Due to with deficiencies in the building design with regard to fire prevention, which cannot be resolved structurally with any justifiable effort, the University of Mainz decided to abandon the old building and to construct a new building according to the current state of science and technology. According to current planning, the relocation of the (radionuclide) laboratory and administration wing to the new building and thus the abandonment of the old building will take place in 2024.

The following **improvements** related to fire protection were reported in the NAR for the **FR MZ research reactor**:

- The first fire safety review from 1962 resulted in the requirement for the implementation of additional access and escape routes and doors as well as the fire-resistant design of the

building's load-bearing structures. Furthermore, heat and smoke removal equipment was required for the staircases.
- Based on the fire safety review from 1982, the beams and walls of the new ventilation centre to be built on top of the adjacent institute building were made of non-combustible building materials, and the storey ceiling was made fire-resistant.
- The fire safety review from 1992 led to the separation/segregation of the reactor area from the institute building as a separate fire compartment. An additional fire-resistant door was installed for this purpose. The doors to the storage room for fresh fuel were designed as fire doors, and the fuel element safe is fire-resistant.
- According to the fire safety review in 1994, some glazing were replaced by fire-resistant fire protection glazing.
- The fire safety review of 2013 led to the replacement or repair of some fire protection seals that were not suitably implemented. Moreover, an additional fire damper was installed in a ventilation duct to the reactor hall.
- As a result of an information notice by GRS (WLN 2013/02) from 2013, a safety review was carried out with special focus on fire protection seals for cable penetrations and openings in fire walls. This resulted in comprehensive improvements which were implemented according to the state of the art in science and technology.
- In 2014, major weaknesses were identified in the horizontal and vertical fire barriers in the corridor area of the laboratory building, which was one of the reasons for pushing the construction of a new institute building instead of a refurbishment of the existing building. In the area of the reactor facility, missing fire walls and inadequate doors for separating fire compartments were also identified, which led to the replacement with fire-retardant fire doors and the implementation of additional fire barriers.

FRM II at Technical University of Munich

The following **strengths** related to fire protection were reported in the NAR for the **FRM II research reactor:**

- The already conceptual minimisation of permanent fire loads is a significant strength in fire prevention.
- Administrative requirements for dealing with temporary fire loads (e.g. use of non-combustible containers) and potential ignition sources (e.g. provision of fire watches) contribute additionally to fire prevention.
- The concept of partitioning the facility installation into fire compartments and fire sub-compartments with comprehensive possibilities for mitigating harmful effects in the event of fire and the provision of a dedicated on-site fire brigade always on standby make a decisive contribution to fire protection and thus to compliance with damage prevention.

No **weaknesses** related to fire protection were reported in the NAR for the **FRM II research reactor**.

The following **lessons learned** related to fire protection were reported in the NAR for the **FRM II research reactor**:

- The following events were highlighted:
    - 2021: Actuation failure of a fire damper by fusible link have occurred. During the annual inspection of the approx. 210 fire dampers of the facility with expert participation, one fire damper did not close by fusible link as requested. The cause was found to be a decreasing spring force of the release spring. The spring was replaced, and repetitive recovery tests were successfully completed. The event was classified as a single fault;
    - 2021: Overheated hot plate in an exhaust of the nuclear fuel laboratory. The hot plate switched off automatically after a few minutes. As a consequence, the drying process was completely changed; in particular, a hot plate is no longer used;

   - 2020: Smoke development in a conventional server room due to an overheated electronic component. As a consequence, the air conditioning of the room was improved and the heating load reduced at the same time;
   - 2016: Overheated transformer (24 V) in a scientific experiment. As a consequence, the cooling of the affected transformer was improved;
   - 2009: Fire dampers did not close as requested during an in-service inspection. Measures to prevent a recurrence included the use of reproducible test conditions with special tools, the replacement of the torsion springs of the release device during maintenance.

- External feedback of experience is provided by exchanges with the licensees of research reactors at national (AFR) and international level (RROG, RRFM) as well as by Information Notices prepared by GRS and their feedback and considered as applicable.

The following **improvements** related to fire protection were reported for the **FRM II research reactor**:

- Several smoke detectors were retrofitted in the FRM II and a special tool for improved inspections of fire protection dampers was procured. Furthermore, a mechanical closure valve in the fire extinguishing system with drinking water was retrofitted with a mechanical lock. Based on operating experience or changes in the regulation, the fire safety and alarm regulations were updated several times.
- Additional spray nozzles were retrofitted as a precautionary measure in the area for the allocation storage of low-level waste since the fire loads stored there may exceed the maximum admissible amounts according to the fire load list.
- Retrofitting of individual duct smoke detectors in the air make-up system, the ventilation systems in the supervised area of the reactor building and the access building (emergency power backed-up and operational area).

<u>Fuel cycle facilities</u>

Fuel fabrication facility BFL

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

- The fire prevention and defensive fire protection measures taken at BFL were already considered in the design of the plant and have proven themselves in more than 40 years of operation. Even in the event of a fire, its spread is effectively prevented, and the protection goals are met.

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

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

- After the fire in the laboratory area in 2018, technical fire protection measures and extending the fire detection and alarm system to include automatic notifications to the operations control centre were carried out.
- After the fire in the laboratory area, a transferability test was carried out, which included a comprehensive check of the electrical heaters in the nuclear production building for the presence of combustible substances in the vicinity and, where necessary, an assessment of the effectiveness of tests and interlocks.
- Operating experience shows that micro-fires are controlled at BFL and that measures against recurrence are implemented after the occurrence of events. For example, findings from strong chemical reactions of zircaloy chips in vacuum cleaners led to improvements in the vacuum cleaners used.

- Information Notices related to deficiencies at fire doors of certain construction types, and to malfunctions in certain types of fire detectors have led to the replacement of some fire doors and a review of the correct operation of the fire detection and alarm systems.
- The plant internal on-site fire brigade regularly carries out fire drills. Fire alarm evacuation drills are also carried out regularly in conjunction with a fire drill using the on-site fire brigade, and drills are carried out with the external fire brigades. Regular reports on the drills carried out are submitted to the nuclear supervisory authority. Experiences from the regular exercises are assessed for further improvement defensive fire protection and identified improvements are implemented.

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

Fuel enrichment facility UAG

The following **strengths** related to fire protection were reported in the NAR for the **UAG fuel enrichment facility:**

- Regular fire protection plant inspections with the nuclear supervisory authority, fire prevention inspections by the fire protection service and performance records as well as the annual review of the performance level of the on-site fire brigade by the Münster district government.
- The fire alarm technology for area-wide fire protection monitoring (fire detection and alarm system), the extinguishing provisions as well as the mobile firefighting equipment are periodically tested and maintained by plant personnel and independent inspectors to confirm their functionality. The qualified members of the on-site fire brigade are regularly trained and drills are regularly held in cooperation with the on-site emergency personnel (staff drills).

No **weaknesses** related to fire protection were reported in the NAR for the **UAG fuel enrichment facility**.

The following **lessons learned** related to fire protection were reported in the NAR for the **UAG fuel enrichment facility**:

- In the case of a fire at the fuel fabrication facility UAG, it was examined whether the cause of the fire identified could also be applicable to the UAG. The UAG came to the overall conclusion that a direct applicability is not to be expected. Nevertheless, the UAG identified potential for improvement during the investigations and equipped the exhaust air ducts of the room ventilation systems with additional aspirating smoke detectors.
- Smaller improvements based on operational experience or feedback from experience were implemented. These include, for example, a protection goal adjustment based on the findings of the new plant, the retrofitting of linear heat detectors in accordance with DIN EN 52 in the area of pipes carrying UF6 or the installation of duct smoke detectors based on the information notice from GRS and findings from the fire event in the BFL.

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

Spent fuel storage facilities

Decentralised spent fuel storage facility at the Biblis si**te (BZB)** and the **central storage facility North (ZLN)** in Rubenow

No **strengths**, **weaknesses**, **lessons learned** and **improvements** related to fire protection were reported in the NAR for the **decentralised spent fuel storage (facility BZB)** and the **central storage facility North (ZLN)**.

Radioactive waste storage facilities

On-site Biblis 1 and 2 radioactive waste storage facilities AZB 1 and AZB 2 and the central waste storage facility North ZLN

The following **strengths** related to fire protection were reported in the NAR for the **Biblis 1 and 2 radioactive waste storage facilities AZB 1 and AZB 2** and the central **waste storage facility North ZLN:**

- The consideration of fire protection already during the planning and construction of the radioactive waste storage facilities is purposeful.
- The fire protection concepts and measures meet and exceed the legal requirements. In updating the fire protection concept, amendments and updates to the relevant regulations are evaluated and incorporated where necessary. Fires have not occurred in the storage buildings during the operating period.

No **weaknesses**, **lessons learned** and **improvements** related to fire protection were reported in the NAR for the **Biblis 1 and 2 radioactive waste storage facilities AZB 1 and AZB 2** and the central **waste storage facility North ZLN.**

Installations under decommissioning

Reprocessing plant Karlsruhe (WAK) and Karlsruhe vitrification facility (VEK) under decommissioning

The following **strength** related to fire protection was reported in the NAR for **WAK and VEK**:

- The measures taken for fire prevention and fire protection need to be adapted with each plant modification during decommissioning. As an example, minimising fire loads in the WAK and VEK is an important fire prevention measure. Administrative requirements regarding temporary fire loads and potential ignition sources also contribute to fire prevention.

No **weaknesses** related to fire protection were reported in the NAR for **WAK and VEK**.

The following **lessons learned** related to fire protection were reported in the NAR for **WAK and VEK**:

- The dismantling of the fixtures in the cells of the VEK requires the use of electrically operated cutting tools. In one analysis, it was assumed that this could cause a fire. For the fire accident assessment, only the release into the plant is considered for the VEK. Due to the existing retention systems, a spread into the surrounding area is excluded. Combustible electrical cables and hose lines are laid in the cell wing. They will be replaced in the course of dismantling. In the course of dismantling, they will be cut into pieces and packed in drums. For the activity released into the cell wing in the event of a fire, the release fractions specified in the GRS Konrad transport study are applied analogously. For waste from dismantling in packages, the waste package group for unfixed and non-compactable waste is used. For the events with thermal impact, load class BK3 (corresponding to a thermal impact lasting 60 min at 800 °C) is assumed to be sufficiently conservative. Both the cell wing and the ventilation system withstand this event.
- Fire protection on a constantly changing construction site is much more difficult to implement than in a new building. Conventional regulations and standards for fire protection change in the course of ongoing dismantling and usually involve higher requirements than during the operating period. When modifications are made to the old building, they have to be checked against the requirements for new buildings and a permissible resolution has to be found.
- The modifications that occur as the dismantling progresses are reviewed by the competent supervisory authorities with regard to their impact on fire safety within the scope of modification notifications. Particular attention is paid to the aspects of ageing management and updates of documents.

The following **improvement** related to fire protection was reported in the NAR for **WAK and VEK**:

- Existing fire sub-compartments within a building were merged; therefore, compensatory replacement measures had to be realised, such as the development of new access and escape routes through staircases.

4. Peer-review conclusions

4.1 Attributes of the NAR and the information provided

The candidate installations are not exactly the ones which were the subject of the Board's review prior to the national self-assessment. During the selection process, the grouping of NPPs was refined. NPPs were reported in the Section on NPPs in operation (whether fueled or defueled). The recommendation of the Board to consider additional facilities (RR under decommissioning) as candidate installations was considered, and their non-inclusion has been justified in the NAR.

In general, the national report responds to the technical specifications, however specific descriptions provided therein are sometimes unclear or lacking in detail or context to allow to draw conclusions about their safety significance. Consequently, the identification of potential peer review findings based on the information in the NAR was not straightforward.

There are no comments on the structure of the NAR.

In general, the outcomes of the self-assessment were clearly mentioned.

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 presentations in the country review workshop were taken into account in the conclusion of the peer review (see section 4.2).

4.2 Peer review findings

The self-assessment did not reveal any weaknesses in the nuclear installations.

Based on the self-assessment and the peer review discussions, no finding was identified for Germany by the TPR team.

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.