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National Assessment Report

Report of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) on the ENSREG Topical Peer Review Fire Protection

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Division S I 5 Post office box 12 06 29, 53048 Bonn, Germany

E-Mail: SI5@bmuv.bund.de

Website: http://www.bmuv.de

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Abbreviations

AFR	Arbeitsgemeinschaft der deutschen Forschungsreaktoren Association of German Research Reactors
AKR	Ausbildungskernreaktor Nuclear training reactor
ANF	Advanced Nuclear Fuels GmbH
AtG	Atomgesetz Atomic Energy Act
AVR	Arbeitsgemeinschaft Versuchsreaktor GmbH Experimental reactor at Jülich
AZA	Abfall-Zwischenlager Ahaus Ahaus radioactive waste storage facility
AZB	Abfall-Zwischenlager Biblis Biblis radioactive waste storage facility
AZG	Abfall-Zwischenlager Gorleben Gorleben radioactive waste storage facility
AZN	Abfall-Zwischenlager Neckarwestheim Neckarwestheim radioactive waste storage facility
AZO	Abfall-Zwischenlager Obrigheim Obrigheim radioactive waste storage facility
AZP	Abfall-Zwischenlager Philippsburg Philippsburg radioactive waste storage facility
AZR	Abfall-Zwischenlager Grafenrheinfeld Grafenrheinfeld radioactive waste storage facility
AZS	Abfall-Zwischenlager Stade Stade radioactive waste storage facility
AZU	Abfall-Zwischenlager Unterweser Unterweser radioactive waste storage facility
AZW	Abfall-Zwischenlager Würgassen Würgassen radioactive waste storage facility
BASE	Bundesamt für die Sicherheit der nuklearen Entsorgung Federal Office for the Safety of Nuclear Waste Management
BER II	Berliner Experimentier-Reaktor II Berlin experimental reactor II
BetrSichV	Betriebssicherheitsverordnung Industrial Safety and Health Ordinance
BfS	Bundesamt für Strahlenschutz Federal Office for Radiation Protection
BFL	Brennelement-Fertigungsanlage Lingen Lingen fuel fabrication facility

BGZ	BGZ Gesellschaft für Zwischenlagerung mbH
BImSchV	Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes Ordinance on the Implementation of the Federal Immission Control Act
BMUV	Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucher-schutz Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumers Protection
BWR	Boiling Water Reactor
BZA	Brennelemente-Zwischenlager Ahaus Ahaus spent fuel storage facility
BZB	Brennelemente-Zwischenlager Biblis Biblis spent fuel storage facility
BZD	Brennelemente-Zwischenlager Grohnde Grohnde spent fuel storage facility
BZF	Brennelemente-Zwischenlager Brokdorf Brokdorf spent fuel storage facility
BZG	Brennelemente-Zwischenlager Gorleben Gorleben spent fuel storage facility
BZI	Brennelemente-Zwischenlager Isar Isar spent fuel storage facility
BZK	Brennelemente-Zwischenlager Krümmel Krümmel spent fuel storage facility
BZL	Brennelemente-Zwischenlager Lingen Lingen spent fuel storage facility
BZM	Brennelemente-Zwischenlager Gundremmingen Gundremmingen spent fuel storage facility
BZN	Brennelemente-Zwischenlager Neckarwestheim Neckarwestheim spent fuel storage facility
BZP	Brennelemente-Zwischenlager Philippsburg Philippsburg spent fuel storage facility
BZR	Brennelemente-Zwischenlager Grafenrheinfeld Grafenrheinfeld spent fuel storage facility
BZU	Brennelemente-Zwischenlager Unterweser Unterweser spent fuel storage facility
CDF	Core Damage Frequency
DIN	Deutsches Institut für Normung e.V. German Institute for Standardization
EB	Entsorgungsbetriebe Waste management facilities
EC	European Commission
EN	European Norm

EnBW	EnBW Energie Baden-Württemberg AG
EnKK	EnBW Kernkraft GmbH
ENSREG	European Nuclear Safety Regulators Group
ESK	Entsorgungskommission Nuclear Waste Management Commission
EU	European Union
EWN	EWN Entsorgungswerk für Nuklearanlagen GmbH
FHA	Fire Hazard Analysis
FRJ	Forschungsreaktor Jülich Jülich research reactor
FRM II	Forschungs-Neutronenquelle Heinz Maier-Leibnitz Research Neutron Source Heinz Maier-Leibnitz
FR MZ	Forschungsreaktor Mainz Mainz research reactor
GG	Grundgesetz für die Bundesrepublik Deutschland Basic Law for the Federal Republic of Germany
GKN	Kernkraftwerk Neckarwestheim Neckarwestheim nuclear power plant
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit gGmbH
HAW	High Active Waste
IAEA	International Atomic Energy Agency
JEN	JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH
KBR	Kernkraftwerk Brokdorf Brokdorf nuclear power plant
KIT CN	Karlsruher Institut für Technologie Campus Nord Karlsruhe Institute of Technology Campus North
KKE	Kernkraftwerk Emsland Emsland nuclear power plant
KKI	Kernkraftwerk Isar Isar nuclear power plant
KKP	Kernkraftwerk Philippsburg Philippsburg nuclear power plant
KNK	Kompakte natriumgekühlte Kernreaktoranlage Compact sodium-cooled nuclear reactor plant
KRB	Kernkraftwerk Gundremmingen Gundremmingen nuclear power plant
KTA	Kerntechnischer Ausschuss Nuclear Safety Standards Commission
KTE	Kerntechnische Entsorgung Karlsruhe GmbH
KWB	Kernkraftwerk Biblis Biblis nuclear power plant

KWG	Kernkraftwerk Grohnde Grohnde nuclear power plant
KWU	Kraftwerk Union AG
LüAR	Richtlinie über brandschutztechnische Anforderungen an Lüftungsanlagen Guideline on fire protection requirements for ventilation systems
MIndBauRL	Muster-Industriebau-Richtlinie Model industrial buildings directive
NAR	National Assessment Report
NPP	Nuclear Power Plant
NSD	Nuclear Safety Directive
OSART	Operational Safety Review Team (IAEA programme)
PKA	Pilotkonditionierungsanlage Gorleben Gorleben pilot conditioning plant
PSA	Probabilistic Safety Analysis, part of the PSR
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
RHWG	Reactor Harmonisation Working Group
RR	Research Reactor
RRFM	Research Reactor Fuel Management (European Research Reactor Conference)
RROG	Research Reactor Operators Group
RS Manual	Reactor Safety and Radiation Protection Manual
RSK	Reaktorsicherheitskommission Reactor Safety Commission
RWE	RWE Power AG
SRL	Safety Reference Level
SSC	Structures, Systems and Components
SSK	Strahlenschutzkommission Commission on Radiological Protection
StrlSchG	Strahlenschutzgesetz Radiation Protection Act
StrlSchV	Strahlenschutzverordnung Radiation Protection Ordinance
SUR	Siemens Unterrichtsreaktor Siemens research reactor designed for teaching purposes
SZB	Standort-Zwischenlager Brunsbüttel (Brennelemente-Zwischenlager) Brunsbüttel spent fuel storage facility
ToR	Terms of References
TPR	Topical Peer Review
TUM	Technische Universität München Technical University of Munich

UAG	Urananreicherungsanlage Gronau Gronau uranium enrichment facility
VdS	VdS Schadenverhütung GmbH
VEK	Verglasungseinrichtung Karlsruhe Karlsruhe vitrification facility
VENE	Vattenfall Europe Nuclear Energy GmbH
VGBE	Internationaler Fachverband für die Erzeugung und Speicherung von Strom und Wärme e.V. International technical association for the generation and storage of electricity and heat, organised as registered society
WAK	Wiederaufarbeitungsanlage Karlsruhe Karlsruhe reprocessing plant
WENRA	Western European Nuclear Regulator’s Association
WGWD	Working Group on Waste and Decommissioning
WLN	Weiterleitungsnachricht der GRS GRS information notice (non-public)
ZLN	Zwischenlager Nord Storage facility North

Summary

The nuclear regulations, which form the assessment standard for the work of the nuclear supervisory authorities in Germany, supplement the existing conventional fire protection regulations as required.

The German nuclear regulations are regularly updated, also on the basis of international standards and findings. The German licensees exchange information on the subject of fire safety in their own working groups and expert committees.

The nuclear installations operated in Germany are continuously adapted to the state of the art in science and technology in the field of fire safety. Operating experience from the German installations confirms the effectiveness of fire safety in German installations.

The approach practised in the frame of fire safety analyses and fire protection concepts described below ensures that the high safety level of the German nuclear installations is maintained.

Foreword

According to Article 8e of Directive 2014/87/EURATOM amending Directive 2009/71/EURATOM (Nuclear Safety Directive – NSD) /EU 14/ and § 24b AtG /ATG 22/, Germany is obliged to review the safety of nuclear installations every six years on the basis of a predefined technical topic (so-called "Topical Peer Review" – TPR). The first TPR (TPR I) took place in 2017/18 on the topic of "Ageing Management" for nuclear power plants and research reactors. The second TPR (TPR II) is scheduled for the period 2023/24. At its 41st meeting in November 2020, the European Nuclear Safety Regulators Group (ENSREG) agreed on "Fire Protection" as the topic for the TPR II. Following the meeting, it was specified that aspects of "fire prevention" should also be taken into account under this topic.

The material requirements that are checked within the framework of the TPR II are listed in the so-called "Technical Specification" /WEN 22/.

The peer review is carried out in several steps. The relevant results will then be published. The following procedure is planned:

- The EU member states are obliged to carry out a national self-assessment, which is to be reported in so-called "National Assessment Reports (NARs)". Other states may participate in the TPR on a voluntary basis. This report represents the NAR of the German self-assessment for the TPR II.
- The member states and the European Commission (EC) as an observer conduct a peer review of the national self-assessments of the other member states.
- If necessary, follow-up measures will be agreed upon.

At the 42nd ENSREG meeting in March 2021, ENSREG approved the scope of the TPR II proposed by WENRA. In principle, all nuclear installations that fall under the NSD /EU 14/ are to be taken into account in the TPR II, including, in contrast to the TPR I, enrichment facilities, nuclear fuel fabrication facilities, reprocessing plants, storage facilities for spent fuel and on-site radioactive waste storage facilities, in addition to nuclear power plants and research reactors.

1 General information

1.1 Nuclear installations identification

The following is a general description of which nuclear installations fall under the NSD /EU 14/ and are eligible for consideration in the TPR II. Subsequently, the national selection is described in accordance with the Terms of Reference for the TPR II. A complete list of all nuclear installations can be found in Appendix A1.

1.1.1 Qualifying nuclear installations

1.1.1.1 Nuclear power plants

On 15 April 2023, Germany ceased to use nuclear energy for electricity generation. In accordance with § 7(1) AtG, licences for the construction of nuclear power plants will no longer be issued.

In Germany, a total of 33 nuclear power plants including prototype and demonstration plants were in operation. Three nuclear power plants (NPPs) with Konvoi type pressurised water reactors (PWRs) were in power operation at three sites until recently.

As stipulated in the Atomic Energy Act, the authorisation for power operation of the last three nuclear power plants – Neckarwestheim, Unit 2, Isar, Unit 2 and Emsland – expired on 15 April 2023. This implies that all nuclear power plants would formally fall under the installations under decommissioning in the TPR II. Six nuclear power plants still have nuclear fuel in their respective spent fuel pools.

Since fire protection means are not immediately reduced with shutdown, this report also includes the description of the entirety of fire safety means and measures of nuclear power plants in power operation or shortly after final shutdown.

1.1.1.2 Research reactors

Six research reactors with a thermal power between 100 mW and 20 MW are operated in Germany. The licensees are public or state-funded universities or research institutions. Two of these reactors with a thermal power of 100 kW (FR MZ) and 20 MW (FRM II) are operated as neutron sources for research. The other four research reactors are training reactors with a thermal power of 100 mW (SUR, Siemens teaching reactor) or 2 W (AKR-2, training reactor of the Technical University of Dresden) for practical training in the fields of reactor physics and radiation protection at the universities of Furtwangen, Stuttgart, Ulm and the Technical University of Dresden. These four belong to the homogeneous zero-power reactors. In addition, six research reactors are under decommissioning in Germany and free of nuclear fuel. Three other research reactors have been shut down permanently. One of them still contains fuel elements.

According to the Technical Specification of the second TPR (TPR II) /WEN 22/, research reactors as defined in the Safety Reference Levels for Existing Research Reactors of WENRA /WEN 21/ (i.e. research reactors with the exception of critical and subcritical assemblies, homogeneous zero-power reactors and accelerator-driven systems) have to be considered in the topical peer reviews and thus for the NAR.

1.1.1.3 Fuel cycle facilities

Two fuel cycle facilities are in operation in Germany. A uranium enrichment facility is operated in Gronau/Westphalia (UAG) by Urenco. The plant started operation in 1985 and has an unlimited operating licence. In the production process, gaseous uranium hexafluoride is enriched with the help of cascades of gas centrifuges. The authorised maximum enrichment level is 6 wt % uranium 235.

A Framatome fuel fabrication facility (BFL) is located in Lingen and operated by Advanced Nuclear Fuels GmbH (ANF). The plant started producing fuel assemblies for light water reactors in 1979 and has an unlimited operating licence. In 1991, the dry conversion process was introduced to convert enriched uranium hexafluoride into uranium dioxide powders and pellets. The maximum enrichment level of the fuel produced is limited to 5 %.

Karlsruhe is home to the Karlsruhe reprocessing plant (WAK), which was built in the 1960s as a pilot plant for later commercial reprocessing and is currently being decommissioned. A vitrification facility (VEK) was built at the site to solidify the high-level radioactive operational waste from the WAK into vitrified waste suitable for disposal.

1.1.1.4 Spent fuel storage facilities

In Germany, spent fuel is stored in both central and decentralised storage facilities.

The central storage facilities are designed as dry storage facilities for the storage of spent fuel in transport and storage casks. They include the Gorleben spent fuel storage facility (BZG), the Ahaus spent fuel storage facility (BZA) and the storage facility North (ZLN) in Rubenow. In addition, there is the AVR cask storage facility in Jülich.

The BZG has a licence for the storage of nuclear fuel in the form of spent fuel from light water reactors as well as vitrified high-level radioactive waste (vitrified high-level radioactive fission product solutions from the reprocessing of German spent fuel). According to the Atomic Energy Act, no further storage of vitrified high-level radioactive waste is planned.

According to the licence granted, spent fuel from various German nuclear power plants may be stored in the BZA. In addition, the storage of spent fuel from experimental, demonstration and research reactors in various types of casks is also authorised. It is planned to use the BZA for the spent fuel from the research reactors still in operation and those under decommissioning.

According to the 8th modification licence of 21 July 2016, the planned storage of spent from the experimental reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) in 152 transport and storage casks in the BZA has also been approved. These casks are currently located in the AVR cask storage facility in Jülich.

In addition to spent fuel from the Soviet-designed power reactor units in Rheinsberg and Greifswald, spent and fresh fuel from the compact sodium-cooled nuclear reactor plant (KNK II), from the nuclear ship Otto Hahn as well vitrified waste canisters with high-level radioactive waste from the Karlsruhe reprocessing plant (WAK) are currently stored in the ZLN. On 29 May 2019, the licensee submitted an application for a licence to store the 74 CASTOR® casks in a new building due to the tightened safety requirements for the storage of nuclear fuel since 2011.

In addition to the above-mentioned storage facilities, spent fuel is also stored in the AVR cask storage facility in Jülich. Here, the spent fuel spheres from the operation of the experimental reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) are stored in 152 transport and storage casks. Storage currently takes place on the basis of orders issued by the competent supervisory authority of the Land of North Rhine-Westphalia; most recently, an order was issued for the removal of nuclear fuel from the AVR cask storage facility. For this purpose, JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN) is pursuing two options, the transport of the AVR fuel to the Ahaus spent fuel storage facility (BZA) or the construction of a new storage facility at the Jülich site. In parallel to the removal options, JEN is trying to obtain at least a temporary licence (application for nine years) for the existing storage facility.

The decentralised storage facilities for spent fuel were built at the following twelve nuclear power plant sites:

- Biblis site (BZB),
- Brokdorf site (BZF),
- Brunsbüttel site (SZB),
- Grafenrheinfeld site (BZR),
- Grohnde site (BZD),
- Gundremmingen site (BZM),
- Isar site (BZI),
- Krümmel site (BZK),
- Lingen site (BZL),
- Neckarwestheim site (BZN),
- Philippsburg site (BZP),
- Unterweser site (BZU).

They are designed as dry storage facilities with passive air convection cooling in which transport and storage casks (dual-purpose casks) that are mainly loaded with spent fuel or radioactive waste from reprocessing are stored. The protective effect during specified normal operation and for different accident conditions was proven in the licensing procedure for a storage period of at least 40 years. Therefore, the licences for storage are currently limited to 40 years, starting with the emplacement of the first casks.

1.1.1.5 On-site radioactive waste storage facilities

According to the scope of the TPR II (see Section 00.3 of the Technical Specification /WEN 22/), storage facilities for radioactive waste are only to be considered if they are operated at the same site and in direct connection with a nuclear installation from one of the above-mentioned types.

For the storage of radioactive waste with negligible heat generation, independent facilities are available at various nuclear power plant sites and other nuclear installations for the radioactive waste produced on site. These are listed below. Storage areas and facilities operated under the licence of the nuclear power plants at the site and whose fire protection is implemented within the scope of this licence fall under the respective explanations for the corresponding nuclear power plants. This also applies to other nuclear installations with facilities or areas for buffer storage and interim storage.

Central storage facilities within the scope of the TPR II include:

- the Gorleben radioactive waste storage facility (AZG),
- the Ahaus radioactive waste storage facility (AZA),
- the Unterweser 1 and 2 radioactive waste storage facilities (AZU 1 and AZU 2)
- the storage facility North in Rubenow (ZLN), and
- the waste management facilities, Karlsruhe.

At the sites of nuclear power plants, there are the following radioactive waste storage facilities that are operated in connection with a nuclear installation but with an independent licence and fall within in the scope of the TPR II:

- Biblis 1 and 2 radioactive waste storage facilities (AZB 1 and AZB 2),
- Grafenrheinfeld radioactive waste storage facility (AZR),
- Neckarwestheim radioactive waste storage facility (AZN),
- Obrigheim radioactive waste storage facility (AZO),
- Philippsburg radioactive waste storage facility (AZP),
- Stade radioactive waste storage facility (AZS), and
- Würgassen radioactive waste storage facility (AZW).

In addition, individual storage areas of spent fuel storage facilities are also licensed for the storage of radioactive waste, as is the case at the Biblis storage facility and the Ahaus storage facility. These installations are already included in the list of installations in paragraph 1.1.1.4 and are also dealt with below as part of these.

For the reception and storage of radioactive waste from research, industry and medicine, the German Länder operate the Land collecting facilities. These do not per se fall within the scope of the NSD /EU 14/ and thus of the TPR II, as explained above. The following four Land collecting facilities are operated at the same site as other nuclear installations covered by the TPR II:

- the Land collecting facility of Baden-Württemberg in Karlsruhe,
- the Land collecting facility of Berlin,
- the Land collecting facility of Mecklenburg-Western Pomerania (and Brandenburg) in Rubenow, and
- the Land collecting facility of North Rhine-Westphalia (and Lower Saxony) in Jülich.

1.1.1.6 Installations under decommissioning

A reprocessing plant was built in Karlsruhe (WAK) under the management of the local research centre and started operation in 1971. The plant was designed as a pilot project to gain information and knowledge on the planning, construction and operation of an industrial reprocessing plant. The plant is a nuclear installation in the sense of § 7 AtG /ATG 22/ and has been under decommissioning and dismantling since 1990. In the process building of the WAK, all process engineering components have been removed and thus most of the activity. In the other WAK facilities, the systems have been emptied and some of them have been dismantled or are being dismantled. Only measures for decontamination and the removal of pipe penetrations and a few remaining facilities are still ongoing. This means that the majority of fire loads has been removed.

The operation of the plant has generated 60 m^3 of high-level radioactive fission product solution. This high-level radioactive waste was vitrified in the Karlsruhe vitrification facility (VEK) between September 2009 and June 2010. The VEK was set up between 1999 and 2005 for this purpose only. As a result of the activities, 140 canisters with vitrified high-level radioactive waste were produced, which were packed in five CASTOR® HAW 20/28 CG and transported to the ZLN. Since the end of operation, the VEK is also being dismantled. Intermediate- and low-level radioactive materials are still handled in the VEK.

Other installations that have been permanently shut down or are under decommissioning and dismantling are dealt with in the following paragraphs that address the respective installation types.

1.1.2 National selection of installations for the TPR II and justification

Already during the preparation of the TPR II, each participating member state selected the installations that should be subject to review in the TPR II. The participating countries identified so-called "qualified installations", i.e. installations within the scope of the TPR II (see /WEN 22/). Due to the large number of "qualified installations", a "national selection" was made by the member states in accordance with the following recommendations in /WEN 22/:

- The national selection of "candidate installations" should include at least one installation of each category addressed in the NSD /EU 14/, provided that it is present in the participating country and may pose a significant radiological risk in case of fire. Those "candidate installations" representative of the other "qualified installations" that are not considered in detail in the self-assessment, are referred to as "represented installations".
- The sample shall be representative of the various types of installations and technologies.
- When selecting the installations to be considered, attention should be paid to similarities with regard to the fire protection concept implemented.

The initial selection was then refined through an iterative exchange in the WENRA TPR working group. The iterations took into account the following criteria:

- Ensuring that the various types of installations and technologies (within each installation type) are represented.
- Ensuring that, in grouping installations within each type, due account was taken of the potential fire safety hazard and risks (including the inventory and state/mobility of the radioactive

substances) and the variability in the type of fire safety approaches implemented (i.e. selected installations will be representative of implemented similar approaches).

- Ensuring that the final list of "candidate installations" presented to the TPR board results in all "represented installations" (i.e. installations not reported in the NARs) receiving transferable insights from those reported.
- Ensuring that all participating countries are involved proportionately to their nuclear estate in scope of the TPR II.

There are three ways to select the "candidate installations":

- by grouping installations with similar characteristics,
- through the coordinated sampling approach described in Annex 4 of /WEN 22/,
- through a combination of both.

The list of proposed "candidate installations" was reviewed and commented by the TPR board and submitted to ENSREG. The selection of installations for the entire TPR II is a combination of the national selections proposed by the supervisory authorities in order to allow for a meaningful peer review.

1.1.2.1 Nuclear power plants

First of all, the fire protection of the last three Konvoi type nuclear power plants in operation in Germany is described in terms of "candidate installations".

Based on this, the fire protection modifications during decommissioning and dismantling are described. In this way, the graded approach is suitably presented, and the fire protection of all German nuclear power plants is thus represented for both power operation and under decommissioning in the sense of the TPR II.

As soon as fuel elements are no more present, the radiological risk from fire is no longer significant so that these installations do not have to be further considered in this national report in line with the requirements of the Technical Specification /WEN 22/. Nevertheless, further details are given in various sections of this report.

1.1.2.2 Research reactors

In the selection procedure in /WEN 22/, all research reactors to be considered according to the criteria of the Technical Specification (see Table 1-2) were selected as so-called "candidate installations". As explained in paragraph 1.1.1.2, these are:

- the FRM II pool research reactor with a thermal power of 20 MW_{th} as a "candidate research reactor" with higher risk potential,
- the TRIGA Mark II type research reactor FR MZ with a thermal power of 0.1 MW_{th} as a "candidate research reactor" with low risk potential.

Since the fire protection provisions are not immediately reduced with the permanent shutdown, these installations also include the permanently shut down research reactor with fuel elements still being present. With the removal of the fuel elements, the radiological risk due to fire decreases to a no longer significant level, so that these research reactors do not need to be considered further in this national report in accordance with the requirements of the Technical Specification /WEN 22/. Statements on possible reductions of the requirements made for nuclear power plants after fuel removal in this report apply analogously.

1.1.2.3 Fuel cycle facilities

In Germany, there is one facility per installation type of the fuel cycle (uranium enrichment facility, fuel fabrication facility and reprocessing plant) to be dealt with in the TPR II, namely the UAG, the BFL and the WAK, which are all considered in the TPR II for this reason. In the further course of the NAR, the WAK is treated together with the VEK as a plant under decommissioning due to the decommissioning and dismantling that has been taken place since 1990 (see paragraph 1.1.2.6).

1.1.2.4 Spent fuel storage facilities

As described in paragraph 1.1.1.4, in the Federal Republic of Germany, spent fuel is stored both in central storage facilities and in decentralised on-site storage facilities. The aim of the selection for the TPR II was to make a selection that is representative of this concept. Therefore, a central and a decentralised spent fuel storage facility were selected for consideration in the TPR II:

The ZLN was selected as the central fuel storage facility. It is the largest of the central spent fuel storage facilities in Germany in terms of the net mass of spent fuel stored there and is therefore representative of the other central storage facilities.

The decentralised storage facilities located at the power reactor sites follow the concept of dry cask storage. Amongst each other, they show a negligible variance with respect to aspects relevant in terms of fire protection, so that the consideration of a single facility is considered as covering all of these. In the frame of the TPR II, the Biblis spent fuel storage facility (BZB) is considered as a representative example.

Detailed information on the two facilities can be found in paragraph 1.1.3.4.

1.1.2.5 On-site radioactive waste storage facilities

Since facilities for the storage of radioactive waste in Germany show only a low variability among each other and, in addition, only a low risk potential in the event of fire, the radioactive waste storage facility at the ZLN and the radioactive waste storage facilities at the Biblis site (AZB 1 and AZB 2) for the decentralised storage of radioactive waste are considered as examples of the facilities considered in the TPR II (see paragraph 1.1.1.5). Further information on the facilities can be found in paragraph 1.1.3.5.

In addition, it should be noted that the storage of radioactive waste licensed and carried out at other nuclear installations is also covered by the relevant considerations: this particularly applies to the UAG in Gronau, the BFL of the ANF in Lingen and to the nuclear power plants and research reactors.

The selection made thus comprehensively covers the storage of radioactive waste in Germany as far as it is in the scope of the NSD.

1.1.2.6 Installations under decommissioning

According to the Technical Specification for the TPR II /WEN 22/, installations under decommissioning with a considerable radiological risk due to fire are to be considered in particular. In Germany, these are particularly those installations that are not yet free of fuel elements. These are already covered by the selection made in paragraphs 1.1.2.1 and 1.1.2.2.

Furthermore, according to the Technical Specification of TPR II /WEN 22/, the WAK, including the VEK, is a plant in which dismantling activities have not yet been completed and in which the occurrence of a fire could lead to radiological risks or consequences for workers, the public or the environment.

1.1.3 Key parameters per installation

1.1.3.1 Nuclear power plants

Until 15 April 2023, there were still three nuclear power plant units in commercial power operation in Germany and four other nuclear power plant units not yet free of fuel elements. Table 1-1 shows the most important parameters according to the TPR II Technical Specification /WEN 22/. The locations of the nuclear power plants considered in the NAR are shown in Figure 1-1.

Table 1-1 Nuclear power plants considered in the NAR

Nuclear power plant Site Other installations at the site		**a) Licensee** **b) Manufacturer** **c) Owner (shareholder)**	**Type** **If applicable, capacity (gross) [MW$_{el}$]**	**Construction line**	**a) Date of first partial licence** **b) First criticality** **c) Shutdown date**
1	**Neckarwestheim 2 (GKN II)** Neckarwestheim, Baden-Württemberg	a) EnBW Nuclear Power (EnKK) b) KWU c) EnBW (62.41 %), TWS Kernkraft GmbH (37.59 %)	PWR 1400	4 Konvoi	a) 09.11.1982 b) 29.12.1988 c) 15.04.2023
	Further NPP unit (GKN I)	a) EnKK b) KWU c) EnBW (48.4 %), TWS Kernkraft GmbH (51.6 %)	PWR 840	2	a) 24.01.1972 b) 26.05.1976 c) 06.08.2011
	Residual waste treatment centre (RBZ)	Gesellschaft für nukleares Reststoffrecycling mbH (GNR)			
	Spent fuel storage facility (BZN)	BGZ Gesellschaft für Zwischenlagerung GmbH	Dry storage facility for spent fuel		
	Radioactive waste storage facility (AZN)	BGZ Gesellschaft für Zwischenlagerung GmbH	Storage facility for radioactive waste		2022 ---

Nuclear power plant Site Other installations at the site		a) Licensee b) Manufacturer c) Owner (shareholder)	Type If applicable, capacity (gross) [MW_{el}]	Construction line	a) Date of first partial licence b) First criticality c) Shutdown date
2	**Isar 2 (KKI 2)** Essenbach, Bavaria	a) PreussenElektra GmbH b) KWU c) PreussenElektra GmbH 75 %, Stadtwerke München GmbH 25 %	PWR 1485	4 Konvoi	a) 12.07.1982 b) 15.01.1988 c) 15.04.2023
	Further NPP unit (KKI 1)	a) PreussenElektra GmbH b) KWU c) PreussenElektra GmbH	BWR 912	69	a) 16.05.1972 b) 20.11.1977 c) 06.08.2011
	Spent fuel storage facility (BZI)	BGZ Gesellschaft für Zwischenlagerung GmbH	Dry storage facility for spent fuel		2007 2047
3	**Emsland (KKE)** Lingen, Lower Saxony	a) Lippe-Ems nuclear power plants b) KWU c) RWE Nuclear GmbH	PWR 1400	4 Konvoi	a) 04.08.1982 b) 14.04.1988 c) 15.04.2023
	Spent fuel storage facility (BZL)	BGZ Gesellschaft für Zwischenlagerung GmbH	Dry storage facility for spent fuel		2002 2042
4	**Gundremmingen C (KRB C)** Gundremmingen, Bavaria	a) RWE Nuclear GmbH b) KWU c) RWE Nuclear GmbH	BWR 1344	72	a) 16.07.1976 b) 26.10.1984 c) 31.12.2021
	Further NPP unit KRB A	a) RWE Nuclear GmbH b) AEG/General Electric c) RWE Nuclear GmbH	BWR 250		a) b) 14.08.1966 c) 13.01.1977
	Further NPP unit KRB B	a) RWE Nuclear GmbH b) KWU c) RWE Nuclear GmbH	BWR 1344	72	a) 16.07.1976 b) 09.03.1984 c) 31.12.2017
	Spent fuel storage facility (BZM)	BGZ Gesellschaft für Zwischenlagerung GmbH	Dry storage facility for spent fuel		2006 2046
5	**Philippsburg 2[1] (KKP 2)** Philippsburg, Baden-Württemberg	a) EnBW Nuclear Power (EnKK) b) KWU c) EnBW	PWR 1468	3	a) 06.07.1977 b) 13.12.1984 c) 31.12.2019
	Further NPP unit (KKP 1)	a) EnBW Nuclear Power (EnKK) b) KWU c) EnBW	BWR 926	69	a) 06.07.1977 b) 09.03.1979 c) 06.08.2011
	Spent fuel storage facility (BZP)	BGZ Gesellschaft für Zwischenlagerung GmbH	Dry storage facility for spent fuel		2007 2047

[1] Since spring 2023, KKP 2 has been free of fuel elements.

Nuclear power plant Site Other installations at the site		**a) Licensee** **b) Manufacturer** **c) Owner (shareholder)**	**Type** **If applicable, capacity (gross) [MW$_{el}$]**	**Construction line**	**a) Date of first partial licence** **b) First criticality** **c) Shutdown date**
	Radioactive waste storage facility (AZP)	BGZ Gesellschaft für Zwischenlagerung GmbH	Storage facility for radioactive waste		2020 ---
	Residual waste treatment centre (RBZ)	Gesellschaft für nukleares Reststoffrecycling mbH (GNR)			
6	**Grohnde (KWG)** Grohnde, Lower Saxony	a) PreussenElektra GmbH b) KWU c) PreussenElektra GmbH 83.3 %, Stadtwerke Bielefeld 16.7 %	PWR 1430	3	a) 08.06.1976 b) 01.09.1984 c) 31.12.2021
	Spent fuel storage facility (BZD)	BGZ Gesellschaft für Zwischenlagerung GmbH	Dry storage facility for spent fuel		2006 2046
7	**Brokdorf (KBR)** Brokdorf, Schleswig-Holstein	a) PreussenElektra GmbH b) KWU c) PreussenElektra 80%, Vattenfall Europe Nuclear Energy GmbH 20%.	PWR 1480	3	a) 25.10.1976 b) 08.10.1986 c) 31.12.2021
	Spent fuel storage facility (BZF)	BGZ Gesellschaft für Zwischenlagerung GmbH	Dry storage facility for spent fuel		2007 2047

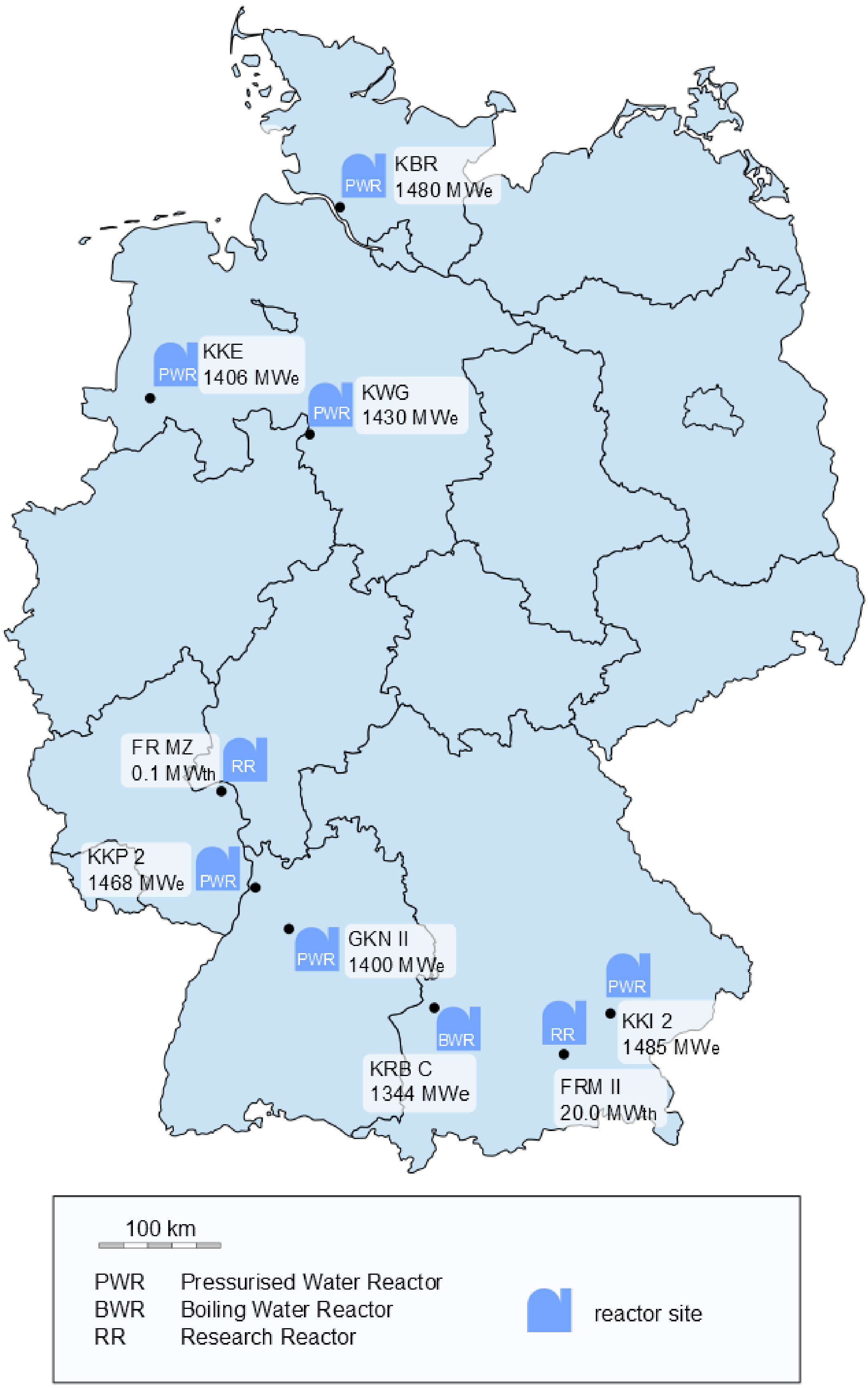

Figure 1-1 Nuclear power plants and research reactors considered in the NAR

1.1.3.2 Research reactors

In the following Table 1-2, the essential parameters, as specified in the Technical Specification of TPR II /WEN 22/, are given for the relevant installations mentioned in paragraph 1.1.2.2. The location of the research reactor sites considered in the NAR is shown in Figure 1-1.

Table 1-2 Research reactors considered in the NAR

Research reactor Site Other installations at the site		**Licensee**	**Reactor type** **Thermal power [MW_{th}]** **Thermal neutron flux** **$[cm\ s^{-2}]^{-1}$**	**First criticality**
1	**FRM II** Garching, Bavaria	Free State of Bavaria, State Ministry of Education and Culture, Science and the Arts, Technical University of Munich	Swimming pool (tank in pool)/ compact core 20 $8 \cdot 10^{14}$	02.03.2004
	FRM	Free State of Bavaria, State Ministry of Education and Culture, Science and the Arts, Technical University of Munich	Swimming pool (MTR) 4 $4 \cdot 10^{13}$	31.10.1957 Decommis-sioning licence 03.04.2014
2	**FR MZ** Mainz, Rhineland-Palatinate	University of Mainz, Institute for Nuclear Chemistry	Swimming pool/ TRIGA Mark II 0.1 $4 \cdot 10^{12}$	03.08.1965

FR MZ

The FR MZ is located on the campus of the Johannes Gutenberg University Mainz. Adjacent to the reactor building are the nuclear chemistry laboratory buildings in the Department of Chemistry.

FRM II

The FRM II is located on the campus of the Technical University in Garching near Munich (TUM). Neighbouring institutes about 100 m away are the Institute for Radiochemistry and the Physics Department. The faculties of Mechanical Engineering and Chemistry are located at a much greater distance.

With regard to the storage facility for spent fuel elements at FRM II, the following applies:

- The storage of spent fuel elements takes place entirely under water.
- The pool is protected against water loss by several barriers. Replenishment is possible via various paths.

Other solid radioactive waste is stored in rooms fully monitored by automatic fire detection. Liquid low- and intermediate-level waste water is stored in steel tanks in the liquid radioactive waste storage facility. Here, too, fire detection is ensured by fire detectors. The so-called staging area for radioactive waste is additionally equipped with a spraywater deluge fire extinguishing system.

1.1.3.3 Fuel cycle facilities

As already described, there are three fuel cycle facilities in Germany, two of which, the fuel fabrication facility in Lingen (BFL) and the uranium enrichment facility in Gronau (UAG), are in operation and are listed here, whereas the reprocessing plant in Karlsruhe (WAK) is being dismantled (see paragraph 1.1.3.6). The key parameters of the facilities in operation according to the specifications of TPR II /WEN 22/ are given in Table 1-3. The locations of the fuel cycle facilities considered in the NAR are shown in Figure 1-2.

Table 1-3 Fuel cycle facilities considered in the NAR

Fuel cycle facilities Site Other installations at the site		**Licensee**	**Installation type**	**a) Start of operation** **b) End of licence**
1	**BFL fuel fabrication facility** Lingen, Lower Saxony UF_6 – storage hall waste storage facility	Advanced Nuclear Fuels (ANF) GmbH	Fuel fabrication facility	a) 1979 b) ------
2	**UAG uranium enrichment facility Gronau** Gronau, North Rhine-Westphalia	Urenco Deutschland GmbH	Enrichment facility	a) 1985 b) ------

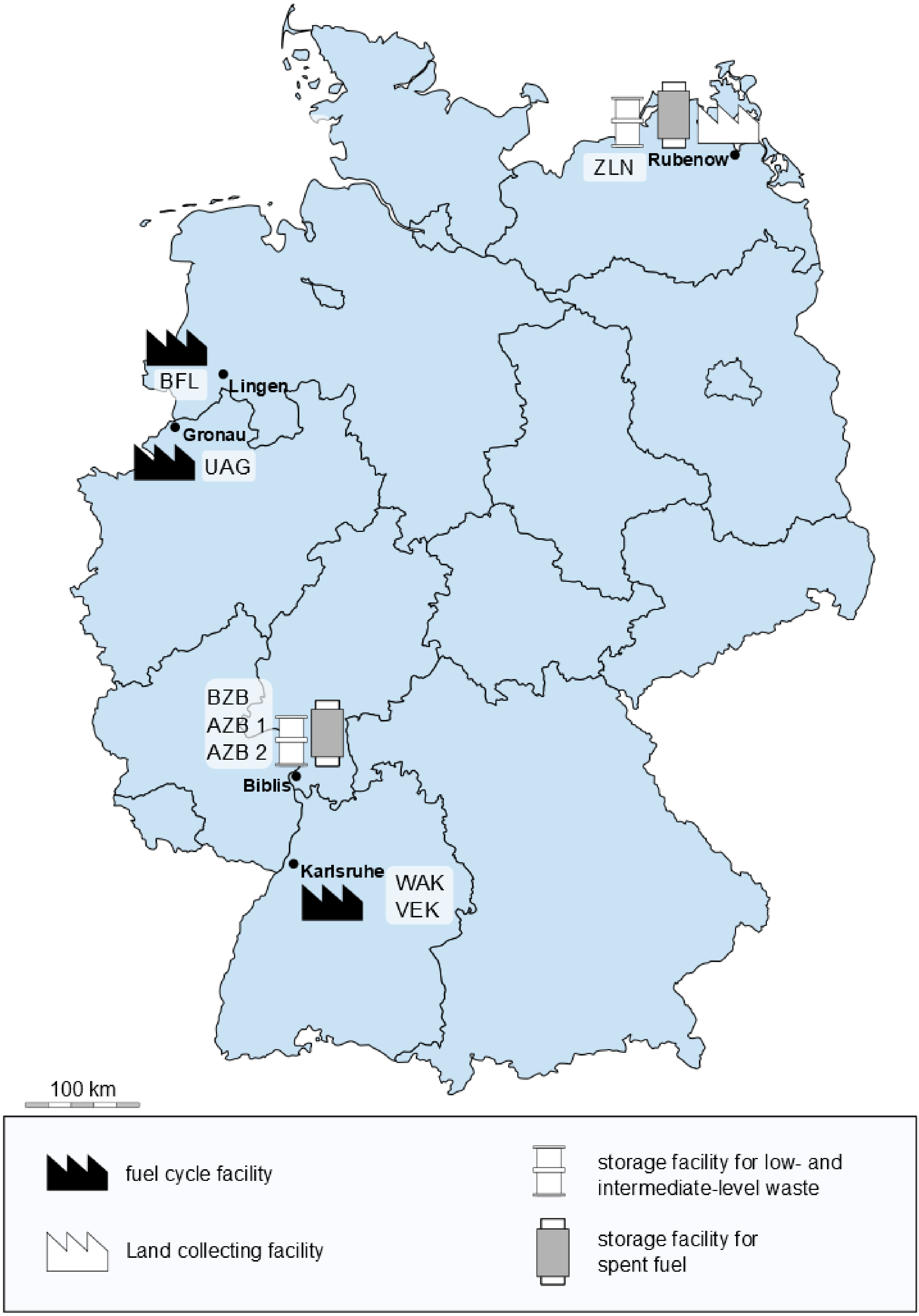

Figure 1-2 Nuclear fuel cycle and storage facilities considered in the NAR

1.1.3.4 Spent fuel storage facilities

As described in paragraph 1.1.2.4, the transport cask storage facility at the ZLN was selected as an example of a central storage facility, and the storage facility for fuel elements at the Biblis site in Hesse as an example of a decentralised spent fuel storage facility.

The ZLN is located at the site of the Greifswald nuclear power plant (Lubmin) in Rubenow (Mecklenburg-Western Pomerania), which is currently being dismantled. It is operated by EWN Entsorgungswerk für Nuklearanlagen GmbH (EWN). The transport cask storage facility was commissioned in 1999 and has a licensed operating period until 2039. 583 Mg of heavy metal are stored in dry casks in the transport cask storage facility of the complex (Hall 8). These originate primarily from the Soviet-designed power reactors in Rheinsberg and Greifswald, from KNK II, the nuclear ship Otto Hahn and from the WAK. 74 of the 80 cask locations are currently occupied by CASTOR® casks of five different designs (as of 2023). These are divided into 61 CASTOR® 440/84, five CASTOR® HAW 20/28 CG, four CASTOR® KNK, three CASTOR® KRB-MOX and one CASTOR® 440/84 mvK.

Other radioactive waste is temporarily stored in halls 1 to 7 of the ZLN (see paragraph 1.1.2.5). In addition, the licensee of the ZLN also operates the Land collecting facility for Mecklenburg-Western Pomerania on the site, which is shared by the Land of Brandenburg.

The Biblis spent fuel storage facility (BZB) is located within the plant security fence of the Biblis nuclear power plant site. It is operated by BGZ Gesellschaft für Zwischenlagerung mbH. The high-level radioactive waste from the operation of units A and B of the Biblis nuclear power plant is stored there according to the dry cask storage principle. In addition, the BZB is intended to receive reprocessing waste from abroad. It is divided into a loading area with a cask maintenance station, two storage areas and an access and technical area. The storage building has a total capacity of 135 storage positions. It has been licensed to hold an inventory of a maximum of 1,400 t of smelter metal and a maximum of 5.3 MW. Currently (as of March 2023), 102 CASTOR V/19 | 6 CASTOR HAW28M are stored there. In addition, the storage facility has a licence for the storage of other radioactive waste; within this frame, 138 casks of the MOSAIK® type are currently stored in Hall 2 (as of March 2023). The BZB was commissioned in 2006 and has a 40-years operating licence until 2046. The two radioactive waste storage facilities (AZB 1 and AZB 2) are also located at the site, see paragraph 1.1.3.5.

The locations of the spent fuel storage facilities considered in the NAR are shown in Figure 1-2.

Table 1-4 Spent fuel storage facilities considered in the NAR

	Spent fuel storage facilities Site Other installations at the site	Licensee	Installation type	a) Start of operation b) End of licence
1	**Transport cask storage facility at the ZLN** Rubenow, Mecklenburg-Western Pomerania, Greifswald NPP ZLN radioactive waste storage facility Mecklenburg-Western Pomerania Land collecting facility	EWN Nuclear Waste Management Plant GmbH	Dry storage facility for spent fuel	a) 1999 b) 2039
2	**Storage facility for high-level radioactive waste Biblis (BZB)** **Biblis** Hesse Biblis NPP (KWB) Radioactive waste storage facilities AZB 1 and AZB 2	BGZ Gesellschaft für Zwischenlagerung GmbH	Storage facility for radioactive waste	a) 2006 b) 2046

1.1.3.5 Radioactive waste storage facility

As described in paragraph 1.1.2.5, the waste storage facility at the ZLN (together with the Land collecting facility of Mecklenburg-Western Pomerania (and Brandenburg) as well as the radioactive waste storage facilities AZB 1 and AZB 2 at the Biblis nuclear site were selected as examples for consideration in the NAR.

ZLN waste storage facility at the Rubenow site near Greifswald: In addition to the spent fuel storage facility already described in paragraph 1.1.2.4, a radioactive waste storage facility with a licensed storage capacity of 165,000 m^3 is also operated at the ZLN. It is used for the storage of operational and decommissioning waste and residual materials from the decommissioning of the Greifswald and Rheinsberg NPPs and other nuclear installations, with the aim of conditioning of this waste. In addition, the Land collecting facility for Mecklenburg-Western Pomerania (and Brandenburg) is operated in the ZLN. According to the licence, the Land collecting facility has the capacity of a 20' container and is intended for waste from medicine, research and industry.

At both facilities operated at the Biblis site, the low- and intermediate-level radioactive waste from the operation and dismantling of the Biblis nuclear power plant is stored until it is transferred to a repository. The storage facilities are operated by BGZ. AZB 1 was commissioned in 1982, AZB 2 in 2018. The total activity that may be stored according to the licences is 3.071 E+15 Bq and 2 E+17 Bq respectively.

Table 1-5 Radioactive waste storage facilities considered in the NAR

	Radioactive waste storage facilities Site Other installations at the site	**Licensee**	**Installation type**	**a) Start of operation** **b) End of licence**
	Central storage facilities for radioactive waste			
1	**Radioactive waste storage facility of the ZLN** Rubenow, Mecklenburg-Western Pomerania, Greifswald NPP, Transport cask storage in the ZLN	EWN Nuclear Waste Management Plant GmbH	Storage facility for radioactive waste	a) 1998 b) ------
2	**Mecklenburg-Western Pomerania Land collecting facility at the ZLN** Rubenow, Mecklenburg-Western Pomerania Greifswald NPP, Transport cask storage in the ZLN	EWN Nuclear Waste Management Plant GmbH	Land collecting facility	a) 1998 b) ------
	Decentralised storage facilities for radioactive waste			
1	**Biblis radioactive waste storage facility 1 (AZB 1)** Biblis, Hesse Biblis NPP (KWB) Biblis storage facility for high-level radioactive waste (BZB)	BGZ Gesellschaft für Zwischenlagerung GmbH	Storage facility for radioactive waste	a) 1982 b) ------
2	**Biblis radioactive waste storage facility 2 (AZB 2)** Biblis site, Hesse Biblis NPP (KWB) Biblis storage facility for high-level radioactive waste (BZB)	BGZ Gesellschaft für Zwischenlagerung GmbH	Storage facility for radioactive waste	a) 1982 b) ------

The locations of the storage facilities for radioactive waste considered in the NAR are shown in Figure 1-2.

1.1.3.6 Installations under decommissioning

For Germany, as described in paragraph 1.1.1.6, the WAK is a fuel cycle facility (reprocessing plant) under dismantling. It is considered as an installation under decommissioning. The Karlsruhe vitrification facility (VEK), which serves to vitrify the fission product solutions remaining in the WAK, is also located at this site. In addition to the explanations in paragraph 1.1.1.6, the key parameters of both facilities according to the specifications of TPR II /WEN 22/ can be found in Table 1-6.

Table 1-6 Installations under decommissioning considered in the NAR

Installation under decommissioning Site Other installations at the site	**Licensee**	**Installation type**	**a) Start of operation** **b) End of licence**
Karlsruhe reprocessing plant (WAK) Karlsruhe, Baden-Württemberg	Kerntechnische Entsorgung Karlsruhe (KTE) GmbH	Reprocessing plant	a) 1971 b) 1990
Karlsruhe vitrification facility (VEK)	Kerntechnische Entsorgung Karlsruhe (KTE) GmbH	Vitrification facility	a) 2009 b) still in operation

The location of WAK and VEK are shown in Figure 1-2.

1.1.4 Approach to development of the NAR for the national selection

The process for preparing the NAR based on the Technical Specification for the TPR II /WEN 22/ and the ENSREG Terms of References (ToR) was started at the end of June 2022 by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the nuclear supervisory authorities of the Länder.

The process comprised the preparation of the reports on the individual sections, the self-assessment by the licensees, the review by the competent nuclear supervisory authorities (regulators) of the Länder and the preparation of the overall report by the BMUV.

For the NAR, the nuclear supervisory authorities of the Länder and the operators of the nuclear installations (licensees) within the scope of the TPR II prepared the corresponding parts of the NAR. The report sections of the nuclear power plant licensees were prepared under the auspices of the VGBE (Association for the Generation and Storage of Electricity and Heat).

The nuclear supervisory authorities were involved in the preparation of the NAR from the beginning. This ensured that they were able to contribute at an early stage both to a better understanding of the preparation of parts of the NAR prepared by the licensees and to the contents of the report itself.

From April 2023 to June 2023, the reports of the licensees were reviewed by the nuclear supervisory authorities of the Länder and supplemented as required. From July 2023 onwards, the BMUV compiled the contents of the Länder reports in an overall report. From July 2023 to October 2023, the NAR was coordinated and translated by all stakeholders. It was published on the BMUV website in October 2023.

The report is publicly available on the BMUV website www.bmuv.de in German and English.

The aim of the German report is to present the fire protection of the installations to be considered in the TPR II according to the Technical Specification /WEN 22/ with a focus on the radiological risk, in a way to ensure comparability in the sense of a peer review. This includes experiences from available fire safety analyses as well as from the fire protection concepts and their implementation.

Furthermore, similarities of the different types of nuclear installations as well as differences in the fire safety analyses and their results as well as in the fire protection concepts and their implementation – due to different regulations and designs – are highlighted.

Nuclear power plants under decommissioning are dealt with in the corresponding paragraphs on nuclear power plants.

1.2 National regulatory framework

Germany is a republic with a federal structure and is composed of 16 federal states (in German called Länder).

In addition to its responsibility for the nuclear safety of nuclear installations and radiation protection, the BMUV is also responsible for the organisation, staffing and resources of the federal nuclear licensing and supervisory authority (regulatory body).

In the Länder, the supreme Land authorities have been designated as the competent nuclear licensing and supervisory authorities. Within the framework of supervision, the respective nuclear authority of the Land monitors compliance with the nuclear regulations.

The distribution of responsibilities between the Federation and the Länder provides for the licensing and supervisory authorities of the Länder to take administrative action on their own responsibility. The Länder thus have the competence for the subject matter and remain responsible for the administrative action with external effect.

In practice, the Länder carry out the tasks assigned to them on their own responsibility. However, the Federation exercises supervision of legality and expediency within the framework of federal executive administration. To implement its conceptions, the Federation can issue binding instructions to the Länder regarding the subject matter or legal issues and with respect to the management of procedures. Before doing so, however, a consensual agreement is sought.

Communication with the licensee, which includes any legally binding action, is performed by the Länder (competence to execute duties).

The essential processes of nuclear supervision of the Federation and the Länder as well as their interfaces are described in the "Handbook on Cooperation between the Federation and the *Länder* in Nuclear Law" (Supervision Manual).

1.2.1 National regulatory requirements and standards

In Germany, the requirements for structures, systems and components (SSC) important to safety are laid down in the Atomic Energy Act /ATG 22/, the "Safety Requirements for Nuclear Power Plants" (SiAnf) /BMU 15/, and the nuclear safety standards of the Nuclear Safety Standards Commission (KTA) on fire protection in nuclear power plants /KTA 15/, /KTA 15a/, /KTA 15b/.

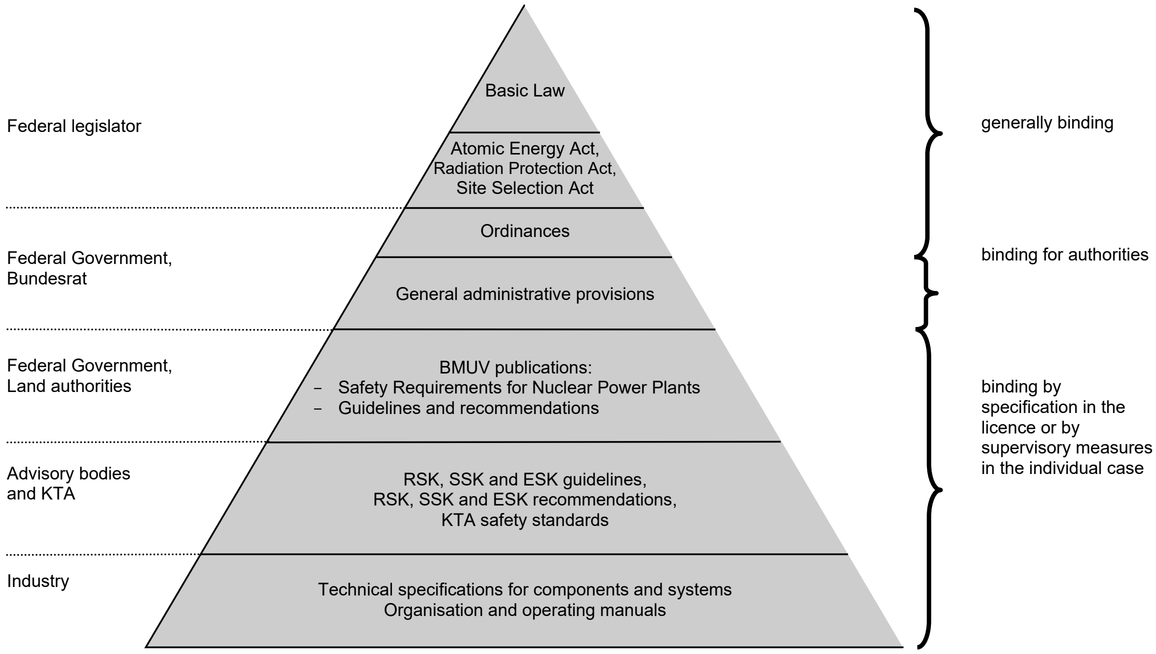

Figure 1-3 National regulatory pyramid

The framework for the national German nuclear legislation and the development of national German nuclear standards and guidelines is the regulatory pyramid shown in Figure 1-3. The upper hierarchical levels of the regulatory pyramid contain generally binding laws and ordinances. In Germany, these are the Basic Law (GG) /BMJ 22a/, the Atomic Energy Act (AtG) /ATG 22/, the Radiation Protection Act (StrlSchG) /BMJ 22/ and the ordinances issued on the basis of the Atomic Energy Act.

The Basic Law lays down fundamental principles that also apply to nuclear law. The fundamental rights laid down in the Basic Law, in particular the fundamental right to life and physical integrity, form the basis for the standard to be applied to protective and precautionary measures for nuclear installations, which is further specified in the hierarchical levels of the regulatory pyramid (see Figure 1-3). In addition, the Basic Law contains regulations on the responsibilities of the Federation and the Länder for law making and law enforcement.

The Atomic Energy Act and the Radiation Protection Act contain the basic national regulations on protective and precautionary measures, radiation protection and the disposal of radioactive waste and spent fuel in Germany and form the basis for the associated ordinances.

Statutory ordinances may contain additional authorisations for the promulgation of general administrative provisions. General administrative provisions govern the actions of the authorities and thus only have a direct binding effect for the supervisory authorities. They have, however, a direct external effect if they are used as a basis for decisions by the authorities.

After consultation with the Länder, the Federation publishes announcements (in the form of requirements, guidelines, criteria and recommendations). As a rule, these are regulations made in agreement with the competent licensing and supervisory authorities of the Länder for the uniform application of the Atomic Energy Act. The BMUV announcements describe the views of the federal supervisor on general issues related to nuclear safety and supervisory practice and provide the Land authorities with orientation for the enforcement of the Atomic Energy Act. They are referred to by the competent Land authorities within the framework of licensing procedures or their supervisory activities under their own responsibility. This ensures that enforcement in the various Länder is carried out in accordance with comparable standards. These standards become binding for licensees when they are taken into account in nuclear licences or orders issued by the nuclear supervisory authority.

The requirements for fire protection can be found in the nuclear regulations in the documents listed below:

- "Safety Requirements for Nuclear Power Plants" /BMU 15/,
- further announcements and guidelines of the BMUV,
- guidelines and recommendations of the Reactor Safety Commission (RSK), the Nuclear Waste Management Commission (ESK) and the Commission on Radiological Protection (SSK),
- nuclear safety standards of the KTA,
- technical specifications for active and passive fire protection means, and
- organisation and operating manuals.

The various fire protection features and active measures to control fire hazards are an essential part of the requirements laid down in the German nuclear regulations.

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.

The German nuclear regulations, in particular safety standard KTA 2101.1 /KTA 15/, require a fire protection concept and a fire hazard analysis for nuclear power plants, which must be updated regularly. In addition, a probabilistic fire risk assessment (Fire PSA) must be conducted regularly for commercially operated nuclear power plants as part of the periodic safety review (PSR).

For research reactors, the above statements apply with the limitation that a "graded approach" is applied relative to the risk potential. This means that, for example, a Fire PSA does not have to be conducted within the scope of the PSR.

Fire protection for storage facilities for spent fuel or radioactive waste is essentially based on the conventional (non-nuclear) building law, which exists in Germany at the level of Land law. Further provisions result, e.g. from the recommendations of the ESK, in particular the Guidelines for dry cask storage of spent fuel and heat-generating radioactive waste (version of 10.06.2013) /ESK 13/ and the Guidelines for the storage of radioactive waste with negligible heat generation (version of 09.12.2021) /ESK 21/, as well as from the analogous application of the above-mentioned KTA safety standards to the storage facilities in the frame of licensing and supervision.

A fire protection concept is a protection-goal oriented overall assessment of structural, equipment-related, operational and defensive fire protection means and their combined effects. The fire protection concept for German nuclear installations follows the principles of the defence-in-depth concept with regard to fire safety. The first level of fire protection consists of preventing the occurrence of incipient fires. Fire prevention comprises two main aspects: limiting the amount of combustible materials and their ignition potential as well as avoiding potential ignition sources, both as far as reasonably practical.

The second level of safety is the prevention of fire spreading from the fire source to potential targets in order to prevent inadmissible damage to items important to safety. This is done primarily through passive fire protection means, such as qualified structural fire barriers or, if this is not practicable, by separation through distance and additional compensatory protection measures.

Passive fire protection is not the only means for preventing damage to a nuclear installation. For this reason, the German nuclear safety standards /KTA 15/, /KTA 15b/ require suitable and reliable active fire protection measures, which include fire detection features for a timely localisation of an incipient fire as well as a large number of fire extinguishing features, including stationary and mobile fire extinguishing systems and equipment, but also measures of the operational and administrative fire protection, e.g. firefighting by a dedicated professional on-site fire brigade.

In order to maintain the high level of protection against plant internal fires, the following preventive measures, amongst others, are considered important:

- regular fire safety walk-throughs, including the identification of temporary fire loads and potential ignition sources,
- comprehensive periodic in-service inspections of fire protection systems and equipment, and
- preventive maintenance, such as an early replacement of fire detectors.

These measures to support fire protection are continuously enhanced, extended and improved based on observations and findings from operating experience (including monitoring, testing, inspection and maintenance) and new insights from experimental and analytical research in accordance with the state of the art in science and technology as well as the evaluation of internal and external operating experience.

The "Safety Requirements for Nuclear Power Plants" /BMU 15/ contain requirements with respect to internal hazards, such as fire, which must also take into account the objectives and requirements for fire protection.

The objective of the KTA safety standards is to specify safety requirements for achieving the protection goals laid down in the Atomic Energy Act, the Radiation Protection Act and the Radiation Protection Ordinance further specified in the "Safety Requirements for Nuclear Power Plants" /BMU 15/ for demonstrating that the necessary precautions against damage caused by the construction and operation of the installation have been taken according to the state of the art in science and technology (AtG /ATG 22/, § 7(2) and (3). The KTA safety standards are reviewed to ensure that they are up to date and revised if necessary. In particular, the continuous enhancements of the international regulatory framework are taken into account.

General requirements from the safety related requirements regarding fire protection are provided in detail in the KTA Safety Standard 2101, parts 1 – 3 /KTA 15/, /KTA 15a/ and /KTA 15b/. These basically apply to nuclear power plants and research reactors. Accordingly, they can also be applied to nuclear fuel cycle and storage facilities.

Part 1 of this safety standard contains the basic requirements for fire protection in nuclear power plants including detailed informative annexes on the fire hazard analysis and the fire protection concept, while Part 2 provides detailed guidance on structural (mainly passive) fire protection means. Part 3 is dedicated to active measures for fire detection and alarm as well as for fire extinguishing, for which detailed technical standards and guidelines are available.

Accordingly, the licensees of nuclear power plants have to prepare a systematic fire protection concept in accordance with the requirements of /BMU 15/ and /KTA 15/, which must be documented and updated based on operating experience and relevant insights from research.

In addition, aspects of fire protection are comprehensively assessed in the frame of the PSR, which is performed for all German nuclear installations. For nuclear power plants and research reactors, this includes a detailed deterministic fire hazard analysis (FHA) and, if applicable, a probabilistic fire risk analysis (Fire PSA) as required in /KTA 15/. Detailed guidance on PSA methods and data for Fire PSA is available in the Technical Supplements to the German PSA Guide /FAK 05/, /FAK 05a/, /FAK 16/.

A current, more detailed presentation of the German fire safety regulations for nuclear power plants can be found in /MEL 20/.

For research reactors, legal design principles from the conventional area are primarily applied (see below). These are supplemented by the fire protection regulation for nuclear power plants, which is graded according to the hazard potential. The same applies to the storage facilities in Germany already covered above.

The regulations in the area of building law and occupational health and safety also apply to the nuclear installations:

- laws:
  - building regulations of the Länder,
  - fire brigade and fire protection laws of the Länder,
  - trade regulations,
- statutory ordinances:
  - Industrial Safety and Health Ordinance,
  - Workplace Ordinance,
- recognised rules of technology:
  - DIN/EN/ISO standards,
  - VDE guidelines,
  - VdS guidelines.

1.2.2 Implementation/Application of international standards and guidance

In the following, an overview of the international requirements that have been taken into account in the national regulatory framework is given.

At the European level, the recently developed Reactor Harmonisation Working Group (RHWG) Issue SV "Internal Fire Actions" of the WENRA Safety Reference Levels (SRLs) for Existing Reactors 2020 /WEN 21/ (which replaces the previous Issue S "Protection against Internal Fires" in 2014) sets out the basic requirements for fire protection in nuclear power plants.

For research reactors, WENRA has developed its own SRLs for fire protection (Issue S) /WEN 20/. In Germany, the regulations for nuclear power plants are applied mutatis mutandis to research reactors. This also includes the requirements of the WENRA SRLs.

The Working Group on Waste and Decommissioning (WGWD) has prepared four thematic reports for the following topics: storage of radioactive waste and spent fuel, decommissioning of nuclear installations, disposal, and processing of spent fuel and radioactive waste. The SRLs developed for the storage of radioactive waste and spent fuel /WEN 14/ and for decommissioning /WEN 15/ apply to the corresponding installations in the scope of the TPR II. The SRLs of the RHWG developed for operating nuclear power plants and research reactors also apply to the spent fuel pools as parts of these installations.

WENRA has not developed SRLs for fuel cycle facilities. Therefore, there are no equivalent standards to those mentioned above regarding the expected practices in relation to these installations. In the absence of WENRA SRLs for fuel cycle facilities, a selection and interpretation of guidelines and practices has been developed from the SRLs for other installations and the IAEA standards and guidelines that provide the framework for the NAR.

The relevant IAEA requirements for fire protection in the design and operation of nuclear installations are contained in Specific Safety Requirements SSR 2/1 "Safety of Nuclear Power Plants: Design" /IAE 16/, SSR 2/2 "Safety of Nuclear Power Plants: Commissioning and Operation" /IAE 16a/ and SSR-3 "Safety of Research Reactors" /IAE 16b/. The recommendations for fire protection in the design and operation of nuclear power plants have recently been updated and published in the IAEA Specific Safety Guides SSG-64 "Protection against Internal Hazards in the Design of Nuclear Power Plants" /IAE 21/ and SSG-77 "Protection against Internal and External Hazards in the Operation of Nuclear Power Plants" /IAE 22/.

Directive 2014/87/EURATOM amending Directive 2009/71 EURATOM /EU 14/ of the European Council requires a PSR every ten years. IAEA Safety Guide SSG-25 "Periodic Safety Review for Nuclear Power Plants" /IAE 13/ of the IAEA Safety Standards requires the review of fires as internal hazards in the section "Safety factor 7: Internal hazards". According to the IAEA Specific Guide SSG-3 "Development and Application of Level 1 Probabilistic Safety Assessment" /IAE 10/ and its current revision SSG-3, Rev. 1 /IAE 23/, probabilistic fire risk analyses are required at least for nuclear power plants. The German nuclear regulatory framework complies to a high degree with the latest IAEA guides mentioned above.

2 Fire safety analyses

The objective of fire safety analyses for nuclear installations is to demonstrate that fires and their consequences do not lead to harmful effects due to ionising radiation (radiological safety objective, see Radiation Protection Act). The safety of persons and the protection of the environment (conventional non-nuclear protection goals, see building law and workplace legislation) must also be ensured to the extent required.

For nuclear reactors and other nuclear installations, the achievement of the nuclear protection goal is ensured by demonstrating that the following individual fundamental safety functions:

- to shut down the reactor and keep it in a safe shutdown state (nuclear reactors only),
- to ensure the removal of residual heat (only nuclear reactors and heat-generating assemblies), and
- to prevent an inadmissible release of radionuclides

are not inadmissibly impaired by fires and their consequences.

Evidence that the (individual) fundamental safety functions are achieved is specifically provided by demonstrating that the SSC important to safety required for the fulfilment of the fundamental safety functions are not inadmissibly impaired in the event of fire.

Evidence of compliance with the conventional non-nuclear protection goals is usually provided by meeting the prescriptive requirements and is not a separate part of the fire safety analyses.

The fire protection measures aim at preventing fires from starting, quickly detecting and extinguishing fires that do start and preventing the spread of fires that have not been extinguished.

2.1 Nuclear power plants

2.1.1 Types and scope of fire safety analyses

The fire protection objectives in nuclear power plants are, on the one hand, compliance with the nuclear protection goals. The precautions required according to the state of the art in science and technology against damage caused by the construction and operation of the installation (AtG /ATG 22/, § 7(2)3 are taken if the protection goals specified in the Atomic Energy Act, the Radiation Protection Act /BMJ 22/ and the Radiation Protection Ordinance /BMJ 21/ and further specified in the "Safety Requirements for Nuclear Power Plants" /BMU 15/ and the "Interpretations of the Safety Requirements for Nuclear Power Plants" /BMU 15a/ are achieved.

The fundamental safety functions are also specified in KTA 2101, Part 1 /KTA 15/:

- control of reactivity,
- cooling of the fuel elements,
- confinement of the radioactive substances, and

- limitation of radiation exposure.

These define the requirements for the SSC whose functions are necessary to comply with the fundamental safety functions and the radiological safety objectives according to the "Safety Requirements for Nuclear Power Plants" /BMU 15/, sections 2.3 and 2.5.

On the other hand, compliance with the conventional non-nuclear fire protection goals must be achieved:

- prevention of fire occurrence,
- prevention of the spread of fire and smoke (fire propagation),
- in the event of a fire, the saving of lives, and
- enabling effective fire extinguishing.

For operating nuclear power plants (power operation and low-power and shutdown operation), deterministic fire hazard analyses and probabilistic fire risk analyses (so-called Fire PSA) are performed.

The approach for the analyses is a postulated fire. In the fire area, all components are assumed to be failed; possible consequential effects and/or events are investigated. The fire area is usually limited by building structures with fire protection requirements.

These analyses are carried out for the phase of commercial power operation oriented to the corresponding protection goals, including the core and spent fuel pool cooling functions. The plant operational state of the outage (low-power and shutdown operation) is covered by the considerations for power operation.

The Fire PSA assesses possible plant transients that may occur due to fire events. The Fire PSA aims at performing a quantitative assessment of fire scenarios for nuclear power plants in operation (power as well as low-power and shutdown operation) in accordance with the state of the art in science and technology (in particular the PSA Guideline /BMU 05/ and its Technical Supplements on PSA Methods and Data /FAK 05/, /FAK 05a/, /FAK 16/).

The Fire PSA pursues the following specific objectives:

- identification and analysis of accident sequences of plant-internal fire events that contribute significantly to the frequency of plant damage states,
- quantification of the frequencies of plant damage states resulting from these event sequences,
- identification of significant effects and their contribution to the plant damage frequency due to fire events,
- identification of possibilities for improvements in systems engineering, modes of operation and fire protection features, and
- identification of approaches for optimising the operating instructions used for the mitigation of incidents and accidents.

The aim of the Fire PSA is to demonstrate the balance of the safety concept.

Based on simplifying assumptions on fire-induced failures of systems and components, these are analysed regarding their effect on the frequency of plant damage states.

Event combinations are taken into account in the design of the installations and their operation and are considered accordingly in the deterministic and probabilistic fire safety analyses. Combinations of a fire with another anticipated event are assumed according to /BMU 15/ if the events to be combined are causally related or if their simultaneity has to be considered due to the probability and the extent of damage. For deterministic analyses, this is done based on the requirements of KTA 2101.1 /KTA 15/, /KTA 15a/, /KTA 15b/, for probabilistic analyses by means of site- and plant-specific analyses. According to KTA /KTA 15/, it has to be investigated site- and plant-specifically if event combinations with fire need to be analysed. KTA /KTA 15/ explicitly requires the superposition of the following hazards in the frame of deterministic analyses:

- component failure and consequential fire,
- explosion and consequential fire,
- earthquake and consequential fire, and
- lightning and consequential fire.

The superposition of component failure with a consequential fire is considered by a redundant design including fire protection by segregation (see paragraph 2.1.2) or the provision of a stationary extinguishing system. Potential internal flooding, e.g. by fire extinguishing measures, is bounded by the analyses of internal hazards.

According to the design of the installation against internal explosion (KTA 2103 /KTA 15c/) and lightning effects (KTA 2206 /KTA 22/), there is usually no causality between these events and a consequential fire.

Event combinations of earthquake and independent, temporally correlated fire are site-specifically considered (depending on the intensity of the design earthquake and the occurrence frequency of the combination) according to KTA 2101.1 /KTA 15/.

Event combinations of earthquakes and either consequential fires or independent, temporally correlated fires are considered in the probabilistic safety analysis for earthquakes as a superposition of events. Possible subsequent fires are considered within the scope of the event sequences to be analysed for such scenarios. The Technical Supplements on PSA Methods /FAK 05/ and /FAK 16/ specify the scope of a seismic PSA.

Furthermore, the level of detail of the considerations is specified depending on the earthquake intensity (see the following Table 2-1 from /FAK 16/). For example, from an intensity I of more than VI, equipment whose failure could cause a fire, e.g. lubricant vessels, is checked during a plant walk-through.

Table 2-1 Defence-in-depth demonstration for the event earthquake (from /FAK 16/)

Site intensity I_0	Safety demonstration	Remark
$I_0 \leq VI$	No analysis required	According to KTA 2201 /KTA 15/, there is a minimum design level.
$VI < I_0 \leq VII$	Simplified analysis required	Performing an analysis that shows that earthquakes that are one intensity stronger than earthquakes that are currently assigned to a frequency of occurrence of 10^{-5}/a are mitigated
$I_0 > VII$	Detailed analysis required	Performing the analysis according to paras.3.6.4.4 to 3.6.4.6 using the safety margin factor method

An essential finding of the seismic PSA is that due to the assumed wide destruction in plant areas without seismic design (e.g. collapse of the turbine building), the effects of additional consequential fires provide only an insignificant contribution to the core damage frequency.

In summary, it can be stated that the structural fire protection means for segregation or the separation of redundant trains by a sufficient distance as implemented in the nuclear power plants is fundamental for the consideration of fire scenarios. If a fire scenario only leads to the failure of one redundant train of the safety system, this fire is mitigated taking into account the fundamental safety functions.

PSA for internal and external hazards are generally limited to Level 1. Probabilistic analyses are to be explicitly conducted for the internal hazards fire and flooding according to /FAK 05/ and /FAK 16/. These also include event combinations (e.g. fire and consequential flooding, flooding and consequential fire, etc.). /FAK 16/ also includes Level 1 Fire PSA for low-power and shutdown plant operational states.

With regard to the probabilistic assessment of fire events, fire-induced failures of systems and components are analysed with regard to their effect on the frequency of plant damage states, based on simplifying assumptions. The primary focus of the Fire PSA is on fire events that lead to event sequences resulting in reactor scram. Moreover, fire events that do not themselves lead to disturbances of plant operation but require precautionary reactor scram (if necessary, with limited availability of items important to safety) due to the deterioration and the associated unavailability of items important to safety.

For the analysis of fire events, those fire compartments, i.e. compartments in which fires can occur, must be determined where the corresponding scenarios may develop at all. Typically, a fully developed fire and the failure of the entire equipment in the compartment are conservatively assumed for these fire compartments in the event of fire suppression failure.

Nuclear power plants under decommissioning and dismantling

From the end of commercial power operation of a nuclear power plant, the fire hazard analysis conducted for power operation is initially still valid as a bounding analysis.

Already with the end of commercial power operation, the number of the items important to safety still required with regard to the shutdown capability and core cooling is instantaneously reduced. Systems, e.g. for reactor scram or high-pressure injection, are no longer needed. Such systems can then be permanently decommissioned in line with the concept for the post-commercial safe shutdown phase. For these systems, the structural separation by fire barrier in order to separate fire sub-compartments becomes obsolete. These fire sub-compartments can be removed if other still necessary process engineering systems are not adversely affected and the conventional non-nuclear fire protection requirements are still met.

With the core being placed in the spent fuel pool, the requirements for safety-related systems are further reduced.

Finally, the nuclear risk potential is significantly reduced by removing the fuel elements from the reactor installation (fuel-element-free installation). At the latest when the fuel elements have been removed, structural segregation or separation by distance of the process systems is no longer necessary. According to the current German regulations /ATG 22/, a PSR and thus a Fire PSA are no longer required for installations under decommissioning.

Core and fuel element damage states[2] do not have to be assumed for a reactor installation free of fuel elements. According to the applicable German regulations, such as the PSA Guideline /BMU 05/ and its Technical Supplements on PSA Methods and Data /FAK 05/, /FAK 05a/, /FAK 16/, a PSA and thus a Fire PSA are no longer required for installations under decommissioning.

For nuclear power plants under decommissioning (after defuelling), the fire protection requirements are predominantly reduced to those from the conventional non-nuclear regulations. In individual cases, locations with an increased risk potential with respect to the fundamental safety functions remain at places where radioactive residues or wastes are stored or processed if relevant releases into the environment are possible in case of fire. This may be the case if significant releases to the plant environment can occur within the controlled area with limited filtering option.

During the decommissioning and dismantling of a nuclear power plant, additional combustible materials (e.g., residue processing machines, gases for cutting or welding) or potential ignition sources (e.g. hot work) are introduced into the plant. The resulting changes in fire loads and potential ignition sources and the resulting fire hazards must be assessed and, if necessary, further fire protection means derived.

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2 According to /FAK 05/, a "damage state" is a plant state during which the fuel element cooling is no longer controlled by the systems provided for this purpose. Without further measures, core damage will occur. A damage state can possibly be transferred into a safe state (subcritical, long-term core cooling) by accident management measures and thus the occurrence of a core damage state can be prevented. A core damage state is defined as a plant state that occurs when an initiating event cannot be mitigated by the systems provided for in the design and by preventive emergency measures or by alternative measures and when nuclear material (usually control rod material) in the reactor begins to melt. Analogous to the core damage state, the term "fuel element damage state" is introduced in /FAK 16/ for low-power and shutdown states as a separate unmitigated end state.

2.1.2 Key assumptions and methodologies

In fire hazard analyses, the occurrence of a fire is always assumed. According to KTA 2101, it may be assumed that no more than one fire need be postulated at the same time. According to the "Safety Requirements for Nuclear Power Plants" /BMU 15/, the occurrence of a fire does not have to be assumed if the combustible material is encapsulated and the encapsulation remains functional during specified normal operation and in case of all postulated design basis accidents.

For each fire to be assumed, the fire hazard analyses also include its propagation possibilities and thus a failure of SSC in the fire compartment.

The SSC required for compliance with the nuclear protection goals were determined during the plant design. In the event of a fire, the safety functions are ensured by the redundant arrangement of items important to safety and their separation/segregation regarding fire protection. The entirety of all fire protection means (structural, equipment-related, operational and defensive) ensures that a failure of an individual fire protection measure in the event of fire is inconceivable from a safety point of view.

Fire protection includes firefighting means to combat risks to life, health and property caused by a fire. This is ensured at nuclear power plants in operation (power, low-power and shutdown as well as post-commercial safety shutdown operational states) by the provision of a dedicated, sufficiently efficient professional on-site fire brigade in accordance with the Land law. During dismantling, firefighting can be provided by the public off-site fire brigade depending on the prevailing hazard situation, if necessary, with the support of a works fire brigade that is not state regulated (see paragraph 3.1.1).

Fire protection aspects are always taken into account during the planning of modification and dismantling measures. The work permit procedure ensures that fire protection issues are taken into account in all relevant activities.

2.1.3 Fire phenomena analyses: overview of models, data and consequences

Fire effects that can be considered are according to /KTA 15/:

- temperature development in the fire compartment,
- temperature development outside the fire compartment,
- smoke development and spreading,
- flying sparks, burning dripping, and
- pressure build-up in the fire compartment.

Within the German design approach, detailed considerations of the fire effects (e.g. temperature, pressure, smoke, soot) within a fire sub-compartment are not necessary because, as a rule, all SSC in the affected fire sub-compartment are conservatively assumed to fail in the event of fire. In exceptional cases (e.g. containment of a PWR), credit is also taken of the separation by distance.

2.1.4 Main results/dominant events (licensee´s experience)

The leading radiological accident is determined in the event analyses for plant operation. Fire effects are taken into account. In this context, fire effects are of minor importance.

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:

- reduction of fire loads in the enhancements of the individual model lines of nuclear power plants,
- modification of the oil supply to the reactor coolant pump to reduce the fire load,
- 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, as the results of the follow-up analyses also clearly demonstrated.

In case of fire events which may affect more than one redundant train, retrofitting of the equipment-related fire protection, e.g. by implementation of automatically actuated stationary extinguishing systems, has been realised due to a retrospectively no longer possible structural separation by fire barriers.

The frequencies determined within the Fire PSA for hazard or core damage states do not lead to a dominant contribution of fire events. The PSA results confirm the high safety level of the German nuclear power plants also with regard to fire events.

The updates of the fire safety analyses within the scope of the PSR also did not identify any further significant potential for optimisation.

Occasional plant-specific probabilistic fire risk analyses showed that a modification of the basic state of a fire extinguishing valve from "open" to "closed" and the resulting improved isolation possibility of an extinguishing water pipe represents an increase in safety with regard to plant-internal flooding in the event of a break of this pipe. This benefit outweighs the slightly higher failure probability of the extinguishing water supply due to an opening function failure of the valve.

In the frame of the licensing procedure for decommissioning and dismantling of a nuclear power plant, the releases of radioactive materials and their radiological impacts have been demonstrated for additionally assumed dismantling-specific fires, see /FOR 20/. Release fractions needed for the assessment are taken e.g. from the Konrad transport study /RIC 17/.

2.1.5 Periodic review and management of changes

Fire protection aspects are of great importance during operation and are continuously assessed. For example, in addition to the PSR,

- national or international operating experience,
- relevant regulatory changes, and
- all modifications

are always analysed and assessed regarding fire protection issues. If this results in changes in the fire protection requirements, these are implemented in the frame of the supervisory procedure.

Fire safety analyses are an integral part of the PSR. They are updated in the plant description, the (deterministic) safety status analysis and the probabilistic safety analysis. This allows a periodic comprehensive analysis of all fire protection provisions.

Examples of changes are provided in paragraph 2.1.4.

2.1.5.1 Overview of actions

Due to the regular consideration of fire protection issues in accordance with paragraph 2.1.5, the PSR updates did not result in any further significant fire protection optimisations.

As part of the work permit procedure, technical and administrative means where necessary, such as qualified fire-resistant encapsulations, provision of fire watches, are implemented.

2.1.5.2 Implementation status of modifications/changes

Modifications resulted from the first PSRs, which were conducted more than ten years ago. These were implemented in a timely manner. Further significant improvements in fire protection were not derived from subsequent PSRs.

2.1.6 Licensee's experience of fire safety analyses

For the design and construction of nuclear power plants, the fire protection aspects were assessed as part of the licensing procedure.

Fire safety analyses are an essential part of assessing and optimising the safety level. The comprehensive fire safety analysis conducted in the frame of the first PSR for each installation has indicated the potential for improvements.

The subsequent fire safety analyses conducted within the last PSRs did not reveal any further significant weaknesses.

2.1.6.1 Overview of strengths and weaknesses identified

The most important parameter affecting the fire protection concept already considered in the design is the procedural and fire-protection-related separation of items important to safety needed for compliance with the nuclear protection goals.

The significance of this design feature was demonstrated by the fire hazards analyses. In plant areas with stringent separation, there were few opportunities for optimisation. In areas with insufficient structural separation (by fire barriers), measures for a retrospective separation or compensatory equipment-related fire protection measures (e.g. installation of fire extinguishing systems) were necessary.

2.1.6.2 Lessons learned from events, reviews, fire safety related missions, etc.

Insights were gained, amongst others, from the following fire events during the operation of German nuclear power plants:

- Transformer fire

  A short circuit occurred in a main transformer during undisturbed power operation. A large amount of smoke was released. The fire detectors of the air supply fans of the electrical building were actuated. The associated ventilation system was consequently automatically switched to "smoke extraction mode", i.e. the electrical building was supplied purely by fresh air (without recirculation). This resulted in an increase of fire gases entering the electrical building, particularly the main control room of the plant. The aerosols in the smoke were filtered out through the supply air filters.

  The control of the ventilation system by fire detectors in the air supply rooms of the electrical building and the thus actuated ventilation of the electrical building only with outside air served to prevent a distribution of smoke inside the building via the recirculation mode in the event of a fire in the electrical building. The design of the ventilation system did not consider a fire outside the building in the near vicinity of the air inlet openings.

  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.

  At the time of the event, it was regulated in the affected plant that the deputy shift supervisor was also tasked as troop leader of the on-site fire brigade. Consequently, this arrangement was changed (personnel separation of the positions of deputy shift supervisor and fire brigade troop leader) in order to prevent that in the event of a fire, members of the shift team who could take over potential advisory and relief functions of the control room shift supervisor are not available.

- Consequential damage due to a fire after oil leakage from a main coolant pump

  During an in-service inspection, a small oil leakage occurred due to an assembly error at a screw connection of the lifting oil line for the main coolant pump. This caused an autoignition of leaking oil at a hot component. The event shows that despite preventive measures, oil leakages and their ignition cannot be completely excluded. The area of the main coolant pumps with possible oil leaks and high system temperatures with simultaneous poor accessibility is generally a plant area with increased risk, which is protected by suitable measures (e.g. by the use of spraywater deluge extinguishing systems, the use of liquid-tight insulations, or an integrated oil supply). The sequence of fire detection and alarm and firefighting confirmed the correctness and sufficient functionality of the means for fire detection (fire detectors and television camera for verification of the fire) and fire suppression at the reactor coolant pumps by manually actuated stationary spraywater deluge systems.

The following insights resulted from fire events during the decommissioning and dismantling of German nuclear power plants:

- Smouldering fire of residues in a waste container inside the drying facility (see also /FOR 19/).

  During the drying process of mixed wastes in a non-air-tight heating chamber, a smouldering fire occurred inside the waste container. Due to the powder state of the waste, its ignition temperature decreased to an extent that the waste could self-ignite under the given process parameters. It turned out that the smouldering fire could be brought under control and successfully extinguished by the fire extinguishing system (CO_2 inerting) and firefighting by the on-site fire brigade. With additional measures taken afterwards (modification of the process parameters, additional demonstration of a non-spontaneous ignition of the material to be dried, adjustment of reporting criteria, etc.), the probability of a recurrence of the event was considerably reduced.

- Self-extinguishing fire of the steam generator dismantling enclosure (for publication see /ART 22/)

  During the dismantling of the steam generators in the installation position using a wire saw, a small incipient fire occurred. Due to the fine dust exposure during the dismantling of the steam generator, the area was enclosed and provided with a separate ventilation. In addition, all fire detectors were taken out of operation. The enclosure consisted of a frame made of scaffolding material (non-combustible) and films of building material class B1 according to DIN 4102 which were glued at the joints by means of fabric adhesive tape (combustible). During the sawing operation through an inhomogeneous structure, a small piece of a spacer was also cut off, which fell approx. 5 m deep into a corner of the building. Here, there was an overlap of the films fixed with adhesive tape. As a result of the high temperature initiated by the wire sawing process in the spacer piece, these ignited. Due to the use of B1 material, the fire had already self-extinguished before the dedicated on-site fire brigade arrived. In order to further minimise the risk of a fire, the following additional measures have been taken:

  1. Cutting outside the area of small cuttings or prior to removal of the small cuttings in the area of the saw wire to ensure the distribution and/or removal of the heat energy introduced by the wire;
  2. Recurring thermal control of the cuttings (rope exit) during cut control, before break periods, and at the end of work, including documentation;
  3. In case of measuring temperatures > 100 °C, provision of a fire watch (up to < 100 °C).

Amongst others, relevant insights resulted from the following international fire events:

- Fukushima reassessment of seismically induced fire hazards

  Based on the findings from the event at the Fukushima Dai-ichi and Fukushima Dai-ni sites on 11 March 2011 and the event at the Kashiwazaki-Kariwa nuclear power plant, Unit 3 on 16 July 2007, the licensees have conducted reassessments of seismically induced fire hazards.

The fire suppression concept has been reviewed and it has been demonstrated that the installations are not directly dependent on external support in the event of earthquakes or other external hazards. Moreover, it has been demonstrated that there is more than one means of access for rescue vehicles to the power plants. If necessary, technical equipment can be used to restore access routes or entrances that have been impaired after earthquakes.

Earthquake-induced destruction of fire extinguishing features has been reassessed. If stationary fire extinguishing systems and equipment are damaged, mobile equipment can be used for firefighting. A supply of extinguishing water by mobile equipment is currently possible, and accessibility to the buildings important to safety is ensured.

The availability of the stockpiling of chemical extinguishing media after an earthquake or in the event of other external hazards has also been analysed and re-assessed.

Some of the examples demonstrate that fire risks remain of fundamental importance during the decommissioning of nuclear power plants, even if in this phase of operation the focus is on the protection of people, since the mobilisable activity inventory can no longer lead to significant radiological consequences.

Insights from reviews of fire protection measures:

- Findings on fire doors of older design (year of manufacture up to approx. 1976)

  During an inspection of older fire doors that had already been removed, a displacement (sagging) of the mineral wool mats in the door leaf was found in conjunction with the assessment and replacement of fire doors. An inspection of comparable doors partly showed an incomplete filling with mineral wool. The incomplete filling of fire doors was attributed to a lack of quality assurance in the context of self-monitoring and external monitoring during door manufacturing at the respective manufacturer's factory. Ageing effects were assumed to be the reason for the displacement of the mineral wool. As a result of these findings, comparable doors were analysed regarding their construction, checked for defects and, if necessary, replaced or refurbished. As a further consequence of these events, information notice WLN 2013/02A (see Appendix A2) was prepared. Resulting from that, defects in fire doors of older design were found in other German nuclear power plants. The affected doors were replaced by new ones or, in individual cases, re-assessed, applying engineering methods for fire protection.

- Findings on cable and pipe penetration seals

  In the frame of fire protection retrofitting, systematic inspections of pipe and cable penetrations were carried out. It was found that some of the penetration seals had sheet metal closures but were not filled with mineral wool. It turned out that the fire wall penetrations investigated had not been properly installed with respect to their required fire protection function. Since this was observed to be a systematic deficit, 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. As a result of this event, information notice WLN 2013/02 (see Appendix A2) was prepared. Resulting from that, improvements were carried out in some German nuclear power plants, in particular of section isolations by pipe penetration seals and improved labelling at the location and in the documentation.

The added value of the continuous monitoring and assessment of fire protection means, e.g. in-service inspections (according to KTA, see paragraph 3.3) and fire protection walk-throughs in accordance with plant-specific procedures, was confirmed by the positive results of the last PSR.

Insights from international fire protection "missions" are not available for German nuclear power plants.

The main results and insights from periodic reviews (PSR and PSA) have already been presented in paragraph 2.1.4.

2.1.7 Regulator's assessment and conclusions on fire safety analyses

The fire safety analyses for German nuclear power plants are correctly presented in paragraph 2.1.

2.1.7.1 Overview of strengths and weaknesses identified by the regulator

In accordance with the regulatory requirements (see paragraph), 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 always ensured a high fire protection level, taking into account the state of the art in science and technology.

Based on this level achieved during power operation, residual operation and decommissioning of the nuclear power plants now represent a different mode of operation compared to the preceding power operation period, which will continuously change as dismantling progresses, which may have a direct impact on the fire protection requirements.

The need for additional or modified fire prevention means may result from the dismantling processes applied and the equipment and tools used.

For the remaining operation period, there is a possibility of fire due to the fire loads present in the installation, due to the systems remaining in operation from the previous power operation period, replacement systems implemented, the increase in the number and types of hot work assignments, and the modifications in plant areas and fire compartments. These possibilities for fire can be mitigated by the fire protection means available from the preceding power operation period.

The possibility of fire during residual operation may be increased by the measures and processes of dismantling.

2.1.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

For considering the above-mentioned boundary conditions during residual operation and dismantling of the nuclear power plants, the necessity of additional specific fire protection means is assessed in the supervisory procedure when specifying the dismantling planning by means of a modification notification or dismantling descriptions.

Decommissioning of systems takes place within the frame of modification procedures. In the supervisory procedure, they are checked to ensure their justification regarding fire protection and the absence of feedback effects on the systems remaining in operation.

2.1.7.3 Conclusions drawn on the adequacy of the licensee's fire safety analyses

Overall, the fire safety analyses described above for all plant operational states ensure that the fire protection features and measures are suitable for ensuring that the protection goals are met and that the required functions can be performed during the remaining period of operation.

2.2 Research reactors

Within the fire safety analyses for research reactors, no distinction is made à priori between different plant operational states with regard to fire protection.

Combinations of events (e.g. fire after earthquake) have been considered by always postulating fires. In concrete terms, e.g. access is ensured either by the installation of earthquake-proof doors or by designing the doors to be so light that they can still be opened with the means available to the fire brigade even if they are jammed. The separation of redundant trains remains ensured. Fire protection features are designed to be mechanically stable after earthquakes.

2.2.1 Types and scope of fire safety analyses

FR MZ

The fire protection provisions chosen as bounding for the FR MZ are based on the low risk potential of a TRIGA reactor resulting from the low inventory and the inherent safety of the fuel. Conventional fire protection measures have been implemented at the FR MZ, as for other laboratory buildings and research facilities. The reactor building was classified as a building of a special type or use according to § 50 of the building regulations of Rhineland-Palatinate. The structural as well as equipment-related provisions for fire protection were continuously extended over the plant operating lifetime according to the state of the art in science and technology. Figure 2-1 shows a site map of the reactor facility with adjoining laboratory and administration buildings, as available for the professional fire brigade in Mainz in charge and as present in the fire brigade information centre in the vestibule of the old building. The outline of the new building currently under construction was added subsequently and is not to scale. Updated plans have to be prepared for this and agreed by the respective authority in charge of fire protection.

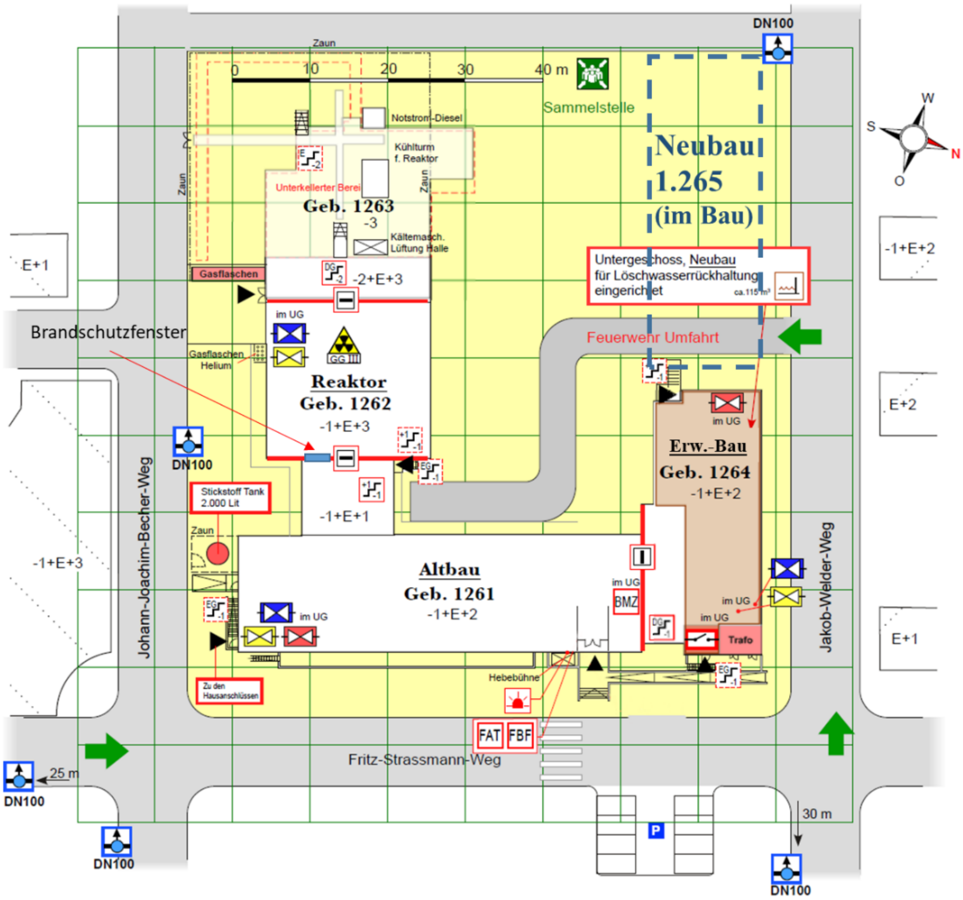

Figure 2-1 Fire-protection-specific site plan of the FR MZ (fire compartment boundaries marked in red)

The first fire safety review for the Mainz research reactor was carried out as part of the licencing of the reactor in 1962 and resulted in a series of "fire safety requirements" that were entirely implemented. Due to a building construction measure on the old building adjacent to the reactor hall, another fire safety review was conducted in 1982, which mainly resulted in requirements regarding measures for this building, which were implemented shortly after. On behalf of GRS, a fire safety review was carried out within the scope of a study on the "situation at research reactors regarding fire protection and their safety assessment" in 1992, which came to the conclusion that the conventional fire protection provisions are sufficient for the FR MZ. In 1994, the cooling circuits of the TRIGA Mainz were replaced, making another fire safety review necessary.

As a result of an information notice by GRS (WLN 2013/02) from 2013, another 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, a renovation study of the old building was carried out. In the frame of this study, another fire safety review was carried out.

FRM II

As part of the deterministic analyses, the admissible fire load density per floor area of the room [kW/m^2] was specified in a room-specific fire load list for each room and the necessary measures (type and scope of fire detection, provision of extinguishing media on site, necessity of sprinkler systems, implementation of fire compartments and fire sub-compartments) were derived from this list. Compliance with these room-specific limit values is ensured by:

- assessment of plant modifications with regard to fire safety, particularly in the event of modifications to the experimental facilities and scientific set-ups,
- administrative measures in the frame of the work permit procedure,
- personnel training as part of the mandatory annual instructions and exercises,
- regular walk-throughs by plant personnel and external experts (fire brigade, experts).

If necessary, the above-mentioned provisions will be adjusted accordingly.

2.2.2 Key assumptions and methodologies

FR MZ

The fire safety reviews carried out are exclusively assessments that have been carried out after plant walk-throughs. For the fire scenarios assumed, neither explicit analyses nor model calculations were conducted. This seems to be justified in view of the low risk potential of the FR MZ with its low radioactive inventory and the consequent requirements that do not exceed those for conventional non-nuclear fire protection. This is supported in particular by the following characteristics:

- inherent safety of the reactor due to the design of the fuel elements and the fuel in a manner that even in the event of fire and/or the failure of infrastructure, no release can occur as a result of fuel assembly cladding damage;
- low radioactive inventory.

FRM II

For the FRM II, it was postulated that all fire loads present can be mobilised. Based on the maximum admissible or maximum present fire loads in conjunction with the given boundary conditions and SSC including the need for their protection, suitable fire protection provisions have been defined. These include determining the number and type of fire extinguishers to be provided at the location, installing stationary sprinkler or spraywater deluge extinguishing systems, and implementation of qualified fire barriers, etc.

2.2.3 Fire phenomena analyses: overview of models, data and consequences

FR MZ

Neither a formal fire hazard analysis nor a Fire PSA has been carried out for the FR MZ as there were no regulations applicable for such analyses at the time the installation was built. Even later, the conventional non-nuclear fire protection requirements did not consider the need for such analyses. In agreement with the supervisory authority, corresponding analyses are not needed for the FR MZ.

FRM II

The following fire effects need to be considered /KTA 15/:

- temperature development in the fire compartment,
- temperature development outside the fire compartment,
- smoke development and smoke spread,
- flying sparks, burning dripping, and
- pressure build-up in the fire compartment.

In the German design approach, detailed analyses of the fire effects (e.g. temperature, pressure, soot) within a fire sub-compartment are not necessary because in the event of fire, all SSC in the affected fire sub-compartment are conservatively assumed to fail.

It was postulated that one fire occurs. Several fires initiated in parallel were not assumed according to KTA 2101 /KTA 15/. However, the fire extinguishing system is designed such that it allows several necessary fire extinguishing operations/activities in parallel.

2.2.4 Main results/dominant events (licensee´s experience)

FR MZ

As already mentioned in paragraph 2.2.1, there have been several fire safety assessments at the FR MZ that have resulted in retrofitting measures to take the facility to the state of the art. The reasons for these assessments were pending improvements or information notices (see Appendix A2). The conventional non-nuclear fire protection requirements have been fully implemented at the FR MZ.

FRM II

In the frame of fire safety assessments and the first PSR, the fire hazard analyses did not reveal any weaknesses. The results confirm the high safety level of the FRM II also with regard to fire events.

2.2.5 Periodic review and management of changes

FR MZ

The first PSR in accordance with the Atomic Energy Act, in which fire protection was also assessed, was completed at the FR MZ in 2021. This did not result in any requirements regarding fire protection measures at the FR MZ.

The need for fire protection modifications is specified by the Facility Management/Fire Protection Department of the Johannes Gutenberg University Mainz. Minor measures are implemented independently. Larger structural fire protection provisions are implemented by the public-sector Landesbetrieb Liegenschaften- und Baubetreuung (LBB) of the Land of Rhineland-Palatinate, if required.

FRM II

No new deterministic fire safety analysis was carried out for the FRM II as part of the PSR. In the frame of the probabilistic safety analyses (PSA), fire was considered as part of the internal and external hazards.

Modifications are handled according to the procedures laid down in the operating manual. Details for the setting up and modification of the scientific experiments can also be found in the operating manual.

With respect to the PSR, there were no consequences for fire protection. Fires were considered within the PSA as "internal hazards". The assumed occurrence frequency is 5 E-02 per year. The core damage frequency (CDF) according to the Fire PSA is approx. 8 E-08 per year. This is less than 1 % of the total CDF and therefore negligible.

Fire protection aspects are of high importance during operation and are continuously assessed. Typically

- national or international operating experience,
- relevant modifications of regulations, and
- all modifications

are always analysed and assessed regarding fire protection issues. If this results in requirements for fire-safety-related modifications, these are implemented in the frame of the supervisory procedure.

Fire-safety-related modifications are implemented in the frame of the change modification according to the operating manual. Modifications/retrofits have already been described in paragraph 2.2.4. The measures concerned the complete renewal of the CYE fire detection and alarm system after discontinuation by the manufacturer and the renewal of the safety lighting due to obsolescence.

2.2.5.1 Overview of actions

FR MZ

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.

During the very extensive retrofitting measures for the replacement of the cooling circuits, according to the fire safety review in 1994, the glazing between the east wall of the reactor hall and the office of the radiation protection officer on the ground floor and the electronic workshop on the first floor in the connecting building between the reactor hall and the old building was replaced by fire-resistant fire protection glazing in accordance with DIN 4102, Part 13 (see Figure 2-1).

The fire safety review of 2013 that was carried out as a consequence of information notice WLN 2013/02 "Findings on structural fire protection measures in the nuclear power plant [...]"led to a series of measures. In this context, some fire protection seals that were not or not suitably implemented in accordance with the applicable technical regulations were repaired or replaced. Moreover, an additional fire damper was installed in a ventilation duct to the reactor hall.

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

Due to the regular fire protection issues dealt with in accordance with paragraph 2.2.5, the PSR did not result in any further significant fire protection optimisations.

As part of the work permit procedure, technical and administrative means where necessary, such as qualified fire-resistant encapsulations, provision of fire watches, are implemented.

2.2.5.2 Implementation status of modifications/changes

FR MZ

All measures required in past fire safety reviews concerning the reactor building and its extension have meanwhile been implemented. The shortcomings regarding fire barriers in the corridors of the old building will remain with the agreement and tolerance of the authorities until the new building is occupied (probably in 2024). However, the fire protection status of the old building has no repercussions for the reactor building. In future, a complete structural and thus also fire protection separation will be carried out before the old building is decontaminated and dismantled.

FRM II

No measures resulted from the PSR. Other measures will be implemented in a timely manner. There are no open issues.

2.2.6 Licensee’s experience of fire safety analyses

The concept applied at both research reactors of specifying admissible fire loads, deriving from this the necessary fire protection provisions, applying the defence-in-depth concept, and conducting regular internal and external inspections, has proved to be robust in practice and can be implemented to the extent needed. A need for further analyses could not be identified.

2.2.6.1 Overview of a strengths and weaknesses identified by the regulator

FR MZ

In summary, it can be stated that the majority of the observed findings have resulted from the increasingly strict requirements for structural fire protection over the last decades. Particularly, missing fire barriers or fire doors have to be mentioned in this context. This indicates that fire protection is of high importance at the FR MZ and that it is continuously adapted to the state of the art in science and technology. Exceptions are the respective measures are implemented, and deficiencies in the implementation. Furthermore, fire protection has been continuously enhanced in coordination with the competent authority since the existence of the FR MZ and is kept consistent with the state of the art of science and technology.

All requirements for measures were timely implemented in cooperation with the supervisory building authority in charge and/or the building owner.

FRM II

In the frame of the PSR for FRM II, so far there have been no findings indicating that the existing fire protection provisions need to be adjusted. Should any indications for necessary optimisation potential emerge in the frame of these analyses, these will be implemented in a timely manner in the supervisory procedure.

2.2.6.2 Lessons learned from events, reviews, fire safety related missions, etc.

Amongst others, information from the following sources was used for the research reactors and considered to the extent required:

- reportable events at the research reactors and at other installations,
- information notices of GRS,
- insights from on-site inspections and plant walk-throughs, and
- insights from in-service inspections and operating experience.

According to the German regulations, "missions" are not prescribed for research reactors and are therefore not carried out systematically.

FR MZ

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 technical safety organisation carried out a study on behalf of the regulator 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 1100 °C at the fuel elements, a subsequent release of radionuclides due to fuel element cladding damage is to be expected. However, none of the intervention reference values according to the SSK guideline /SSK 04/ for means necessary for the protection of the population was exploited by more than 30 %. Despite the consideration of a combination of the destruction of the reactor core with a liquid fire, this result confirms the assessment that for the FR MZ, conventional fire protection measures are sufficient and, assuming a more likely fire scenario, no SSC are affected in such a way that the nuclear protection goals are endangered.

The licensee draws further empirical values from previous fire brigade operations at the site.

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. As a consequence, the topic was increasingly pointed out in the initial and annual follow-up instructions. The procedure for taking fire alarm lines out of operation was clarified to the employees.

The fire at the headquarters of the manufacturer of the TRIGA reactors, General Atomic, led to a request to all TRIGA licensees to retrofit fire detection and alarm systems. This was the initiator for the installation of a fire detection and alarm system at the FR MZ.

In 2018, a hot ventilation motor led to an intervention by the fire brigade, triggered by a smoke detector. Smoke was produced by the overheated motor, but no fire occurred. There was no radioactive release and only material damage occurred at the motor itself, which was replaced as a result of the intervention. This event has shown that everything from the smoke detection up to the notification of the fire brigade, the on-call service, the reactor team, and the organisation of the intervention on site, goes as intended.

The licensee assesses the events outlined above as events considered in the design, for which no specific fire protection measures can be derived.

FRM II

As a result of knowledge gained (information notice (see Appendix A2)), several smoke detectors were retrofitted in FRM II and a special tool for improved inspections of fire protection dampers was procured (see the below-mentioned event on fire protection dampers from 2009). Furthermore, a mechanical closure valve in the fire extinguishing system with drinking water was retrofitted with a mechanical lock (see the below-mentioned event on the fire extinguishing system from 2009). Based on operating experience or changes in the regulation, the fire safety and alarm regulations were updated several times.

So far, there have been no events at the FRM II requiring a significant change in fire protection measures. Where necessary for plant operation, adjustments were made to fire protection. For example, 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.

The experience with the defence-in-depth concept applied is positive throughout. The following events relevant for fire protection occurred at the FRM II:

- 2021: Actuation failure of a fire damper by fusible link. 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 electrical actuation of the fire damper from the control room would have been available. 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. The overheating resulted from the small amount of evaporated liquid. Smouldering of a few cubic centimetres of organic grinding dust occurred. There was no release of radioactivity or contamination and no personal injury. Overall, there was only extremely minor material damage. The concept of fire compartments prevented the smoke from spreading to other parts of the building. 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. Due to the heat development, the ceiling cooling system installed in the room also detached itself from its mounting. There was neither any personal injury, nor any release of radioactivity, nor any contamination. There was only minor material damage. No fire spreading to other fire compartments occurred. As a consequence, the air conditioning of the room was improved and the heating load reduced at the same time.
- 2018: Incipient fire in a vacuum cleaner. Low smoke development. The automatic fire detectors detected the smoke development. Smoke development finished by itself before the fire brigade arrived. There was neither a releases of radioactivity nor any personal injury and only extremely minor material damage to property.
- 2016: Overheated transformer (24 V) in a scientific experiment. Low smoke development in the neutron conductor hall. There was neither a fire spreading to other fire compartments nor a release of radioactivity, nor any contamination. There was no personal injury and only very minor material damage. As a consequence, the cooling of the affected transformer was improved.
- 2010: Short-term pressure drop in the fire extinguishing system with drinking water due to external reconnection work on the water supply by the water board. This case is covered by the measures provided for in the operating manual and, in the specific case, by available substitute measures.
- 2009: Short-term unavailability of the fire extinguishing system with drinking water due to external construction measures. The wrong valve was inadvertently closed by the specialist company carrying out the work. As a measure against recurrence, an additional mechanical safeguard was installed to prevent unauthorised operation. The company concerned was trained and the customer (public building authority) as well as the project management company commissioned by the customer were made aware accordingly.
- 2009: Fire dampers did not close as requested during an in-service inspection. Unfavourable test conditions under which a reproducible sharp release was not reliably possible and in some cases also fatigue of the torsion spring in the release device were identified as causes. 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 and, if necessary, a shortening of the test interval in case of any findings.

External feedback of experience is provided by exchanges with the licensees of research reactors at national (Arbeitsgemeinschaft Forschungsreaktoren – AFR) and international (e.g. Research Reactor Operators Group – RROG, RRFM (Research Reactor Fuel Management)) level. With regard to fire protection, there were no indications that would have led to an improvement or to the need for technical or administrative adjustments. The information notices by GRS are another source of information. Regarding fire protection, these led to the 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).

The licensee assesses the events described here as being of only minor safety significance, which did not result in any special measures. In this context, no further measures were needed.

2.2.7 Regulator’s assessment and conclusions on fire safety analyses

FR MZ

From the point of view of the competent supervisory and licensing authority, the continuous assessment of the safety at the FR MZ, which was correctly and completely described in the previous paragraphs, demonstrates an appropriate protection suitable for the risk potential of the plant. This fire safety level comprehensively meets the requirements of the conventional non-nuclear and nuclear regulations. This was also confirmed i.e. by the PSR of the FR MZ completed in 2021.

FRM II

The descriptions of the type and scope of the fire safety analyses for the FRM II in paragraph 2.2.1 and the assumptions and methodologies in paragraph 2.2.2 representing the basis for these as well as the fire effects analysed in paragraph 2.2.3 in accordance with the nuclear standards and regulations are correctly presented.

This also applies to the analyses conducted within the PSR, which did not result in any optimisations of fire protection.

2.2.7.1 Overview of a strengths and weaknesses identified by the regulator

FR MZ

The competent authorities could not identify any deficiencies in the fire protection of the FR MZ. This was confirmed during the PSR carried out in 2021 and the associated examination of fire protection. Weaknesses have therefore not been identified and are not objectionable from the perspective of the competent authority. In addition, it should be mentioned that even in a design extension event (emergency), there are no significant releases at the FR MZ. This was shown e.g. by the robustness analysis of the research reactors.

FRM II

Measures for improving fire safety at the FRM II have not yet been identified within the scope of the PSR and PSA (see also paragraph 2.2.6.1). Thus, no optimisation approaches for fire safety have resulted from the PSR and PSA to date. Nevertheless, the analyses currently being completed ensure that the high fire safety level is maintained.

2.2.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

The official instruments, be it regular on-site inspections or supervisory support in the implementation of recommendations from information notices or in the context of the examination of reportable events or checks in the frame of in-service inspections, have so far not necessitated any extensive adjustments regarding fire safety.

Moreover, the fire protection measures taken in the operating regulations have been demonstrated to be a proven means of preventive fire protection. Therefore, no adjustments have been needed in the supervisory procedure so far.

2.2.7.3 Conclusions drawn on the adequacy of the licensee's fire safety analyses

FR MZ

The previously outlined equipment-related and administrative fire protection means which are regularly checked and assessed in the supervisory procedure serve as a constant fire safety analysis. The knowledge gained from this procedure is considered for the permanent improvement of the high fire safety level of the FR MZ and is to be assessed as beneficial from the point of view of the competent authority.

FRM II

The insights obtained so far from the fire safety analyses are suitable for the FRM II, which is a nuclear facility of recent design, to verify the very high fire safety level already ensured during construction.

2.3 Fuel cycle facilities

2.3.1 Types and scope of fire safety analyses

The precautionary measures required according to the state of the art in science and technology against damage caused by the construction and operation of the installation (§ 7(2)3 AtG) have been taken if the nuclear protection goals specified in the Atomic Energy Act, the Radiation Protection Act and the Radiation Protection Ordinance and further specified in the "Safety Requirements for Nuclear Fuel Supply Facilities" are achieved. The safety requirements also lead to concrete recommendations for action specific to fuel element production and uranium enrichment to meet the requirements for the necessary precautions against damage.

In accordance with the safety requirements for the fabrication of light water reactor fuel elements with low-enriched uranium as well as for uranium enrichment facilities according to the gas ultracentrifuge principle, the following basic protection goals arise:

- confinement, retention and shielding of radioactive materials,
- minimisation and control of the discharge of radioactive substances,
- minimisation and control of exposure and contamination of operating personnel,
- ensuring subcriticality,
- prevention of fire and explosion or their early detection and effective control,
- preventing a release of uranium hexafluoride,
- design appropriate to operation and maintenance in order to avoid contamination and keeping radiation exposure of operating personnel low, and
- compliance with radiation protection with a view to decommissioning and disposal of the facility.

The design of the facility must therefore comply with the protection goal "prevention of fire and explosion or their early detection and effective suppression", particularly with regard to a fire. Appropriate precautionary measures are therefore taken to prevent the development of a fire as far as possible. If a fire cannot be ruled out, it must be reliably detected, and firefighting must be carried out at such an early stage that a fire remains limited to an incipient fire and is extinguished.

According to the Land building regulations for fire protection, the following conventional protection goals must also be met:

- preventing the development of a fire,
- preventing the spread of fire and smoke,
- allowing the rescue of people (and animals), and
- allowing effective extinguishing operations.

Structural, operational and organisational measures to prevent, confine and suppress fires have been taken for the BFL and the UAG, taking into account the above-mentioned requirements (see Section 3 on the fire protection concept).

2.3.2 Key assumptions and methodologies

BFL and UAG

Methodically, the fire protection concept presents the means for fire prevention, the organisational and administrative fire protection concerns and the provisions relating to defensive fire protection as well as the structural fire protection means and the equipment-related fire protection provisions in accordance with the applicable legal regulations. The fire safety regulations as part of the operating manual specify the organisational and technical means required for fire prevention and effective fire suppression while taking into account criticality safety and radiation protection aspects. Should an individual fire protection means prove to be ineffective in the event of fire, compliance with the protection goals is still ensured by the entirety of all fire protection means.

Fire safety aspects are always taken into account during the planning of plant modifications. The work permit procedure ensures that fire safety concerns are accounted for all relevant activities.

BFL

The BFL fuel fabrication facility is designed in such a way that in the event of a fire, it is detected and extinguished at an early stage so that a fire is limited to an incipient fire. Extinguishing a fire in the initial phase is ensured by various measures, such as the redundant fire detection and alarm systems and the permanently present on-site fire brigade. Systems with safety relevance (e.g., fire detection and alarm systems) are redundant, parallel and completely independent of each other so that their functionality is ensured at all times.

UAG

The UAG uranium enrichment facility is designed in a way that in the event of a fire, it is detected and extinguished at an early stage so that a fire is limited to an incipient fire. Extinguishing a fire in the initial phase is ensured by various means, such as comprehensive fire protection monitoring (fire detection and alarm system) and the permanently present on-site fire brigade.

2.3.3 Fire phenomena analyses: overview of models, data and consequences

BFL

The event "fire in a fire sub-compartment" was considered in the event analysis of BFL since fires in a fire sub-compartment cannot be excluded.

In the case of the BFL, the event "fire in a fire sub-compartment" is not a design basis accident since the radiological accident effects are covered by other design basis accidents resulting, e.g. from a component failure and for which the dose level remains far below the accident planning level.

UAG

In the licensing procedure, two design basis accidents were taken as a basis for the design basis accident in the UAG from the accident analyses.

For the area of the uranium enrichment facility, the bounding fire event is determined by the fire of mineral oil of the closed valve heads of pumps in the container hall. For the area of the transfer station, the fire of a truck in the transfer station or in the truck passage in the "product storage" is assumed to be the bounding fire event.

Overall, the protection goal of preventing a major release of radioactive substances in the event of a local fire has been achieved. The protective measures of a structural, equipment related and organisational nature are designed in a way that the spread of fire in the event of a local fire is limited to one fire compartment.

2.3.4 Main results/dominant events (licensee´s experience)

BFL

In the event of a fire in a fire sub-compartment, there is no inadmissible release of radioactive substances. The dose level remains far below the accident planning level. The precautionary measures to minimise the occurrence of a fire, to limit the spread of a fire, and to ensure rapid fire detection and firefighting ensure that fires are extinguished in the initial phase.

UAG

The UAG's fire safety analyses show that, overall, the nuclear protection goals in normal specified operation as well as in design basis accidents are fulfilled in fire events. A local fire will not cause a major release of radioactive substances. Also, a local fire will be quickly detected and effectively suppressed by the operationally active and passive provisions systems. The protective means in terms of construction, plant engineering and organisation are designed in a way that the spread of fire is limited to one fire compartment.

2.3.5 Periodic review and management of changes

BFL and UAG

The fire protection of the BFL and the UAG is reviewed every ten years in each case in the frame of PSRs with a focus on the protection goals. Regular fire protection on-site inspections are carried out with the nuclear supervisory authority and the conventional authorities responsible for fire protection. The reports submitted are reviewed by the experts and concluded with subsequent plant inspections.

The fire safety regulations as part of the operating manual are subject to the operating manual amendment process. In the event of modifications, the fire safety regulations are updated and submitted to the nuclear supervisory authority for approval.

If changes are made to fire prevention and fire protection, the fire protection concept is updated and submitted to the nuclear supervisory authority for approval.

2.3.5.1 Overview of actions

In the frame of the PSR, compliance with the protection goals in case of fire was confirmed without recommendations at the BFL and the UAG. Thus, no measures had to be taken in both facilities.

2.3.5.2 Implementation status of modifications/changes

The procedure for modifications at both BFL and UAG is regulated in the operating manual. This includes modifications in the area of fire protection (structural, equipment related and organisational). Fire protection aspects are taken into account for all modifications.

In the framework of the supervisory procedure, the planned changes, including their realisation, are monitored.

2.3.6 Licensee's experience of fire safety analyses

BFL and UAG

The experience from the operation of the BFL and the UAG shows that effective measures exist with regard to fire protection. The measures regarding structural, plant, operational and organisational fire protection are suitable to meet the protection goals according to the safety requirements for nuclear fuel supply facilities.

2.3.6.1 Overview of strengths and weaknesses identified

BFL

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.

UAG

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 are applied at the UAG to maintain the high level of fire safety. In addition, 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).

During the PSR, compliance with the protection goals in the case of fire was confirmed without recommendations.

2.3.6.2 Lessons learned from events, reviews, fire safety related missions, etc.

BFL

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.

In the case of a fire in the laboratory area, the fire protection concept proved its effectiveness, as the fire did not spread and could be brought under control. The staffing of the on-site fire brigade and the alerting of external fire brigades was optimised by automatically forwarding a fire alarm to the responsible operations control centre, so that a fire can be extinguished at an early stage. A transferability test was carried out, which included an extensive check of the electrical heaters in the nuclear fabrication building for the presence of combustible materials in the vicinity and, if necessary, an assessment of the effectiveness of tests and interlocks.

Information notices 2013/02, which concerned deficiencies at fire doors of certain construction types, and 2016/14, which was due 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 fire protection officer conducts regular inspections of fire prevention and the other fire protection measures taken. Regular fire protection inspections are also carried out with the nuclear supervisory authority and the authorities responsible for fire protection.

Deviations and events including relevant information notices (see Appendix A2) are systematically investigated and precautions against recurrence are implemented with regard to fire prevention.

Events are systematically analysed and precautions against recurrence are implemented regarding fire prevention and defensive fire protection measures (see paragraph 2.3.4).

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 of defensive fire protection and identified improvements are implemented.

During the first PSR, the implementation of the fire prevention provisions was positively assessed.

UAG

In the past, there were only small fires in the UAG that were detected at an early stage by the fire detection technology and self-extinguished or were extinguished by the deployment of operating personnel.

Events are systematically analysed and optimisations derived from the investigation are added to the preventive and defensive fire protection provisions.

- In the case of a fire at the ANF fuel fabrication facility, 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.
- Regular plant walk-throughs are conducted by the fire protection officer, with participation of the nuclear supervisory authority, for preventive fire protection.
- Events found during these checks are systematically evaluated and optimisations derived from the investigation are added to preventive and defensive fire protection provisions.

Further information notices relevant with respect to fire protection (see Appendix A2) have led to a continual improvement of fire safety.

For example, following information notice WLN 2008/07, additional smoke detectors were installed in the supply air ducts of the ventilation system of the control rooms in one of the uranium separation facilities.

No anomalies have been observed from the operating experience to date. Therefore, no recommendations have resulted from the safety-related evaluation of operating experience in the frame of the PSR.

Experiences from regular exercises with external fire brigades are evaluated to further improve fire prevention and improvements identified are implemented.

Operating experience shows that the fire prevention provisions applied are fully effective. The protection goal of fire prevention is comprehensively achieved by the structural, operational and organisational measures.

Experience shows that the above-mentioned protection goals are met if the preventive and defensive fire protection provisions are implemented. In the event of a fire, the fire is limited to the location of its origin and the protection goals are met.

During the PSR, the implementation of the fire prevention provisions was positively assessed.

2.3.7 Regulator’s assessment and conclusions on fire safety analyses

BFL

The presentations of BFL's fire safety analyses in paragraph 2.3 are correct from the viewpoint of the competent supervisory authority.

Fire protection was already considered in the design of the BFL and reviewed in subsequent nuclear licensing procedures with the involvement of expert organisations.

As part of the accident analysis, ANF investigated a local fire in a plant building in accordance with the "Safety Requirements for the Fabrication of Light Water Reactor Fuel Assemblies with Low Enriched Uranium". The results show that the event "fire in a fire sub-compartment" is not to be assigned to the design basis accidents due to the low radiological consequences. The results are clearly below the accident planning level for the effective dose of 50 mSv according to § 104 StrlSchV. Accordingly, the fire effects remain limited to areas separated by fire barriers due to the design of the plant.

UAG

For the design and construction of the UAG, the fire safety aspects were evaluated as part of the licencing procedure. The protective measures of a structural, equipment related and organisational nature as well as defensive fire protection are suitable for limiting the spread of fire to one fire compartment. Insofar as this does not already prevent the release of radioactive substances, the potential radiation exposures in the vicinity of the UAG are limited in a way that the accident planning levels for the effective dose and for the radiation doses pursuant to § 104 StrlSchV are not reached by far. With regard to fire protection, the UAG licensee meets the safety requirements for nuclear fuel supply plants based on the gas ultracentrifuge principle.

2.3.7.1 Overview of strengths and weaknesses identified by the regulator

BFL

On the occasion of the implementation of the first PSR of BFL, fire protection was also reviewed in the associated safety review with status of December 2021 and, as a result, no recommendations were formulated for the implementation of measures for fire safety optimisation at the facility.

In the nuclear supervisory procedure, fire safety is reviewed in case of any modifications to the plant or SSC potentially relevant to fire protection.

UAG

The licensee systematically analyses events in the UAG or findings from other facilities. In addition, the state of the art in science and technology is consistently monitored. As a result, the licensee regularly submits plans for modifications in order to optimise the plant's fire safety and updates the operating documentation.

Weaknesses have not been identified by the competent supervisory authority.

2.3.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

BFL

In the frame of nuclear supervision, regular inspections of the BFL are carried out with the authorised experts and the authorities responsible for conventional non-nuclear fire protection.

In case an findings regarding the status of fire protection, e.g. avoidable fire loads, are observed, they are fixed immediately by the licensee of the BFL. The nuclear supervisory authority convinces itself of the elimination of the findings at the next opportunity. In addition, inspections are carried out as required, e.g. in the case of modification applications with relevance to fire protection.

After the occurrence of reportable events, their cause is systematically analysed, measures are taken to remedy and, if necessary, optimise the situation, and an applicability check is carried out for other plant areas. The proper implementation of the required measures is ensured in regular supervisory meetings and through plant inspections by the nuclear supervisory authority with the authorised experts and their expert opinions.

After the fire in the laboratory area in 2018 (see the descriptions of ANF in paragraph 2.3.6.2), technical fire protection measures and extending the fire detection and alarm system to include automatic notifications to the operations control centre were carried out. Furthermore, by increasing the number of members of the on-site fire brigade and ensuring their constant readiness for action, the defensive fire protection of the site was improved. Overall, the reportable event was comprehensively dealt with and the necessary improvements were fully implemented.

Repeated inspections of fire detection and extinguishing systems and equipment, such as the fire detection and alarm system, are carried out with the participation of the authorised expert consulted by the nuclear supervisory authority. There were no complaints of any safety significance.

UAG

Regular fire safety analyses in line with the KTA Safety Standards are not required for the operation of the UAG. With regard to the 2011PSR, the statement of the licensee is confirmed that the implementation of the fire prevention provisions was positively assessed and thus no consequences regarding to fire protection resulted. After ten years, these measures are currently being reviewed again as part of the 2021PSR.

Fire protection inspections are carried out at regular intervals with the assistance of a fire protection expert, so that all plant areas relevant for approval are inspected over a period of two years. With the exception of easily fixed deficiencies, fire protection in the inspected areas was always unimpaired. Any identified deficiencies are corrected conscientiously and usually in a timely manner.

2.3.7.3 Conclusions drawn on the adequacy of the licensee's fire safety analyses

BFL

The fire protection of BFL is reviewed during the implementation of nuclear licensing procedures and permanently in the frame of nuclear supervision of fire safety.

The expert evaluation of the first PSR of the BFL, which was completed in 2021, also confirms the high fire safety level of the facility as well as compliance with the protection goals relating to fire protection.

The responsible supervisory authority has no indications of any safety deficits.

UAG

Experience during the operation of the UAG shows that the fire prevention provisions implemented are effective. The protection goal of fire prevention is achieved by the structural, operational and organisational measures. From a fire protection point of view, the walk-throughs of the nuclear supervisory areas did not lead to any findings that would have indicated a violation of the licensing conditions or requirements.

2.4 Dedicated spent fuel storage facilities

2.4.1 Types and scope of fire safety analyses

As part of the planning of the facility, a fire safety analysis was prepared by a specialist planner, which contains the basic requirements for preventive and defensive fire protection. The resulting measures form the basis for the fire safety concept and the fire safety regulations.

The fire protection measures serve:

- to prevent fires in the properties and installations,
- to prevent an inadmissible spread of fire,

- to protect people from the dangers of fire, and
- to prevent the release of radioactivity in the event or as a result of a fire.

In addition, fire hazards are determined and assessed at regular intervals, as well as in the event of modifications, by means of:

- workplace-specific risk assessments in accordance with the legal and internal regulations,
- activity-specific risk analyses based on the work permit procedure, as well as
- combinations of a fire with another event.

Within the scope of the licensing procedure and the preparation of the fire protection concept, combinations of a fire with another event were also considered. These include, for example, earthquake or aircraft crash with subsequent fire.

According to the national nuclear regulations, combinations of a fire with another event must be assumed if the events to be combined are causally related or if the simultaneity of the events must be considered due to the probability and the extent of damage.

A corresponding screening has shown that the combinations of a fire with another event are to be considered exclusively with regard to compliance with the fundamental safety functions (subcriticality, tight enclosure and heat removal). Fire protection measures have been taken for the applicable combinations, unless effective and reliable precautionary measures have already been proven to have been taken.

2.4.2 Key assumptions and methodologies

In the case of spent fuel storage facilities, ensuring fire safety is directly related to ensuring nuclear safety and radiation protection.

Compliance with fire safety standards is thus an essential means to ensure nuclear safety and radiation protection.

The basis for the safety analysis are:

- the Radiation Protection Act /BMJ 22/,
- the Radiation Protection Ordinance /BMJ 21/, and
- the analogous application of KTA 2101.1 "Fire Protection in Nuclear Power Plants" /KTA 15/.

2.4.3 Fire phenomena analyses: overview of models, data and consequences

In the spent fuel storage facilities, a design basis accident was assumed (fire of a loaded transport vehicle with the entire vehicle fire loads such as fuel, cables, paints and hydraulic oil; the event is modelled by a temperature impact on the containers of 800 °C for 60 min).

Overall, the protection goal of ensuring that no release of radioactive material occurs as a result of a local fire of the loaded transport vehicle has been achieved. The fire protection measures taken ensure that the safe confinement of the radioactive inventory in transport and storage casks remains ensured even in the event of fire. The precautionary measures to minimise the start of a fire, to limit the spread of a fire and to ensure rapid fire detection and suppression ensure that fires are extinguished in the early stages.

2.4.4 Main results/dominant events (licensee´s experience)

The main result of the fire safety analyses is that in the event of fire impacts, the statutory accident planning levels are complied with.

At the sites of the spent fuel storage facilities and at the adjacent site of the nuclear power plant, there is no contiguous tree population within the outer perimeter that could be affected by a wildfire. Suitable extinguishing means can effectively prevent the spread of a fire. Furthermore, due to the low fire loads in the vicinity of the spent fuel storage facility, in the facility itself and the possibility for the fire brigade to intervene, the spread of a fire to an adjacent building is not to be assumed.

The fire safety analysis of the spent fuel storage facility is evaluated below for the corresponding areas with regard to the special requirements from a nuclear point of view:

- Storage areas

  Due to the use of non-combustible or flame-retardant building materials in the storage areas and the limitation of the amount of combustible operating equipment to what is absolutely necessary for operation during the storage of the transport and storage casks in the spent fuel storage facility, there are only minor fire loads in the storage areas which do not pose any danger to the storage of the nuclear fuel.

- Loading area

  Due to the area-wide distribution of automatic fire detectors in the loading area, an incipient fire is detected at an early stage and can be fought by the operating personnel with mobile fire extinguishing equipment until the arrival of the fire brigade. The possible failure of control equipment (e.g. the container monitoring system) as a result of a fire is harmless from a safety point of view. In the loading area, in the worst-case scenario, the fire of a loaded transport vehicle with the entire vehicle fire loads must be considered. While the transport vehicle is in the loading area, operating personnel are always present so that fires that are just starting can be detected and effectively fought. In this way, a fully developed vehicle fire can be prevented. As a preventive operational fire protection measure, it is planned to uncouple the towing vehicle from the transport vehicle immediately after positioning it and to drive it out of the loading area. The check of the possible fire effects under these conditions has shown that the overall thermal load of the container is lower than the thermal load on which the container design was based. Furthermore, the fire is suppressed by the firefighting through the fire brigade. A release of radioactive substances is not to be expected.

  If there is no container transport or handling, there are only very low fire loads in the loading area. Partitioning the storage building into fire compartments prevents fires from spreading from one part of the building to adjacent parts.

Mobile fire extinguishers and an extinguishing water supply system with sufficient hydrants distributed around the spent fuel storage facility are available to the fire brigade for firefighting. These features are dimensioned according to the expected fire scenarios and enable rapid and effective firefighting.

The fire protection measures taken ensure that the safe confinement of the radioactive inventory in transport and storage casks (e.g. CASTOR® containers) is also ensured in the event of fire. The operational regulations for alerting and firefighting are in line with the requirements. The on-site fire brigade is responsible for firefighting and may be supported by the public fire brigade. In accordance with the operating manual and the fire safety regulations, the personnel entrusted with work in the spent fuel storage facility regularly receive fire protection training.

Fire safety analyses were carried out for the storage facilities. The fire protection measures implemented – as a result of the fire protection analyses – are documented in the operating regulations and are binding for all persons to apply. This means that, as a matter of principle, all work on the operating site of the spent fuel storage facility, on facilities that may affect the safe operation of the spent fuel storage facility, must be carried out in accordance with the work permit procedure with work orders. Within the scope of the technical clarification of work on the operating site, it is checked, amongst others, whether fire protection issues are affected during the performance of the work. If this is the case, measures are specified and described in the fire permit. The described measures must be implemented before the work starts.

2.4.5 Periodic review and management of changes

The fire protection of the spent storage facilities is reviewed every ten years as part of the PSR. Safety documentation and structures, systems and components important to safety are reviewed, taking into account regulatory changes and changes in the state of the art as well as technical standards and guidelines. Furthermore, the operating experience is evaluated, ageing aspects are examined and the incident and accident analysis is revised. In addition, regular fire protection plant inspections are carried out with the nuclear supervisory authority and the authorities responsible for fire protection. The current PSR for the ZLN spent fuel storage facility covers the review period from 1998 to 2020 and is awaiting final approval by the authority. The second PSR for the Biblis spent fuel storage facility is currently being prepared and covers the period from 1 January 2016 to 31 December 2025. The first PSR was completed in 2015 and covered the period from commissioning in 2005.

As part of the operating manual, the fire safety regulations are subject to the operating manual amendment process. In the event of modifications, the fire safety regulations are updated and submitted to the nuclear supervisory authority for review and approval.

If changes are made to the preventive and defensive fire prevention, the fire protection concept is updated and submitted to the nuclear supervisory authority for review and approval.

2.4.5.1 Overview of actions

For the Biblis spent fuel storage facility, the PSR confirmed compliance with the protection goals in the event of fire without recommendations for further measures.

In the current PSR of the ZLN, which is awaiting approval by the authorities, the fire protection organisation, the preventive and defensive fire protection provisions as well as the general safety management for the ZLN were examined. It concludes that the protection goals are met. No measures were specified.

2.4.5.2 Implementation status of modifications/changes

Modifications were not necessary for the Biblis spent fuel storage facility (see paragraph 2.4.5.1).

The current PSR of the ZLN is currently awaiting final approval by the authority. As of to date, no modifications or changes affecting fire safety have been specified.

The procedure for changes is regulated in the operating manual. This includes modifications in the area of fire protection (structural, equipment-related and organisational). Fire safety aspects are considered for all modifications.

In the frame of the supervisory procedure, the planned modifications, including their realisation, are monitored.

2.4.6 Licensee's experience of fire safety analyses

Experience has shown that effective fire protection concepts are in place at the spent fuel storage facilities. The structural, equipment-related, operational and organisational measures are suitable for meeting the protection goals in accordance with the safety requirements for the spent fuel.

2.4.6.1 Overview of strengths and weaknesses identified

The fire prevention provisions in the spent fuel storage facilities are effective and meet the legal requirements. The preventive and defensive fire protection provisions implemented were already considered in the design of the facilities and have proven themselves over the operating period to date. Even in the event of a fire, the release of radioactive substances is effectively prevented, and the protection goals are met. Potential weaknesses are identified at an early stage through the application procedure in the event of modifications and in the course of regular inspections and are fixed or compensated for through compensatory measures.

2.4.6.2 Lessons learned from events, reviews, fire safety related missions, etc., etc.

Regular inspections of the spent fuel storage facilities are carried out in accordance with operational regulations, e.g. the plant operating manuals, to check the effectiveness of preventive fire protection means (e.g. by the responsible fire brigade). In addition, an annual fire inspection is organised together with the supervisory authority and the authorised expert. The results are documented and, in case of deviations, measures are defined and implemented.

Regular drills are carried out with the responsible fire brigade. In addition, practical exercises in the use of fire protection equipment (e.g. fire extinguishers) and the alarm chains (alarm and evacuation exercises) are carried out regularly. Identified improvement measures are then implemented accordingly and incorporated into the operational processes. If the spent fuel storage facility is located in the direct vicinity of another nuclear installation (e.g. a nuclear power plant), joint exercises are also held.

The underlying procedure with regard to fire protection planning, licensing, operation and the regular review and updating of the preventive and defensive fire protection provisions has so far fully met the nuclear requirements. Changes require appropriate notification and are assessed in advance. If risks or weaknesses are identified, measures are initiated to counteract them.

So far, there have been no fires in the spent fuel storage facilities under consideration. In the event of a fire, this would be presented in a corresponding fire detection document and, after discovery, broken down in more detail with an incident report and reported to the authorities.

No other findings from events, reviews or "missions" related to fire protection are known. Fire protection was not explicitly addressed as part of the German ARTEMIS review missions dealing with the waste management side of the fuel cycle.

2.4.7 Regulator's assessment and conclusions on fire safety analyses

Fire protection was already taken into account during the planning and construction of the Biblis and ZLN spent fuel storage facilities. The licensee's statements on the fire safety analyses are correct. The examination in the licensing procedure showed that the fire protection concept for the Biblis spent fuel storage facility and the fire protection concept for the ZLN meet the requirements of the conventional building regulations as well as the nuclear law requirements.

Despite all fire safety precautions, fires were assumed in the licencing procedure as so-called "nevertheless incidents". The following fire events were postulated:

- the fire of a loaded transport vehicle with the entire vehicle fire loads,
- the crash of a military aircraft, and
- a fire in the neighbouring Biblis nuclear power plant or in the adjacent nuclear facilities of the ZLN, especially the radioactive waste storage facility.

The review has shown that even in these cases, the accident planning levels of § 49 StrlSchV (old; now § 104 StrlSchV) are complied with.

Fire protection is also reviewed as part of modification licensing procedures. The last licence for the Biblis spent fuel storage facility was issued by BASE on 19 December 2019. The last licence for the ZLN spent fuel storage facility was issued on 30 April 2010. No further fire protection measures were required under these licences.

2.4.7.1 Overview of a strengths and weaknesses identified by the regulator

The consideration of fire protection already during the design of the storage facilities at both sites was purposeful.

2.4.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

The fire prevention provisions implemented in the spent fuel storage facilities have proven themselves in operation. The PSR also did not reveal any weaknesses.

2.4.7.3 Conclusions drawn on the adequacy of the licensee's fire safety analyses

The results of the licensing and supervisory document reviews confirm the high, safety-oriented fire safety level of the spent fuel storage facilities at both sites under consideration. There are no indications of deficiencies important to safety.

2.5 Waste storage facilities

At the Biblis site, BGZ operates two storage facilities for radioactive waste, AZB 1 and AZB 2, where only the storage of waste takes place. In addition to the storage of radioactive waste, conditioning also takes place in the building of the storage facility North (ZLN).

2.5.1 Types and scope of fire safety analyses

As part of the planning of the facilities, a fire safety analysis was prepared by a specialist planner, which contains the basic requirements for preventive and defensive fire protection. The resulting measures form the basis for the fire safety concept and the fire safety regulations.

The fire protection measures serve:

- to prevent fires,
- to prevent an inadmissible spread of fire,
- to protect people from the dangers of fire, and
- to prevent the release of radioactivity in the event or as a result of a fire.

In addition, fire hazards are determined and assessed at regular intervals, as well as in the event of modifications/changes, by means of

- workplace-specific risk assessments in accordance with legal and international regulations, as well as
- activity-specific risk analyses based on the work permit procedure.

2.5.2 Key assumptions and methodologies

As the storage facilities for radioactive waste are subject to the scope of licensing for nuclear installations, ensuring fire safety must be seen in direct connection with the ensuring nuclear safety and radiation protection.

Compliance with fire safety standards is thus an essential measure to ensure nuclear safety and radiation protection.

The basis for the safety analysis are:

- the Radiation Protection Act /BMJ 22/,
- the Radiation Protection Ordinance /BMJ 21/, and

- the analogous application of KTA 2101.1 "Fire Protection in Nuclear Power Plants" /KTA 15/.

2.5.3 Fire phenomena analyses: overview of models, data and consequences

At the Biblis site, a local fire inside a fire compartment (highest fire risk though a burning transport vehicle in the loading hall upon delivery or dispatch) was assumed as a possible event for the intermediate waste storage facilities. A vehicle fire is immediately detected and fought by the permanently present personnel. The integrity of the containers on the transport vehicle is therefore not at risk. This fire event does not result in any radiological effects.

Overall, the protection objective that no release of radioactive substances occurs as a result of a local fire in the transport vehicle has been achieved. The fire protection measures taken ensure that the safe confinement of the radioactive inventory in waste containers remains ensured even in the event of fire. The precautionary measures to minimise the start of a fire, limit the spread of a fire as well as for rapid fire detection and firefighting ensure that fires are extinguished in the early stages.

For the ZLN, the accident analysis comes to the conclusion that the most serious safety impacts occur in the handling of other unsealed radioactive substances. This handling of combustible other radioactive substances only takes place in one area of the storage facility (caisson 2). In this area, conditioning work is carried out with a high-pressure press. When the high-pressure press is operated as intended, combustible waste, such as textiles, paper, foils, etc., is treated in addition to non-combustible waste. The waste can be delivered loose in plastic bags, in containers or in drums. A fire in caisson 2 (area of the high-pressure press and the drying plant) outside normal working hours, when no operating personnel can detect the fire in progress, was therefore investigated as a covering design basis fire event.

If a fire occurs during working hours, it is detected by the present operating personnel. The fire detection and alarm system triggers fire alarms at the fire alarm boards of the inner security checkpoint and at the on-site fire brigade via non-automatic (manual push-button fire detectors) and automatic fire detectors. Outside normal working hours, a fire is detected by the automatic fire detection and alarm system. The fire dampers of the ventilation system close automatically. The inner security checkpoint also informs the on-site fire brigade. In addition, the on-site fire brigade is to be alerted by the person(s) detecting the fire via an emergency call. Further fire alarms via the automatic fire detectors are possible. At the same time as the fire alarm is raised, the operating personnel will start fighting the fire using hand-held portable fire extinguishers. The alarmed on-site fire brigade arrives at the scene of the fire within 5 min. As soon as it is clear that the fire cannot be extinguished by means of the hand-held fire extinguishers, the operating personnel leave caisson 2 and close the doors and gates. The arriving on-site fire brigade decides on the spot about the use of the fire extinguishing systems of caisson 2. The behaviour of the forces of the fire brigade is laid down in the general arrangements drawing for the fire brigade and in the alarm printout of the hazard alarm system manager of the fire detection and alarm system. Two independent systems are available: a semi-stationary foam extinguishing system and a semi-stationary spraywater deluge system. The semi-stationary foam extinguishing system is used to extinguish fires in the event of an extensive liquid fire. The semi-stationary deluge system is used for fires involving solid waste. Since the combustible waste is handled over the entire caisson, the system covers the entire floor area of the room. Depending on the fire situation, the commander of the on-site fire brigade decides which extinguishing system is to be used. It is also possible to put both systems into operation. Since both systems are fed from the outside (from the loading hall) and the extinguishing nozzles are installed inside the caisson (on the ceiling or wall side), the caisson remains closed during the extinguishing work. In addition, it is cooled from the outside by spraying it with extinguishing water. Appropriate communication facilities, contamination protection equipment and means for monitoring operations are available for the protection of the fire brigade forces. If the on-site fire brigade cannot bring the fire under control with the available means, additional forces are alerted.

The likelihood of a fire starting outside normal working hours is low because there are no ignition sources in the caisson when the work is finished. In addition, all combustible waste is stored in closed containers or barrels after work is finished, so that no waste is present as an open fire load. Should a fire nevertheless start in caisson 2, it is detected by the automatic fire detectors of the fire detection and alarm system and a fire alarm is triggered in the fire alarm boards at the inner security checkpoint and at the on-site fire brigade.

2.5.4 Significant results/dominant events (experience of the licensee)

The fire safety analyses for the radioactive waste storage facilities AZB 1 and AZB 2 came to the conclusion that a local fire would not result in a major release of radioactive substances.

Due to the conditioning in caisson 2, the ZLN may have to deal with unsealed combustible radioactive materials. This is described in more detail in paragraph 2.5.3. As a result, it can be confirmed that even in the case of the design basis accident described there, the limits of § 104 StrlSchV /BMJ 21/ are clearly not reached. The protective measures of a structural, equipment-related and organisational nature are designed in a way that the spread of fire is limited to one fire compartment.

2.5.5 Periodic review and management of changes

PSRs have not yet been carried out for the radioactive waste storage facilities AZB 1 and AZB 2. The first PSRs are scheduled for 2025 (AZB 1) and 2028 (AZB 2).

The current PSR for the ZLN waste storage facility covers the review period from 1998 to 2020 and is currently being prepared. Safety documentation and SSC important to safety are examined, taking into account regulatory modifications and changes in the state of the art as well as to technical standards and guidelines. Furthermore, the operating experience is being evaluated, ageing aspects are being investigated and the incident and accident analyses are being revised. The results are used to develop an action plan as part of the report.

2.5.5.1 Overview of actions

Actions resulting from PSRs for radioactive waste storage facilities have not been identified (see paragraph 2.5.5).

2.5.5.2 Implementation status of modifications/changes

The procedure for modifications is regulated in the operating manual of the radioactive waste storage facilities. This includes modifications in the area of fire protection (structural, equipment-related and organisational). Fire safety aspects are considered for all modifications.

Within the framework of the supervisory procedure, the planned modifications, including their realisation, are monitored.

2.5.6 Licensee's experience of fire safety analyses

The experience of the licensees of the radioactive waste storage facilities shows that effective concepts exist with regard to fire protection. The structural, equipment-related, operational and organisational measures are suitable for meeting the protection goals in accordance with the safety requirements for the storage of radioactive waste.

2.5.6.1 Overview of strengths and weaknesses identified

The fire prevention provisions in the radioactive waste storage facilities are effective and meet the legal requirements. The preventive and defensive fire protection provisions implemented were already considered in the design of the facilities and have proven themselves over the operating period to date. Even in the event of a fire, the release of radioactive substances is effectively prevented, and the protection goals are met.

Potential weaknesses are identified and fixed at an early stage through the application procedure in the event of changes, as well as in the course of regular inspections, or compensated for through compensatory measures.

2.5.6.2 Lessons learned from events, reviews, fire safety related missions, etc.

Regular inspections are carried out in accordance with company regulations to check the effectiveness of preventive fire protection (e.g. by the responsible fire brigade). In addition, an annual fire inspection is organised together with the supervisory authority and the authorised expert. The results are documented, and measures are defined and implemented in case of deviations.

Regular drills are carried out with the responsible fire brigade. In addition, practical exercises in the use of fire protection equipment (e.g. fire extinguishers) and the alarm chains (alarm and evacuation exercises) are carried out regularly. Identified improvement measures are then implemented accordingly and incorporated into the operational processes. If the waste storage facility is located in the direct vicinity of another nuclear facility (e.g. nuclear power plant, fuel storage facility), joint exercises are also performed.

The underlying procedure with regard to fire protection planning, licensing, operation and the regular review and updating of the preventive and defensive fire protection provisions has so far fully met the nuclear requirements. Changes require appropriate notification and are assessed in advance. If risks or weaknesses are identified, measures are initiated to counteract them.

So far, there have been no fires in the waste storage facilities under consideration. In the event of a fire, this would be presented in a corresponding fire detection document and, if required, broken down in more detail with an incident report and reported to the authorities.

In a structurally separated administration and social building at the ZLN, there was a fire event in a server room due to a defective control element and heat accumulation. An event report was prepared for this event. The measures taken were recorded and implemented in a fire investigation report.

No other findings from events, reviews or "missions" related to fire protection are known. Within the framework of the German ARTEMIS review missions, which also deal with the management of radioactive waste, fire protection was not explicitly addressed.

2.5.7 Regulator’s assessment and conclusions on fire safety analyses

Fire protection was already taken into account during the planning and construction of the radioactive waste storage facilities. The licensee's statements on the fire protection analyses are correct.

2.5.7.1 Overview of strengths and weaknesses identified by the regulator

The consideration of fire protection already during the planning and construction of the radioactive waste storage facilities is purposeful.

2.5.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

The measures taken in the radioactive waste storage facilities have proven themselves in operation.

2.5.7.3 Conclusions drawn on the adequacy of the licensee’s fire safety analyses

The results of the licensing and supervisory document reviews confirm the high, safety-oriented fire safety level at both the Biblis and ZLN sites of radioactive waste storage facilities under consideration. There are no indications of safety-related deficits.

2.6 Installations under decommissioning

In this paragraph, only the Karlsruhe reprocessing plant (WAK) including the Karlsruhe vitrification facility (VEK) is considered.

Considerations for nuclear power plants and research reactors are given in paragraphs 2.1 and 2.2.

2.6.1 Key assumptions and methodologies

Due to the advanced stage of dismantling, there are only minor fire loads left in the WAK process building. Most of the technical equipment has been removed. Incipient and small fires are extinguished directly from the inside with available fire extinguishers. In the event of a fire, spreading of the fire to neighbouring buildings or the surrounding area is prevented by structural fire protection or sufficient distances at the outer boundaries of the process building.

Within the VEK, the principle is implemented to use only small quantities of small combustible substances and, where it is unavoidable and larger quantities are used, to protect them by appropriate measures.

An assumed fire can be controlled means of the fire detection and fire extinguishing provisions taken. During dismantling work, the use of electrically operated cutting tools is required. In one analysis, it was assumed that a fire could occur as a result. For the fire accident assessment, only the release into the plant is taken into consideration. The possibility of fire spreading to the environment can be excluded.

2.6.2 Types and scope of fire safety analyses

In addition to the requirements of conventional non-nuclear fire protection, the fire protection measures in the WAK also aim to protect the plant personnel and the environment from the radiological consequences to be considered in the event of an assumed fire.

Due to the status of the plant with fire compartmentation, early fire detection and a low quantity of combustible materials, only local small fires at dismantling locations are taken into account in the safety assessment; a probabilistic fire risk analysis is not available. A fire spreading across buildings can be excluded due to the distance to other buildings.

The safety of the entire WAK plant was last assessed in the "WAK Safety Report, Status 08/98" and is updated with the individual decommissioning licences.

2.6.3 Fire phenomena analyses: overview of models, data and consequences

The WAK/VEK safety report deals with accidents and their prevention. It also defines fire protection requirements that must be fulfilled in order to keep the fire consequences at a lower level.

During dismantling of the fixtures in the cells, aerosols are retained in the event of a fire by the use of cell pre-filter systems and the HEPA filters installed in the exhaust air system. Combustible electrical cables and hose lines are laid in the cells. They are disassembled into pieces in the course of the dismantling. For an assumed fire event of these combustible materials, a thermal impact lasting 60 min at 800 °C is assumed to be sufficiently conservative. The released activity inventory amounts to approx. 1 E+06 Bq. The released activity is filtered via the prefilters and the HEPA filters of the exhaust air system, which is designed and approved for the intended plant operation and discharged to the environment via the exhaust air stack. In the worst case, the activity discharge via the exhaust air stack is < 5 E+02 Bq. The accident planning levels are still not reached due to the retention by the filter section.

The following fire consequences are applicable to the WAK and VEK:

- The ventilation system would possibly be damaged or stopped due to the fire gases and smoke produced, as it is not designed to remove smoke. Since the ventilation is shut down when a fire is detected, this is not relevant.
- The affected area must be decontaminated with regard to the precipitation of fire gases and smoke. This leads to the deployment of personnel and the temporary cessation of dismantling activities.

- Due to the structure of the building and the low fire loads, damage to the statics of the WAK and VEK process building can be ruled out, depending on the duration of the fire and the resulting temperature.

2.6.4 Main results/dominant events (licensee´s experience)

The fire safety analyses for the WAK and VEK came to the conclusion that no inacceptable release of radioactive substances is to be expected in the event of fire. In the event of a fire, the accident planning levels are not exceeded.

2.6.5 Periodic review and management of changes

Since no PSR had to be carried out for the WAK and VEK yet, corresponding statements cannot be made. The fire safety regulations as part of the operating manual available at the WAK in accordance with the requirements of the Nuclear Safety Standards Commission (KTA) are adapted and updated in the frame of the official modification projects according to the respective plant state to be modified.

2.6.5.1 Overview of actions

In the case of modifications, the effects on existing fire protection features must always be assessed when the application is submitted. Due to the progress of dismantling and the on-site situation, fire protection features may also be removed in some places as a result of the dismantling progress.

Solid, combustible residues are collected in suitable residue containers. Since self-ignition of the container contents can be ruled out and no ignition sources are present, no fire can occur.

2.6.5.2 Implementation status of modifications/changes

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.

2.6.6 Licensee’s experience of fire safety analyses

In the frame of the decommissioning licences granted, safety reports and accident analyses were prepared and compliance with the legal requirements or with safety standard KTA 2101, Part 1 to 3 "Fire Protection in Nuclear Power Plants" /KTA 15/, /KTA 15a/, /KTA 15b/ respectively was checked and verified. In the frame of the supervisory procedures under nuclear law, safety assessments are also carried out, which also include a review of the fire protection requirements.

2.6.6.1 Overview of strengths and weaknesses identified

The measures taken for fire prevention and fire protection have already been taken into account in the design of the plant and proven themselves over the operating period to date. This has to be considered again with each plant modification. Even in the event of a fire, the release of radioactive substances is prevented and the protection goals are thus met.

Experience shows that effective fire protection concepts are in place. The structural, equipment-related, operational and organisational measures are suitable for meeting the protection goals in accordance with the safety requirements.

Weaknesses in the fire protection measures have not been identified.

2.6.6.2 Lessons learned from events, reviews, fire safety related missions, etc.

The experience of the WAK with regard to fire prevention provisions is consistently positive. All fires are described by the licensee and reported to the authority.

All plant internal fires must be reported in accordance with the applicable reporting regulations.

So far, there have been no major fires on the WAK and VEK premises. There have only been small fires caused by defective tools. All fires were reliably detected and quickly extinguished. There was no consequential damage.

During the reprocessing operation of the WAK, the occurrence of explosive atmospheres was to be expected due to the formation of radiolysis gas, the operation of electrolytic equipment, the use of strong acids and the handling of combustible liquids. These activities no longer take place due to the condition of the plant, so there are no more substances in the plant that could generate an explosive atmosphere.

There are no findings from international fire safety "missions" for the WAK.

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.

Events are investigated and precautions are implemented in the area of fire prevention and fire protection measures.

Experiences from the regular drills are evaluated for further improvement of defensive fire protection and identified improvements are introduced.

The underlying procedure with regard to fire protection planning, approval, operation and the regular review and updating of the preventive and defensive fire protection provisions show that the above-mentioned protection goals are met. In the event of a fire event, it is limited to the place of origin and the protection goals are met.

2.6.7 Regulator’s assessment and conclusions on fire safety analyses

The presentation in paragraph 0 is applicable to the WAK including VEK.

2.6.7.1 Overview of a strengths and weaknesses identified by the regulator

The safety analysis of 1998 showed that due to the condition of the plant (local small fires cannot be ruled out, but fire spread to other buildings is unlikely), a fire is controlled and contamination of humans and the environment as a result of a fire is not to be expected.

2.6.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

The modifications that occur as dismantling progresses are also reviewed by the competent supervisory authorities with regard to their impact on fire protection within the scope of modification notifications. Particular attention is paid to the aspects of ageing management and updates of documents.

2.6.7.3 Conclusions drawn on the adequacy of the licensee’s fire safety analyses

The analyses and measures of the facility described above as well as the accompanying supervisory review ensure that all fire protection requirements are met.

3 Fire protection concept and its implementation

A fire protection concept is the entirety of all necessary structural, equipment-related, organisational and administrative provisions that prevent the occurrence and spread of fires and enable the rescue of people in the event of fire.

The general protection goals for the technical design and operation of the installations and/or facilities considered in the NAR are as follows:

1. to prevent any unnecessary exposure to radiation or contamination of persons, material goods or the environment,
2. to keep any radiation exposure or contamination of persons, material goods or the environment as low as possible, taking into account the state of the art in science and technology and considering all circumstances of the individual case, even below the established limits;
3. when planning structural or other equipment-related protective measures against design-basis accidents, to take measures to limit radiation exposure due to the release of radioactive substances to the environment into account, notwithstanding requirement (1), considering the potential extent of damage.

On this basis, the general protection goals of fire prevention, early detection and effective fire suppression are derived.

In this context, it must be ensured that the following fundamental protection goals in terms of nuclear safety will not be impaired in the event of plant internal fires and their consequences:

- control of reactivity,
- cooling of the fuel elements and/or removal of the decay heat,
- confinement of the radioactive substances, and
- limitation of radiation exposure.

The following defence-in-depth fire protection measures in their entirety ensure compliance with the nuclear and conventional non-nuclear protection goals:

a) structural fire protection measures (paragraph 3.3),

b) equipment-related fire protection measures (paragraphs 3.2.1 and 3.2.2),

c) organisational and administrative fire protection measures (paragraph 3.2.3), and

d) defensive fire protection measures (paragraph 3.2.3).

For nuclear power plants under decommissioning, the defence-in-depth concept for fire protection measures to comply with the conventional protection goals principally remains valid.

The fire protection concept also takes into account the radiological safety objectives and thus aspects of radiation protection.

The fire protection concepts and their implementation are described in the next paragraphs.

3.1 Fire prevention

3.1.1 Design considerations and fire prevention means

Nuclear power plants

In order to prevent a fire from starting, fire loads and potential ignition sources must be limited to the extent needed for safe operation.

Unavoidable fire loads are:

- separated from unavoidable potential ignition sources, as far as possible by design and the requirements for operation of the equipment, in such a way that ignition of these fire loads is prevented and separated in such a way that persons in secured areas (e.g. in necessary stairwells or airlock vestibules) cannot be endangered, and
- principally segregated in a way that the safety system and the emergency equipment cannot be inadmissibly impaired. If such a separation is not practicable for engineering reasons or due to operational needs, other fire protection measures are available to achieve an equivalent level of protection.

If unavoidable fire loads are present that are not encapsulated, measures are taken to minimise the development of smoke (e.g. through the selection of suitable building materials).

Research reactors

Fire prevention takes place at the research reactors in accordance with the recognised principles of the defence-in-depth safety concept. The following rules apply and are set out in the fire protection concepts and the fire safety regulations in the operating manuals:

- Fire loads are minimised and, if necessary, encapsulated and minimised with regard to smoke development.
- Fire loads are separated from each other as far as possible or stored in different fire compartments. The combustible gases of the cold source are stored in a double enclosure, other combustible liquids or gases are stored in fire-resistant cabinets for dangerous substances and are only openly available on site in daily quantities (usually not more than 1 l). Radiolysis gases produced in the protective gas system (D_2O systems) at the FRM II are recombined by feeding in oxygen well before explosive mixtures are formed.
- Before introducing fire loads into sensitive areas, an assessment by a fire protection officer and, if necessary, the approval of the plant management is required.
- Rooms or containers containing combustible gases are inerted as far as practicable or have a double enclosure (e.g. gas rooms of the cold source).
- Potential ignition sources are minimised and separated from fire loads as far as possible, and hot work is managed under the work permit procedure (FRM II) or by a specific permit (FR MZ).
- In the context of non-essential modifications, fire protection aspects are taken into account according to the modification order of the operating manual.

- Appropriate extinguishing provisions are provided on site, adapted to the unavoidable or operationally necessary fire loads. Monitoring with a direct alert of the on-site fire brigade and/or the professional fire brigade is ensured at all times.

Starting with fire prevention, the aspects of fire protection are analysed in the course of construction or modification of experimental facilities.

Fuel cycle facilities

BFL

Fire protection at the BFL is regulated on a high level in a fire protection concept and in the fire safety regulations laid down in the operating manual. The fire protection concept describes the provisions for fire prevention, the organisational fire protection issues and the provisions for defensive fire protection as well as the structural and equipment-related fire protection means in accordance with the applicable legal provisions (see paragraph 3.3.1.1). The fire protection concept specifies that the fire protection and fire suppression means meet the entire protection goal-oriented requirements of the nuclear regulations.

The fire protection concept of BFL specifies the safety requirements for the fabrication of light water reactor fuel elements with low-enriched uranium contained in the Reactor Safety and Radiation Protection Manual (RS Manual). The protection goals presented in the aforementioned manual result in the additional measures that can be derived from the Land building regulations and the rules derived from them that are necessary due to the special type or use of the facility and require rules derived from this so that the special protection goals can be met.

In order to achieve the protection goal of preventing incipient fires, various principles and precautionary measures are applied. These include:

- structural means related to the design of the buildings,
- the use of non-combustible building materials or generally flame-retardant, unavoidable combustible building materials,
- the formation of fire compartments and fire sub-compartments to confine fires,
- the prevention of fire spread through appropriate structural measures, also via the ventilation systems, e.g. through the implementation of fire dampers in the supply air ducting,
- a stockpiling of limited quantities of combustible substances at the workplaces, if necessary, in specially designed non-combustible containers,
- limiting fire loads to the minimum necessary,
- minimisation of large quantities of combustible operating materials or their safe storage and control,
- minimisation of fire loads and potential ignition sources,
- appropriate design and operation of the systems,
- the storage of combustible operating materials outside the production building.

UAG

The concept of the plant-specific fire protection at the UAG is based on:

- fire prevention through preventive fire protection means,
- early fire detection, and
- effective fighting of incipient fires.

Fire protection at the UAG is regulated on a higher level in a fire protection concept and in fire safety regulations.

The safety requirements for nuclear fuel supply facilities based on the gas ultracentrifuge principle contained in the RS Manual are laid down in the fire protection concept of the UAG. The protection goals presented in the RS Manual result in the additional measures that can be derived in accordance with the applicable Land building regulations and the rules derived from them that are necessary due to the special type or use of the plant so that the special protection goals can be met.

In order to achieve the protection goal of preventing or making the development of fires more difficult and limiting the spread of fire, various fire protection measures are applied. These include:

- the structural design of the buildings (use of non-combustible building materials),
- rooms and areas with special hazards (electrical rooms with high-voltage components, transformers, components of gas systems for combustible gases, radiation protection areas),
- minimising fire loads and potential ignition sources,
- performing hot work under the work permit procedure,
- stockpiling of combustible substances at the workplace to the smallest quantities,
- the storage of combustible substances only in flame-resistant, tightly sealable containers,
- the storage of larger quantities of combustible operating and auxiliary materials separated from installations containing radioactive material in terms of fire protection,
- check/control of the fire loads by the fire safety officer,
- prohibition of smoking in the production buildings.

On-site spent fuel and radioactive waste storage facilities

Preventive fire protection covers measures to prevent a fire and the spread of a fire as well as to secure access and escape routes. It also provides the conditions for effective defensive fire protection. The concept is based on a combination of structural, equipment-related, and organisational and administrative provisions including:

- structural fire protection means: partitioning of buildings into fire compartments as well as the installation of access and escape routes and the selection of suitable building materials,
- equipment-related fire protection features: installation of fire detection and alarm systems and suitable fire extinguishing systems,

- organisational and administrative fire protection measures: organisational and administrative measures for fire protection (fire safety regulations) as well as the administrative selection of the operating equipment to minimise fire loads and the involvement of the fire brigades.

The requirements for fire protection are derived from the applicable laws, statutory ordinances, administrative provisions and the recognised engineering standards and thus result in the following protection goals and requirements:

- preventing the occurrence of fires through the use of non-combustible or flame-retardant building materials and operating equipment,
- limiting the amount of combustible operating equipment to the amount necessary for operation,
- limiting fires to plant areas through appropriate structural means (partitioning into fire compartments),
- rapid detection and localisation of fires through appropriate fire detection features,
- rapid and effective fire suppression,
- training of plant personnel with respect to fire protection,
- providing access and escape routes for rescuing people and fighting fires,
- in-service inspections of structural and equipment-related fire protection features,

The preventive fire protection means aim at preventing fires from starting and to prevent a spreading of those fires occurred. This requires protective means for buildings as well as for mechanical and electrical components. Preventive fire protection includes the minimisation of fire loads. Therefore, non-combustible building materials corresponding to building material class A are used as far as possible to minimise fire loads.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK including VEK.

Fire protection is comprehensively described in the fire protection concept and in the fire safety regulations laid down in the WAK operating manual including the VEK. The concept of plant-specific fire protection is based on preventive fire protection measures, an early and reliable fire detection and an effective fighting of incipient fires as well as measures of defensive fire protection.

The purpose of the fire protection measures at the WAK and VEK is to ensure the safety of the personnel and the environment both from the direct effects of this damaging event and from possible consequential effects. Furthermore, radiological safety objectives must be ensured in addition to the conventional protection goals. In the case of the WAK, these are the "confinement of radioactive materials", the "limitation of radiation exposure" and the "protection of persons working there" according to KTA 2101.1 /KTA 15/.

In the process building, radioactive substances are present as loose contamination on buildings or existing fixtures. Incipient fires must be extinguished by means of available fire extinguishers; self-protection of personnel has priority; in case of fire, the area must be evacuated immediately. If a fire is reported (by staff or by triggering an automatic fire alarm), the on-site fire brigade is automatically alerted. The hazard groups for operations are hazard group III within controlled or restricted areas, and hazard group I in the supervised area or other areas on the premises.

The WAK operating manual covers respective specification in the fire safety regulations and alarm regulations.

To prevent fires from starting and spreading, the following provisions are implemented:

- application of the work permit procedure with the participation of the respective departments,
- preparation of risk assessments before the entire work is started,
- minimisation of the use of combustible materials,
- fire protection separation/segregation,
- automatic closure of the ventilation system in the event of an alarm by the fire alarm board resulting from an automatic actuation of a fire detector or a manual actuation of a push-button detector,
- avoiding the presence of dangerous substances within the plant,
- as far as possible clear arrangement of operational equipment and workplaces,
- collecting of combustible waste in non-combustible, tightly sealed waste containers,
- obtaining a specific hot work permit.

3.1.2 Overview of arrangements for management and control of fire load and ignition sources

Nuclear power plants

Permanent fire loads have already been minimised as far as possible during the development of the design concept. In principle, non-combustible building materials have been used. Unavoidable combustible building materials are always flame-retardant. However, there are unavoidable combustible materials representing negligible fire loads, e.g. flange gaskets, labelling plates and paints on plant components.

Modifications to the design condition are also always assessed regarding their relevance for fire safety within the framework of modification procedures. The principle of minimising fire loads and potential ignition sources is maintained.

Regulations exist for minimising temporary fire loads and potential ignition sources, in particular the following:

- Workplaces must be kept clean. All materials must be removed at the end of work.
- Combustible waste is collected in suitable non-combustible closed containers which are emptied regularly.
- Work with potential ignition sources, e.g. welding, requires a hot work permit specifying the necessary fire protection means.

- Hot work must be avoided as far as possible. If hot work cannot be avoided, precautions will be taken, such as
  - prior removal of fire loads,
  - design of fire mats,
  - provision of portable fire extinguishers, and
  - provision of fire watches.

Compliance with the regulations is ensured, amongst others, by

- training of personnel,
- on-site monitoring through programmes such as "Managers in the field" as well as through occupational health and safety professionals, and
- regular fire safety-specific site walk-throughs.

With regard to organisational fire protection, the essential fire prevention means, e.g. management of combustibles, remain in place during hot work until fire loads are no longer present in the plant or also in individual building areas.

Research reactors

FR MZ

The fire safety regulations also regulate the prescribed fire protection instruction as part of the first mandatory radiation protection and safety instruction by the Radiation Protection Department and on fire protection by the fire protection officer. Workplace-related safety and fire protection training is provided by the direct supervisor. Updated training regarding radiation protection and safety instruction is carried by the radiation protection officer as part of the mandatory annual training and regular fire protection instructions. These instructions are documented by signature and certification documents are kept. Part of these instructions is providing information on handling potential ignition sources, on combustibles and on the avoidance of unnecessary fire loads. The preventive fire protection provisions are monitored through regular walk-throughs by the fire protection officer of the Mainz research reactor.

In addition, there is an opportunity for the employees to participate in a training course conducted by the Mainz fire brigade at irregular intervals, where they can learn how to fight a fire professionally by means of a hand-held portable fire extinguisher.

FRM II

Permanent fire loads have already been minimised as far as possible during the development of the design concept. In principle, non-combustible building materials have been used. Unavoidable combustible building materials are always flame-retardant. However, there are unavoidable combustible materials representing negligible fire loads, e.g., flange gaskets, labelling plates and paints on plant components.

Modifications to the design condition are assessed within the framework of modification procedures.

There are regulations for minimising temporary fire loads and potential ignition sources, in particular the following:

- Workplaces must be kept clean. All materials must be removed at the end of work.
- Combustible waste is collected in suitable non-combustible closed containers which are emptied regularly.
- Work with potential ignition sources, e.g. welding, requires a hot work permit specifying the necessary fire protection means.
- Hot work must be avoided as far as possible. If hot work cannot be avoided, precautions will be taken such as
  - prior removal of fire loads,
  - design of fire mats,
  - provision of portable fire extinguishers, and
  - provision of fire watches.

Compliance with the regulations is ensured, amongst others, by:

- training of personnel,
- the safety officers/fire safety officers,
- site inspections by the authorised expert in accordance with § 20 of the Atomic Energy Act with respect to fire safety, and
- regular fire safety-specific walk-throughs.

Fuel cycle facilities

<u>BFL</u>

At the BFL, attention is paid to minimising fire loads. Combustible material that is not (or no longer) needed is removed from the buildings or areas.

Storage containers, transport pallets and other material required for handling are made of non-combustible materials, preferably metal.

The operationally admissible fire loads are shown in tabular form in the fire safety regulations. Compliance with the maximum additional fire load quantities in the buildings admitted is regularly checked and documented by the fire protection officer and compared with the information in the fire safety regulations. If the admissible fire loads are exceeded, the fire protection officer takes measures to reduce the combustible inventory to the admissible level. The fire loads are also checked as part of regular fire protection walk-throughs with the participation of the nuclear supervisory authority and the authorities responsible for fire protection.

Required hot work with open flames or potential ignition sources, e.g. welding, cutting, grinding, soldering, on the entire site may only be carried out after approval by the department of plant and operational safety. Work on electrical equipment may only be carried out by electrical specialists after approval or by the commissioned electrical specialists of external companies.

UAG

In the design phase of the UAG fire protection concept, the fire loads were minimised as far as practicable. The inventory of fire loads is used for risk assessment of the fire protection situation in the individual fire compartments and/or areas separated by fire barriers within the fire compartments. In the event of modifications in the buildings or during in-service inspections, the inventory of fire loads is adjusted.

The listing of fire loads and the assessment in accordance with the industrial buildings directive are carried out particularly for those areas for which a risk assessment is required if a release of radioactive substances to the environment must be assessed in the event of fire.

Regulations for minimising temporary fire loads and potential ignition sources are laid down in the operating manual, including the following:

- smoke prohibition in the production buildings,
- tidiness and cleanliness of the workplace,
- presence of combustible substances only in the smallest necessary quantities that do not exceed the daily requirements,
- storage of combustible substances only in flame-retardant, tightly closable containers that can withstand the expected mechanical stresses,
- safe disposal of combustible substances after use without delay,
- regular training of personnel regarding fire protection provisions,
- regular fire safety walk-throughs.

On-site spent fuel and radioactive waste storage facilities

In principle, preventive fire protection measures are intended to prevent the occurrence of fire as far as possible and to prevent the spread of fire. Preventive fire protection includes minimising fire loads. In principle, non-combustible building materials were used. Where these materials were not available, hardly inflammable building materials were used and, in exceptional cases, normally flammable building materials. Easily flammable building materials were not used.

The preventive fire protection means are further subdivided into three major areas. These are structural fire protection, equipment-related fire protection, and organisational and administrative fire protection.

Storage of radioactive waste at the storage facility North

For operational reasons, particularly due to the waste conditioning at the site, the following additional significant fire loads exist in addition to those typical of storage facilities:

- combustible raw waste in sealed 20' containers,
- lubricating oil for machines, crane systems, etc.,
- hydraulic oil for the FAKIR press and scrap shear,
- hydraulic oil for the lifting system,

- cable insulation material,
- technical gases.

Potential ignition sources include:

- mechanically generated sparks,
- short circuits, sparking on electrical equipment and lines,
- overheating of drives, electric motors, etc.,
- open flames.

Regarding radioactive substances, combustible and other radioactive substances are stored in the hall areas in a way that they are not to be listed as a fire load application of DIN 18230, since the containers remain tight even in the event of fire. Thus, a fire does not reach the substances. The operational regulations stipulate that in the close vicinity of the storage inventory combustible other radioactive substances may only be stored in suitable containers.

For all maintenance, modification and conditioning measures, a hazard assessment and derivation of administrative/technical measures for preventive/reactive fire protection is carried out as part of the work permit procedure including the following:

- deriving fire protection measures for workplace equipment (occupational health and safety management manual), and
- deriving fire protection measures prior to the start of work (maintenance rules),

To prevent ignition sources, all electrical equipment is tested regularly. The tests are documented. The handling of unsealed combustible radioactive materials takes place exclusively in caisson 2/2a. The storage of the radioactive combustibles takes place in containers, and the mass is administratively limited to the fire load accounted for in the fire load inventory.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK including VEK.

<u>WAK including VEK</u>

To ensure tidiness and cleanliness at the workplaces of the WAK and VEK, the following aspects must be considered in particular:

- operating facilities and workplaces must be arranged as clearly as possible,
- empty packaging material must be removed at the end of work and stored in a safe place,
- flammable waste generated must be collected in non-combustible, tightly sealing waste containers.

In addition, it is prohibited to introduce packaging material into controlled areas. This material should be removed beforehand, if possible, and disposed of appropriately. This is laid down in WAK's fire safety regulations and is part of the annual fire safety instructions for the plant personnel.

Furthermore, the maintenance regulations of the operating manual state that other personnel working in the facility must have higher levels of knowledge (e.g. work supervisors in the sense of the work permit procedure implemented at the WAK). Thus, the required behaviour of the persons responsible for work in the controlled area and the measures taken to prevent fire or to minimise fire loads in the work area are additionally ensured.

3.2 Active fire protection

3.2.1 Fire detection and alarm provisions

3.2.1.1 Design approach

Nuclear power plants

In compliance with KTA 2101 /KTA 15/, /KTA 15b/, a fire detection and alarm system for early fire detection and alarm is implemented with automatic fire detectors and/or manual fire alarm push-buttons. Scope and arrangement of fire detectors depend on the following aspects:

- fire load,
- arrangement of combustible materials in the rooms,
- fire characteristics (flame spread, smoke development) of the combustibles,
- room geometry and ventilation conditions,
- safety significance of systems or components to be monitored,
- personal protection (ensuring rescue), and
- actuation criteria for fire protection features.

Automatic fire detectors are located, in particular, in each of the following areas or in areas with the following systems and equipment:

- switchgears, converters,
- cabinets for instrumentation and control equipment,
- telecommunication centres,
- process computers,
- transformers installed inside buildings,
- stationary battery installations,
- diesel generators including fuel storage,

- large assemblies of cables (especially cable cellars, cable penetrations, cable shafts, cable floors, cable rooms),
- control rooms that are not permanently staffed (this also includes the area behind the control panels as well as the local control rooms, the emergency control room and the control room annexes),
- storage area for fresh fuel,
- area for storage and handling of combustible active waste in the waste storage facility,
- other storage areas for combustible substances, e.g. oil storage,
- decontamination room,
- hot workshops,
- oil-lubricated components with oil filling or oil supply, e.g. the turbo set (for BWRs), the reactor coolant pumps, the feedwater pumps, the main condensate pumps, the safety injection pumps, the high-pressure injection pumps,
- ventilation centres, including, if applicable, filter chambers and air ducts of recirculation systems,
- other significant rooms and rooms at risk of fire that are not accessible during operation.

The fire detection and alarm system ensures the timely localisation of a fire with indication at the fire alarm boards. The necessary display and operating devices are located at a permanently staffed location, e.g. the main control room.

For fire detection and alarm systems in buildings that also contain emergency equipment, a visual and acoustic group alarm for fire and malfunctions of the fire detection and alarm systems is additionally located in the emergency control room.

Devices for alarming in case of fire are triggered automatically or manually. In the case of manual triggering, there is a triggering point located at a permanently staffed location, e.g. the control room.

Fire detection and alarm systems as well as automatically actuated fire detection features are available at the beginning of the dismantling and initially remain in place. Successive removal must take into account individual boundary conditions.

First of all, it is be noted that, as part of the reduction of fire loads, fire detection and fire alarming are shifting during dismantling from automated systems to human detection and alarming. Compliance with conventional building code requirements continues to be ensured.

However, fire detection features remain necessary in some cases also during dismantling, especially as a compensatory measure in room areas with long access and escape routes. The fire detection and alarm system can detect the fire at an early stage and thus accelerate the evacuation of the affected room areas.

Of the room areas mentioned in the above list that are to be provided with automatically triggering fire detectors, many are associated with locally increased fire loads (cable shafts, large assemblies of cables, oil-supplied aggregates) or locally increased ignition probability (converters, large assemblies of cables). After removal of the locally increased fire load (draining of lubrication oil systems) or elimination of the locally increased ignition probability (e.g. disconnection of power cables), the automated alarming required according to KTA 2101 /KTA 15/, /KTA 15b/ will not be necessary. Compliance with conventional building code requirements must still be ensured.

Research reactors

For the design of the fire detection features, KTA 2101.1 /KTA 15/ is applied analogously for both research reactors within the frame of a "graded approach". Furthermore, recognised engineering standards, such as DIN standards, VDE and VdS guidelines, apply.

FR MZ

The research reactor of the University of Mainz has a fire detection and alarm system with automatic notification to the professional fire brigade of the city of Mainz as well as to two lines of the permanent on-call service team of the FR MZ. In addition, there is an acoustic alarm in the reactor building and in all parts of the building. The fire alarm is also forwarded to the main gate of the University of Mainz. The fire brigade information centre with the fire alarm board is located in the vestibule/entrance area of the old building. It contains the fire brigade control panel, the fire brigade display panel and the fire brigade route maps.

FRM II

The rooms at the FRM II are area-wide equipped with suitable fire detectors that trigger an alarm directly at the on-site fire brigade and in the control room. Both locations are staffed 24/7. The fire detection and alarm system is protected by emergency power backup. The fire alarm board is located in a room that is also monitored by fire detectors. Faults in the fire detection and alarm system are reported automatically, and a fault-clearing service is available to rectify them.

A manual alarm is possible at any time via a single number on all stationary and/or mobile phones. In addition, manual push-button fire detectors are available.

If necessary, fire watches are provided and/or patrols established. Faults in the extinguishing water supply and other equipment for fire monitoring and fighting will be dealt with in accordance with the operating manual and in consultation with the fire brigade.

The on-site fire brigade will be at the fire location within 8 min at the latest. If the situation requires, additional fire brigades can be alarmed.

Fuel cycle facilities

BFL

The fire detection and alarm system of the BFL comprises the technical equipment for the area-wide detection and alarm of incipient fires through automatic fire detectors suitable for the area within the buildings of the BFL and consists of several fire detection and alarm systems. The fire detection and alarm systems of the buildings used for nuclear purposes are designed redundantly such that a reliable and rapid detection and alarm of incipient fires is still ensured also in the event of a failure of one of the two independent fire detection and alarm systems. Manual fire alarm push-button detectors are installed in corridors, stairwells, and in access and escape routes.

BFL's fire detection and alarm system complies with the requirements of the conventional non-nuclear regulations, From a technical point of view, it consists of four individual fire detection and alarm systems due to the partially redundant design and the building structure. The requirements of an area-wide automatic fire detection and alarm system (category 1 – full protection") according to DIN 14675 are met by the fire detection and alarm systems.

The external fire brigade is automatically alerted after a delay of 180 seconds, provided that investigating the fire by the on-site fire brigade has not resulted in a false alarm or self-extinguishing of an incipient fire.

In the event of an alarm, the fire detection and alarm systems perform automatic switching actions (fire case matrix), such as closing fire dampers or stopping parts of the ventilation system, in order to ensure compliance with the protection goals in the event of fire.

UAG

The fire alarm system of the UAG is designed in accordance with the requirements of conventional non-nuclear regulations. The requirements of an area-wide automatic fire detection and alarm system (category 1 – full protection") according to DIN 14675 are met by the fire detection and alarm system.

The on-site fire brigade is alerted manually by the shift personnel at the central control room after receiving and evaluating the alarm from the fire detection and alarm system.

To confine fires and to prevent smoke from spreading, automatic fire controls, such as closing fire dampers or fire doors, or shutting down ventilation systems, are actuated via the fire detection and alarm system.

On-site spent fuel and radioactive waste storage facilities

Storage at the Biblis site

The equipment-related fire protection means include features for fire detection and alarm, fire suppression means and ventilation systems as well as equipment for heat and smoke removal.

Regarding equipment-related fire protection measures and the way they are actuated or triggered, the absence of feedback effects on the required safety functions is ensured, also taking into account possible event combinations. Insofar as fire suppression means are needed to ensure the required function of the safety system or the emergency system in the event of fire, the functional availability of the required fire protection provisions has been demonstrated. At the spent fuel storage facility, the focus of the equipment-related fire protection means is on the ventilation systems, the gas cylinder storage as well as on the fire detection and alarm systems.

An automatically actuated stationary fire detection and alarm system is used for fire detection. It has a systemic non-interruptible power supply with a backup time of 30 hours. In the technical equipment rooms as well as in the diesel and tank room, there is comprehensive monitoring by means of automatic fire detectors. In addition, push-button detectors are installed at central locations.

The fire detection and alarm systems of the spent fuel and radioactive waste storage facilities comprise the technical equipment for an area-wide detection of incipient fires with automatic fire detectors inside the buildings suitable for the fire locations. It consists of several fire detection and alarm systems. Manual fire alarm push-button detectors are installed in corridors, stairwells, and in access and escape routes.

Fires are signalled on the central control panel of the fire detection and alarm systems at a permanently staffed location in security centre.

In the event of fire, staff of the security guard service will be alerted by means of an acoustic alarm signal in accordance with the alarm regulations, which are part of the operating manual.

Spent fuel and radioactive waste storage at the storage facility North

In terms of fire protection, the hazard alarm system is understood as the fire detection and alarm system according to DIN 14675-1, -2 with the connected detection elements, the fire alarm boards and/or panels, the engineering controls as well as the alarm devices. The fire alarms are signalled at a permanently staffed location. After receipt of the alarm, the procedure is continued in accordance with the alarm and reporting regulations. In case of danger, all persons in the building are warned and the on-site fire brigade is alerted.

Fire detection and alarm enables an early localisation of the source of a fire so that a spread of the fire can be prevented, e.g. through the targeted use of extinguishing media. With the exception of the halls, the washrooms, anterooms and the toilets, an area-wide monitoring is ensured for all rooms. In addition, manually actuated detectors (push-button detectors) are installed at central locations.

When planning the fire detection and alarm system, the following basic principles were realised with regard to fire detection:

- Automatic fire detectors for an early detection of fires were installed in all rooms with an increased fire load.
- The alarm verification is carried out in 2-detector or 2-group dependency and leads directly to an alert of the on-site fire brigade.

The actuation of the fire detectors triggers an alarm for the monitored area so that the affected area can be localised immediately, and fighting of the reported incipient fire can start in a targeted manner. Type and arrangement of the detectors are planned, taking into account the fire loads to be monitored, the spatial conditions and the environmental influences. The automatic and non-automatic fire detectors are included in the fire protection plans.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

For the early detection of fires, all building areas of the WAK and VEK are monitored by an automatic fire detection and alarm system covering the entire area. Automatic detectors (with optical smoke detectors, heat detectors) and manual fire detectors (push-button detectors) are used. The fire detectors of a fire compartment are combined into at least one detector group. The manual fire alarm push-button detectors are installed at central locations (such as exits, entrances, stairwells, corridors) along the access and escape routes.

All fire alarms triggered by automatic detectors and/or manual fire alarm push-button detectors are displayed on the fire alarm board of the WAK security centre and processed by the security guard service. Each fire alarm received by the fire alarm board is automatically forwarded as a group alarm to the KIT CN alarm control centre. The buildings and rooms equipped with automatic and/or manual fire detectors are shown in the fire protection plans.

In the event of an alarm, the alarm regulations of the operating manual apply. All measures to be taken and responsibilities to be assumed are regulated there.

3.2.1.2 Types, main characteristics and performance expectations

Nuclear power plants

All nuclear power plants have fire detection and alarm systems that comply with the relevant conventional non-nuclear standards. The proper interaction of all components is verified by system approvals.

The fire alarm boards are designed to withstand external hazards, in particular impacts from earthquakes according to KTA 2101 /KTA 15/, /KTA 15b/. For installations under decommissioning and dismantling without fuel elements, which thus have a significantly reduced radiological hazard potential, an earthquake-proof design can be dispensed with after examination of the individual case.

The fire detectors are grouped according to detector groups. Each redundant train is equipped with at least one detector group of its own. The failure of more than one detector group is prevented by appropriate arrangement and design of the transmission lines.

The detectors of a group are arranged only inside or only outside permanently restricted areas in accordance with the Radiation Protection Act. Precautions are taken to ensure that fire detection and alarm for areas that are not accessible during certain operating conditions does not become ineffective by operational effects (such as radiation) until the next accessibility. This is ensured, e.g., by shielding detectors, by the use of smoke absorption detectors, or the implementation of multiple detector groups.

Research reactors

FR MZ

The fire detection and alarm system currently includes 300 fire detection features in a total of 112 detection lines, with a maximum of 10 fire detectors connected to one detection line. In detail, there are 29 push-button detectors for triggering an alarm by personnel. 264 optical smoke detectors are installed in the reactor building, the reactor hall annex and the adjacent institute building. A special flame detector is located in the container of the emergency diesel generator and is used to detect an open fire at the emergency power generator. Due to the high air exchange rate in the case of diesel engine operation resulting in active smoke extraction, a fire could remain undetected for a long time if normal optical smoke detectors were used. In addition, there are six test chamber detectors in the exhaust air duct of the reactor hall to detect a flue gas mixture in the exhaust air.

139 sirens provide an acoustic warning for the reactor personnel and the employees of the adjacent old building.

All facilities are inspected periodically in accordance with the inspection manual (see explanations in paragraph 2.1.5).

<u>FRM II</u>

The requirements of the technical standards were met in the design. The authorised expert confirms that the design complies with the requirements, and the condition as required per design is checked regularly in accordance with the inspection manual as well as during on-site inspections and the fire inspection of the city of Garching. So far, there have never been any deviations important to safety. The installation is maintained at the state of the art and adapted to changing requirements by applying the modification procedure according to the operating manual. In total, there are approx. 300 fire dampers in the ventilation systems at the FRM II as well as approx.1,000 fire walls with approx. 100 fire doors.

The external alarm is usually triggered by the automatic fire detection and alarm system. Fire alarms on the premises are triggered manually by the responsible shift personnel based on automatic information from the fire detection and alarm system or upon request by the fire brigade commander. The own personnel on site is alerted via telephone or person search system.

The fire alarm system is protected by emergency power backup. Adjacent areas are separated and/or segregated by fire barriers to the extent required. Any failure of the fire detection and alarm system is self-reporting.

Building radio is available throughout the installation.

Specific measures to be taken if certain fire alarms are triggered have been specified and are available to the shift personnel, e.g. via route maps.

Fuel cycle facilities

<u>BFL</u>

Fires are signalled on the central control panel of the fire detection and alarm systems at a permanently staffed location in the security centre of the BFL. The on-site fire brigade, which is always present, is simultaneously alerted by means of fire detectors and informed on the alarm location by display on the fire brigade display panels.

In the event of a fire, the staff of the security guard service will be alerted by means of an acoustic alarm signal transmitted by the redundant electrical loudspeaker systems in accordance with the alarm regulations, which are part of the operating manual.

The design approach described in paragraph 3.2.1.1 and implemented at the BFL is based on the assumption that incipient fires can be reliably detected at an early stage and appropriate countermeasures can be taken.

The fire detection and alarm systems of the nuclear and non-nuclear buildings can be operated and read out centrally via a hazard alarm system. In the event of a failure of this system, operation and alarming can take place at the fallback level.

UAG

Due to the implemented design approach described in paragraph 3.2.1.1, a reliable and early detection of incipient fires and initiation of corresponding countermeasures is assumed in the UAG.

All UAG buildings are monitored by an automatic fire detection and alarm system for an early detection of fires. The fire detection and alarm system consists of a total of nine cross-linked fire alarm boards and a higher-level hazard management system. The alarm boards are connected redundantly in an independent cluster network with ring-shaped wiring. The use of fibre optic wiring provides increased safety against electromagnetic interference of the fire alarm boards. The central processing units in the individual fire alarm boards are also redundant so that in case of failure of a unit, an automatic switchover to the standby module takes place.

For fire detection, automatic detectors are implemented in the individual rooms and raised floors. Manual fire alarm push-button detectors are installed in the stairwells and in access and escape routes. The arrangement of the detectors and different detection methods are selected according to their monitoring range so that a fire can be reliably detected at an early stage.

The fire alarm board is located in the permanently staffed "central control room". If the fire detection and alarm system is triggered, a group alarm is transmitted to the guard house. The security guard service secures the public fire brigade's access to the premises.

Alerting the affected areas and the on-site fire brigade is carried out manually by the alarm and call system by the staff of the central control room.

On-site spent fuel and radioactive waste storage facilities

Storage at the Biblis site

The design approach implemented in the storage facility as described in paragraph 3.2.1.1 assumes reliable and early detection of incipient fires and initiation of appropriate countermeasures.

The fire detection and alarm system for the spent fuel and radioactive waste storage facilities is designed in a way that information about disturbances and malfunctions is transmitted to the fire alarm board in the guard house. From there, the group alarms are transmitted to the alarm system located in the security centre. The security centre alerts the fire brigade in charge.

Storage at the storage facility North (ZLN)

The ZLN storage building has an area-wide fire detection and alarm system in accordance with the technical standards. The fire detection and alarm system triggers fire alarms at the fire alarm boards at the inner security checkpoint of the ZLN and at the on-site fire brigade of the former Greifswald nuclear power plant (KGR) (outside the outer security area of the ZLN).

All automatic fire detection features are connected to the fire alarm board. All fire alarms arriving via the detector groups are indicated visually and acoustically. The acoustic alarm can be switched off, while the optical alarm remains as long as the fire detector gives a signal. Different types of automatic fire detectors can be used in each detector group. Depending on the ambient conditions, the following detector types (usually in mixed assignment) are selected: Optical smoke detectors, heat differential detectors, linear smoke detectors, ionisation detectors, and CO detectors. The exhaust air of halls 1 to 7 is monitored for fire gases with CO detectors.

The power supply of the fire detection and alarm system is ensured by two independent power sources. Normally, the fire detection and alarm system is supplied by the grid. In the event of a grid failure, the fire detection and alarm system is supplied by the backup mains. Furthermore, the fire detection system is equipped with an internal battery, which is designed for a capacity of at least 30 hours in case of permanent on-call duty.

The manually actuated fire detectors are combined to separate fire detector groups. These push-button detectors are mounted in a clearly visible and freely accessible position. The detection line is monitored for wire breakage and short circuit according to the closed-circuit principle. Non-automatic fire detectors are located, in addition to automatic fire detectors, mainly in the corridors and next to the exits. When a detector is actuated, the alarm location is visually displayed and recorded at the fire alarm board. At the same time, an acoustic fire alarm is triggered. The necessary measures are immediately taken in accordance with specified operational instructions.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

<u>WAK including VEK</u>

The fire detection and alarm system is a central system for the entire WAK premises. It consists of the so-called “main core” (fire alarm board) and redundantly connected so-called “sub-cores” (i.e. fire alarm panels).

All information and operating modes of the sub-cores are signalled via the main core and displayed on the central control panel in the main control room for processing and registered on the protocol printer of the main core.

Operating and control information is sent from the main core to the respective sub-core, so that this information is also available there. Each sub-core represents an individual fire alarm panel and is the smallest processing unit of the WAK fire detection and alarm system structure. In the event of a faulty line connection between the main core and a sub-core, present alarm and fault signals are transmitted to the main core via a redundant connection. The system availability is ensured. Even in the event of failure of a complete processing unit (sub-core), alarm signalling from this sub-core leads to reliable triggering of the transmission device. The entire system is supplied by the emergency grid and has a non-interruptible power supply for bridging purposes.

3.2.1.3 Alternative/temporary provisions

Nuclear power plants

The necessary provisions are determined on a case-by-case basis. Alternative provisions during maintenance work on the fire detection and alarm system can be, e.g., the provision of a fire watch, an increased patrol frequency, or the provision of active fire extinguishing means.

Research reactors

FR MZ

There is a maintenance contract with the manufacturer of the fire detection and alarm system, which ensures a response time of 4 hours in case of malfunctions. If necessary, compensatory measures (e.g. provision of a fire watch, regular fire-specific patrols, expansion of the extinguishing means on site, etc.) are carried out. Temporary fire detection devices, such as mobile fire detection equipment, have not yet been used at the FR MZ. An alternative fire alarm to the Mainz professional fire brigade can be made at any time by calling the fire brigade's emergency number 0-112 (from a landline telephone on the campus of the Johannes Gutenberg University Mainz) or 112 (from a mobile phone). After completion of hot work, appropriate fire watches are to be implemented for being able to detect smouldering and incipient fires caused by this as early as possible.

FRM II

In case of failure of the fire detection devices, (temporary) compensatory provisions are implemented These include precautionary provision of further extinguishing media, regular walk-throughs, provision of fire watches, if necessary, and alternative methods for alerting the fire brigade, e.g. via telephone. These are coordinated with the fire brigade in accordance with the operating manual.

Fuel cycle facilities

BFL

Alternative and temporary arrangements regarding active fire protection, e.g. in the event of limited availability of fire detection features, are regulated in the BFL operating manual.

In case of a failure of e.g. one of the redundant fire detection and alarm features, daily checks must be carried out to ensure that there are no faults that could inadmissibly affect the still operating fire detection and alarm system.

Work required with open flames or potential ignition sources, e.g. welding, cutting, grinding, soldering, on the entire site may generally be carried out only after approval by the department for plant and operational safety.

UAG

Alternative and temporary precautions regarding active fire protection are regulated at the UAG in operating instructions.

In the event of a failure or partial failure of the fire detection and alarm system, any hot work that may take place in these areas must be stopped immediately and regular patrols must be carried out by the shift personnel. As part of protective measures for welding, burning, and grinding work (hot work with smoke development), groups of fire detectors need to be switched off in this case and appropriate compensatory measures must be taken. These include fire watches, additional fire extinguishers, and the removal from or protective coverage of fire loads in the work area.

On-site spent fuel and radioactive waste storage facilities

Alternative and temporary precautions with regard to active fire protection in the spent fuel and radioactive storage facilities are regulated in the operating instructions.

If temporary provisions need to be specified due to modifications and/or maintenance work, these are recorded in the modification and work permit procedure. If a hot work permit is issued in this context, automatic fire detection can be deactivated in a limited work area. Provisions in this case include, e.g., providing a fire watch, removing fire loads from the work area and providing additional fire extinguishers as well as informing the dedicated on-site fire brigade.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

<u>WAK including VEK</u>

For hot work with smoke development, special work permits are additionally required at the WAK. The temporary precautions for construction sites, dismantling, dusty work, etc. are bindingly specified in the WAK regulations.

In this case, the fire detection and alarm system in the room must be deactivated and appropriate compensatory measures must be taken. These include fire watches, additional fire extinguishers, and removal of fire loads from the work area.

3.2.2 Fire suppression provisions

3.2.2.1 Design approach

Nuclear power plants

Firefighting is carried out by trained personnel with suitable firefighting equipment. The following is used for firefighting:

- hand-held and other mobile fire extinguishers (portable extinguishing equipment),
- above-ground hydrants on the premises and wall hydrants in the buildings,
- stationary fire extinguishing systems.

The fire extinguishing water supply is provided by a fire water ring main system installed underground. This provides fire extinguishing water in sufficient quantity and at the required pressure on the premises and in the buildings without external supply and pump power.

Research reactors

FR MZ

For firefighting of incipient fires, there is portable fire extinguishing equipment (CO_2 or powder hand-held fire extinguishers and extinguishing blankets). In addition, the fire brigade has an inexhaustible supply of extinguishing water through four above-ground hydrants on the streets running along the buildings by means of B-hose connections for firefighting. The water supply here is via a DN 100 ring main of the drinking water network (see Figure 2-1). Stationary extinguishing systems are not required at the FR MZ. The area around the reactor building has sufficient parking areas and access routes for fire trucks in accordance with the Rhineland-Palatinate building regulations.

FRM II

The approaches to be used for the selection, design and areas equipped with fire extinguishing systems comply with the relevant requirements for fire protection with regard to SSC important to safety and potential radioactive releases. The extinguishing water supply is triple redundant (service, well and drinking water). There is no requirement for the active components to remain operable after earthquakes. The requirement for stability and functional integrity after earthquakes is met. Active components (pumps) are replaced by portable equipment of the fire brigade in case of failure after earthquakes. The active systems are designed two-times 100 %. The failure of a line is compensated by the concept of a "ring main" with suitable isolation valves.

Fuel cycle facilities

The design of the above-mentioned firefighting equipment is carried out at BFL and UAG in accordance with the relevant national and Land-specific provisions and regulations, such as the workplace guideline ARS 2.2.

On-site spent fuel and radioactive waste storage facilities

The above-mentioned firefighting equipment is designed in accordance with the relevant national and Land-specific provisions and regulations. A fire brigade consisting of full-time and part-time firefighters trained in accordance with the principles for professional fire brigades is available for firefighting.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

At the WAK and VEK, the design of the above-mentioned firefighting equipment is carried out in accordance with the relevant national and Land-specific provisions and regulations. After the shift supervisor has been alerted on the fire, fire suppression of incipient fires shall be conducted by fire extinguishing equipment available in the near vicinity by persons present at the fire location, provided that this can be done without endangering persons.

Firefighting in the WAK is carried out exclusively by the KIT CN on-site fire brigade. If a larger number of firefighters are needed, this will be led by the KIT CN site fire brigade. The arrival time of the KIT CN on-site fire brigade is about 5 min after the fire alarm. The dedicated KIT CN on-site fire brigade is ready for action 24 hours each day at full strength.

A fire water ring main with underground and above-ground hydrants is available for firefighting at the WAK premises.

In the controlled area, firefighting is additionally carried out under consideration of the specifications of the WAK emergency service provider for compliance with necessary protective means. The person required with the necessary technical qualification as defined under § 54 StrlSchV /BMJ 21/ to assess the radiation hazard during firefighting in the controlled area shall be assigned by the emergency service manager of the KIT CN on-site fire brigade. In the event of a fire, the affected ventilation system is automatically switched to the intended operating mode (supply air is switched off and controlled exhaust air).

The KIT CN on-site fire brigade should preferably use CO_2 or powder extinguishers; the use of light/medium foam is permissible. Water must not be used.

3.2.2.1.1 Extinguishing water supply

Nuclear power plants and FRM II research reactor

An adequately dimensioned ring main system is installed for the supply of extinguishing water to the above-ground hydrants, the wall hydrants in the buildings and for the supply of the fixed (stationary) water-based extinguishing systems. For the supply of extinguishing water, either a natural water source, such as rivers, streams, lakes, or an artificial water source, such as extinguishing water ponds, extinguishing water wells or extinguishing water tanks, with sufficient water quantities is available.

All hydrants or wall hydrants are arranged in a way that a fire on the premises or in the structures can be fought manually. All building structures with equipment of the safety system or with emergency equipment are equipped with extinguishing water pipes. It is ensured that in the event of water being released due to a loss of integrity of such pipes, the required functionality of equipment of the safety system or emergency equipment is maintained.

Redundant pumps with emergency power supply or a power supply independent of the external grid as well as a pressuriser system for the extinguishing water supply are installed. The pumps are spatially separated (by sufficient distance) or protected from each other in a way that the failure of a pump or a feed line into the ring main does not lead to a failure of the flow rate required in case of demand. The pumps are automatically switched on in the event of a pressure drop in the extinguishing water system. They are monitored and operated from a permanently staffed location, e.g. a control room.

The equipment and resources required to establish additional extinguishing water supply (e.g. for feeding into the ring pipeline system or into structural components) are provided.

The extinguishing water supply available at the beginning of the dismantling of nuclear power plants also covers the nuclear requirements, particularly regarding design and capacity. In areas not having to meet nuclear requirements after the end of commercial power operation and/or during decommissioning and dismantling, the extinguishing water supply can be adapted to the requirements of conventional regulations.

FR MZ

At the FR MZ, the extinguishing water supply is provided by four above-ground hydrants on the streets routed along the buildings. Mobile fire pumps can be connected to these via B-hose lines. The hydrants are fed by a DN 100 ring main of the drinking water network (see Figure 2-1).

FRM II

The extinguishing water supply is fed by three independent sources (service water, drinking water well water), each of which is suitable for providing the required quantities of water. If necessary, the Gießenbach stream, flowing past the FRM II site at a distance of approx. 100 m, and the Isar river would also be available as an extinguishing water reserve. The extinguishing water pumps are redundantly designed with emergency power supply. In addition, the fire brigade has sufficient own pumping capacity.

A fire water retention system is available in the installation.

Fuel cycle facilities

BFL

On site, there is a fire extinguishing line with above-ground hydrants that are connected to the city water supply by two feed-ins. Furthermore, there is a fire extinguishing well with a suction pump connected to the backup power supply.

UAG

The emergency vehicle of the on-site fire brigade provides 2,000 l of water for the initial attack. Another water supply can be established close to the building via the extinguishing water ring main with distributed water hydrants. In case of failure of the fire water ring main, the water supply is provided via a fire pond located on site.

On-site spent fuel and radioactive waste storage facilities

At present, the extinguishing water supply for the Biblis spent fuel storage facility and the AZB 1 and ABZ 2 radioactive waste storage facilities is ensured by the extinguishing water system of the neighbouring nuclear installation. This is fed by wells and provides sufficient extinguishing water. Within the framework of self-sufficiency, an independent extinguishing water system is established at BZB by a rainwater retention basin with a connected ring main. The rainwater retention basin is dimensioned in a way that the extinguishing water volume of 192 m^3/h required by building law can be provided over a period of two hours.

In the ZLN, the EWN fire extinguishing network supplies the extinguishing equipment on the premises outside and inside buildings with extinguishing water via a ring main. A maximum of 3,200 l/min is required. The required quantity was determined when the fire protection concept was developed and is supplied by two independent feeds through the existing EWN fire extinguishing network. Thus, in case of failure of one supply, the required quantity of 3,200 l/min can be provided by the second supply. Moreover, it is possible to draw extinguishing water from the storage basin via a stationary suction point. A maximum of 900 m^3 of extinguishing water is available. The following is connected to the firefighting network: above-ground hydrants outside buildings and wall hydrants inside buildings. Above-ground hydrants are available for firefighting on the ZLN premises. The hydrants have two upper outlets with a fixed B-coupling and one lower outlet with a fixed A-coupling.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

At the WAK site (including VEK) there is a fire extinguishing ring main with above-ground hydrants (nominal diameter 100) and two underground hydrants (nominal diameter 80). These are connected to the fire extinguishing ring main of the WAK water supply with an operating pressure of 4 bar.

3.2.2.2 Fire extinguishing systems

Nuclear power plants

In the presence of fire loads that may lead to inadmissible fire effects as described in paragraph 2.1.3, particularly on structural elements forming boundaries of rooms or buildings, the safety system or emergency systems stationary extinguishing systems or equivalent fire protection measures, such as mobile extinguishing features in combination with trained personnel, are provided.

Stationary extinguishing systems are also used if manual firefighting can lead to an unacceptable risk to the firefighters due to difficult accessibility, high local dose rate or insufficient smoke removal.

Stationary extinguishing systems are principally actuated automatically. If the extinguishing system is not actuated automatically, it is ensured that it is actuated early and reliably. For this purpose, actuation criteria as well as instructions for manual actuation of the extinguishing systems are contained in the written operating procedures. Criteria for triggering, e.g. actuation of the fire detection and alarm system, visual inspection by means of the plant's television system as well as failure signals or fault messages, are defined for each individual case.

When assessing automatic actuation, the disadvantages of false triggering were taken into account, e.g. failure of items important to safety, spurious actuation in the event of steam leakage, contamination of the extinguishing water and the application of extinguishing media to parts with a high surface temperature. If large quantities of water are expected to occur during fire extinguishing, e.g. in spraywater deluge extinguishing systems, equipment for collection or discharge of extinguishing water are available, where applicable, via mobile pumps.

Extinguishing water from the controlled area is only discharged in a controlled manner and after activity balancing and appropriate treatment, if necessary.

Automatically actuated stationary fire extinguishing systems are installed for the oil-filled power transformers of the main grid connection (main transformers) and the auxiliary power feeder (auxiliary power transformers) in accordance with KTA 3701 /KTA 14/. This also applies to the backup grid transformers if an inadmissible fire-related impairment of adjacent buildings and installations cannot be excluded. For triggering, e.g., the electrical Buchholz protection, differential protection or temperature-dependent triggering systems are used.

Stationary fire extinguishing systems are to be provided, in particular, in each of the following areas or in areas with the following features:

- turbine oil reservoirs and ducts,
- fuel storage for diesel generator sets in storage and service tanks inside buildings,
- reactor coolant pumps including oil tanks,
- non-encapsulated large assemblies of cables, such as in cable penetrations, shafts, floors and storeys,
- non-encapsulated essential fire loads where manual firefighting is difficult (difficult accessibility, high local dose rate or insufficient smoke removal),
- treatment and storage of radioactive combustible materials,
- IT process computer systems.

The suitability of extinguishing systems is demonstrated for the respective application. The planning and design of extinguishing systems is always performed in accordance with the generally recognised engineering standards, e.g. DIN EN 12845.

The requirements for extinguishing systems correlate to a large extent with those for automatic fire detection (see paragraph 3.2.1.1). In particular, installations with high local fire loads (oils, large assemblies of cables) require both automatic fire detection and an extinguishing system. If high local fire loads are eliminated, not only the requirement for automatic fire detection but also the requirement for a stationary extinguishing system is no longer applicable. Meeting the conventional requirements under building law is still ensured.

Research reactors

In the presence of fire loads that can lead to inadmissible fire effects, particularly on SSC important to safety, as described in paragraph 2.1.3, stationary extinguishing systems or equivalent fire protection provisions, such as portable extinguishing equipment in combination with trained personnel, are provided.

Stationary extinguishing systems are also used if manual firefighting can lead to an unacceptable risk to the firefighters due to difficult accessibility, high local dose rate, or insufficient smoke removal.

Stationary extinguishing systems are principally actuated automatically. In the case of manual actuation, it is ensured that this occurs early and reliably. Criteria for actuation are, e.g., response of the fire detection and alarm system or visual inspection.

If large quantities of water are expected to occur during extinguishing, e.g. in the case of spraywater deluge extinguishing systems, devices for collection or drainage of extinguishing water are provided. Extinguishing water from the controlled area is only discharged in a controlled and activity-balanced manner, if necessary, after appropriate treatment.

Stationary extinguishing systems are provided, particularly in each of the following areas or in areas with the following features:

- shafts with electrical cables from redundant trains,
- treatment and storage of radioactive combustible materials,
- scientific measuring equipment.

The suitability of extinguishing systems is demonstrated for the respective application. Planning and design of extinguishing systems is always performed in accordance with the generally recognised engineering standards.

The requirements for extinguishing systems correlate to a large extent with those for automatic fire detection (see paragraph 3.2.1.1). In particular, installations with high local fire loads (e.g. scientific facilities) require automatic fire detection and alarm systems as well as a stationary extinguishing system.

Fuel cycle facilities

BFL

The BFL has an automatically actuated stationary gas extinguishing system (CO_2).

UAG

The following stationary fire extinguishing systems and equipment for fighting incipient fires are implemented at the UAG:

- stationary, manually actuated spraywater deluge system,
- automatically actuated stationary gas extinguishing systems (nitrogen, inergen).

The uranium enrichment facility has a dedicated on-site fire brigade with appropriate equipment. As part of the operational risk prevention, the on-site fire brigade is responsible for fighting incipient fires and for initiating first measures in the event of a UF_6 release.

On-site spent fuel and radioactive waste storage facilities

In the spent fuel storage facilities, automatically actuated stationary gas extinguishing systems are present.

Conditioning of radioactive waste at the storage facility North

Stationary extinguishing systems include a semi-stationary water-based foam extinguishing system in the administration and social building, in two hydraulic rooms and in caisson 2. The pipes are designed as dry pipes, whereby water with foam agent is fed into the pipe system from the outside in the event of fire. Caissons 2 and 2a are also equipped with a semi-stationary spraywater deluge system applied for solid waste fires.

In addition, there is a manually actuated stationary CO_2 extinguishing system in an electronics room, which is designed in a way that the requirements of the guideline for CO_2 fire extinguishing systems and the safety standards for CO_2 fire extinguishing systems are complied with.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

There are no stationary extinguishing systems in the WAK buildings considered.

3.2.2.3 Types, main characteristics and performance expectations

Nuclear power plants

For fighting incipient fires, a sufficient number of hand-held and other portable fire extinguishers are provided, mainly in all operational rooms, in the stairwells, in front of entrances to operating facilities and in fire-prone areas. The selection of extinguishing media depends on the required fire class, taking into account the systems engineering requirements.

In addition, the minimum technical equipment necessary for firefighting, such as devices, vehicles and equipment, is kept available for the fire brigade required in view of the existing operational hazard.

Stationary water extinguishing systems include, in particular, stationary and semi-stationary spraywater deluge and sprinkler systems.

The gas extinguishing systems used include, e.g., CO_2 or inert gas extinguishing systems. Damage to pressure vessels including the associated fittings of gas extinguishing systems does not impair plant components important to safety.

When room protection extinguishing systems are actuated, a room closure for the area of fire extinguishing is conducted. Unless inadmissible pressure increases in the extinguishing area are prevented by other means, pressure relief devices are kept open during the inflow process. To prevent a pressure drop below the extinguishing gas concentration ahead of schedule, the pressure relief devices are closed after the inflow process.

The controls of the extinguishing systems are designed such that they are not inadmissibly impaired by the fire to be controlled. Irrespective of remote or automatic actuation, manual actuation of the extinguishing system is usually provided.

The actuation of an extinguishing system is displayed in the control room.

Precautions against spurious actuation of the extinguishing systems are taken. Such precautions are, e.g., in the case of automatic actuation by fire detectors, the linking of two detector groups of the extinguishing area or the application of the work current principle for control systems.

Research reactors

FR MZ

A total of 121 hand-held fire extinguishers are distributed throughout the building, which ensure that an initial attack can be carried out to fight the fire. The extinguishers used are mainly powder extinguishers of fire classes A, B and C; the laboratories also have CO_2 extinguishers for liquid fires (fire class B) and fires in electrical systems. Seven extinguishing blankets are used to extinguish incipient fires, e.g. to extinguish liquid fires in experimental containers. A total of nine wall hydrants have been taken out or operation in recent years and replaced by ABC fire extinguishers as specified by the responsible technical safety expert for fire protection.

FRM II

Stationary and semi-stationary spraywater deluge and sprinkler systems are used as fixed water extinguishing systems. The actuations of the extinguishing systems are designed such that they are not inadmissibly affected by the fire to be controlled. Irrespective of remote or automatic actuation, a manual actuation of the extinguishing system is usually also foreseen. Actuation of an extinguishing system is displayed in the control room.

Precautions against spurious actuation are taken for the actuation of extinguishing systems. Such precautions are, e.g. linking of two detector groups for the extinguishing area in case of automatic actuation by fire detectors or the application of the work current principle in case of controls.

Other suitable extinguishing features and media (e.g., hand-held fire extinguishers, wall hydrants, extinguishing blankets, extinguishing sand) are kept on site at the respective locations.

Fuel cycle facilities

BFL

Types, main characteristics and requirements regarding the design of the fire extinguishing features comply with the relevant national and Land-specific provisions and regulations, e.g. workplace guideline ASR 2.2.

In addition to the stationary extinguishing systems, further extinguishing features with suitable extinguishing media, particularly a hydrant network and portable fire extinguishers (preferably CO_2 or powder extinguishers) are available.

UAG

The fire extinguishing features have been designed and implemented in accordance with the applicable regulations and provisions and are monitored by the supervisory authority to the extent specified (see also design requirements in paragraph 3.2.2.1).

In addition to the stationary extinguishing systems, further extinguishing features with suitable extinguishing media are available, particularly a hydrant network and portable fire extinguishers (preferably CO_2 or powder extinguishers).

On-site spent fuel and radioactive waste storage facilities

Types, main characteristics and requirements for the design of the fire extinguishing features comply with the relevant national and Land-specific provisions and regulations, e.g. workplace guideline ASR 2.2. Their implementation was accompanied by the supervisory authority and/or its authorised experts to the extent specified.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

The fire extinguishing features in the WAK and VEK are designed in accordance with the applicable regulations and provisions and are monitored by the supervisory authority and/or its experts to the extent specified.

3.2.2.4 Management of harmful effects and consequential hazards

Nuclear power plants

In addition to the fire-related effects on SSC, the extinguishing measures can also lead to local failures.

Due to the plant design – including separation of redundant trains, plant-internal flood protection concept – inadvertent effects consequential to extinguishing measures affecting more than one redundant train are excluded. Thus, the nuclear protection goals (see paragraph 2.1.1) are not endangered by the effects of fire extinguishing.

Impacts of fire extinguishing media may at most lead to plant transients during specified normal operation resulting from component damage, depending on the location of the fire (e.g. in the turbine hall).

In rooms and areas protected by water extinguishing systems, the extinguishing medium is collected or removed in a controlled and safe manner. For oil supply systems protected by water extinguishing systems, the oil supply installation area is designed such that the arising water-oil mixture can be collected in a targeted manner and removed after the extinguishing process.

In the event of a release of dangerous substances or the accumulation of extinguishing water on the premises in the event of fire, the discharge of these substances into water bodies is prevented. Measures for retention are, e.g.,

- securing road inlets,
- implementation of an oil barrier in the river.

Research reactors

FR MZ

In the event of a firefighting attack in the reactor hall using a considerable amount of extinguishing water, the water would first accumulate in the basement, which is designed as a tub. Ingress of water into the storage pits for fuel elements, where three fuel elements are currently stored in a dry storage basket, is prevented by sealing plugs with elastomer sealing rings. However, the arrangement would remain uncritical even in a water environment. The extinguishing water would then be fed into the wastewater system via a floor drain, where it would enter one of the in total seven wastewater tanks and mix with any potentially radiologically contaminated wastewater already present.

FRM II

In addition to the fire-related effects on SSC, the extinguishing measures can also lead to local failures.

Due to the plant design – including separation of redundant trains, plant-internal flood protection concept – inadvertent effects consequential to extinguishing measures affecting more than one redundant train are excluded. Thus, the nuclear protection goals (see paragraph 2.1.1) are not endangered by the effects of fire extinguishing.

The probability of damage due to spurious actuation of the spraywater deluge or sprinkler system is reduced by the fact that some of the systems are dry ones that are only flooded after investigation of the location by the fire brigade or by clear signalling on instruction or directly by the fire brigade.

Fuel cycle facilities

BFL

Water extinguishing is prohibited in buildings used for nuclear purposes. After an extinguishing attack, no (radioactively) contaminated extinguishing water is produced in these buildings.

For an open area on the premises for parking vehicles loaded with nuclear fuel and emptied containers for uranium hexafluoride, the extinguishing water is retained in the rainwater shaft after an extinguishing attack with water in accordance with the fire safety regulations.

UAG

Contaminated extinguishing water within the buildings is collected in accordance with the extinguishing water retention guideline. In the event of a leakage of dangerous substances or the accumulation of extinguishing water in the event of a fire on the premises, the discharge of these substances into bodies of water is prevented. In order to retain contaminated extinguishing water, the extinguishing water occurring on site is discharged into the retention system and retained.

On-site spent fuel and radioactive waste storage facilities

In the event of a fire, contaminated extinguishing water and its discharge from the spent fuel storage facility is not a concern since only very low fire loads are present and no radioactive releases are to be expected in the fire scenarios analysed. In addition, extinguishing water occurring in the loading area is to be retained there. Further alternative measures can be requested at any time by the plant management, usually after consultation with a fire protection officer.

Conditioning of radioactive waste at the storage facility North

After a fire, the extinguishing water is retained to protect the environment. The extinguishing water from caisson 2 conditioning area and the container storage area, including the loading hall and the airlocks, is fed into the extinguishing water retention basin below caisson 3 by structural means. The access and escape doors to the administration and social building in the caissons are elevated and equipped with corresponding ramps. The extinguishing water retention basin has a coating in accordance with the Federal Water Act. The retention volume is 400 m³. The extinguishing water initially remains in the retention basin until a decision has been made on the type of controlled disposal. The hydraulic compartments are tub-shaped. The retention volume is approx. 18 m³ as defined in the extinguishing water retention guideline. In accordance with this guideline, care is taken in the design of the extinguishing water retention systems to ensure that no fire can spread through extinguishing water discharge. The extinguishing water retention basin is designed such that it can achieve its protective function of safely retaining contaminated extinguishing water even after a design basis earthquake.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

Water extinguishing is prohibited in the controlled areas of the WAK and VEK. No contaminated extinguishing water is released in these buildings after a fire extinguishing attack. Extinguishing water is collected in accordance with the extinguishing water retention guideline. In the event of a release of dangerous substances or the accumulation of extinguishing water in the event of an on-site fire, the discharge of these substances into bodies of water is prevented.

3.2.2.5 Alternative/temporary provisions

Nuclear power plants

Measures taken in the event of unavailability of fire extinguishing features are described in the operating manual. In the event of a failure of the stationary fire extinguishing features, appropriate compensatory measures are specified in accordance with the scope (see paragraph 3.2.1.3), including, e.g.,

- increased inspections of the affected areas,
- provision of additional portable extinguishing equipment, or
- the establishment of provisional extinguishing water supplies.

If a failure of portable fire extinguishing equipment is detected, it is compensated for by replacement or the use of equivalent extinguishing media.

Research reactors

FR MZ

The fire safety regulations of the FR MZ require that a portable hand-held fire extinguisher or other suitable extinguishing features must be placed in the direct vicinity when carrying out work with an increased risk of sparking or high heat generation, e.g. cutting and grinding or welding work. A hot work permit is required for such work. If smoke development is to be expected during the work, the fire detectors in the affected area are to be deactivated for the work period by an employee of the technical property management of the Johannes Gutenberg University Mainz upon request in order to avoid false alarms. During this time period, a permanent fire watch is to be provided. The fire detection and alarm system will automatically switch the fire alarms back after a certain period of time has elapsed.

FRM II

Substitute measures are specified in the FRM II operating manual. These include the establishment of a substitute supply of extinguishing water, the preventive routing of temporary pipes for extinguishing water supply or the provision of fire watches. Further alternative measures can be requested at any time by the plant management, usually after consultation with a fire protection officer.

Further specifications of appropriate alternative measures are made in the frame of the work permit procedure, e.g. – if necessary – for maintenance tasks.

Fuel cycle facilities

BFL

Alternative and temporary arrangements regarding fire extinguishing features, e.g. in the event of limited availability of the extinguishing water supply, are regulated in the BFL operating manual.

If one of the two city supply lines is unavailable, it is possible to switch to the other one to supply the fire extinguishing line and the above-ground hydrants. If required, the fire extinguishing well with suction pump can also be taken into operation in case of failure of the external network and the substitute power supply by means of a mobile power supply of the external fire brigade for the supply of extinguishing water. Further alternative measures can be requested at any time by the commander of the dedicated on-site fire brigade.

In areas where fire extinguishing by water is prohibited, portable powder or CO_2 fire extinguishers are available for effective firefighting.

UAG

Alternative and temporary precautions regarding active fire protection are regulated at the UAG in operating instructions. This includes the establishment of the extinguishing water supply which to be ensured by the dedicated on-site fire brigade in the event of a failure of the general water supply by the city of Gronau. Two portable extinguishing water supply lines are implemented by means of B-pressure hoses from the pump station of the fire pond to the fire station. This corresponds to an extinguishing water demand of 1,200 l/min. Afterwards, the defined junctions are connected to the pump station of the fire pond by A-pressure hoses. This means a direct feed into the ring main. The connection to the public water supply is then closed at nodes to prevent backflow into the public network. This measure is only carried out in case of a fire where an increased extinguishing water flow of 3,200 l/min is required.

In areas where fire extinguishing by water is prohibited to ensure criticality safety, portable powder or CO_2 fire extinguishers are available for effective firefighting.

Further alternative measures can be requested at any time by the operating management, usually after consultation with a fire protection officer.

On-site spent fuel and radioactive waste storage facilities

Storage at the Biblis site

Compensatory measures are specified in the general arrangements drawings for the fire brigade. These include, e.g., provisions in the event of a ring main failure or the provision of fire watches. Further measures can be requested at any time by the operating management, usually after consultation with a fire protection officer. In addition, all work involving open flames as well as welding and grinding work must be carried out in accordance with the work permit procedure. Fire protection certificates are issued in this context. The fire protection certificate specifies measures to be taken in the event of work with an increased fire risk or increased operational impairment of fire protection equipment and also identifies compensatory measures. Fire protection relevance in the work permit procedure also arises if access and escape routes or if entrances or access roads for rescue and fire brigade vehicles are blocked during the work. The fire protection department checks the situation and particularly monitors that designated alternative measures are implemented and not impaired.

Storage at the storage facility North

In the event of a fire, fire squads of the volunteer fire brigades from the surrounding communities can be alerted as a second instance, as well as the Greifswald professional fire brigade as a third instance.

The extinguishing water ring main is subdivided by isolation devices such that in the event of a line break at any point, the supply of extinguishing water is still adequately ensured.

To fight incipient fires, the building is equipped with portable fire extinguishers according to DIN EN 3-7 in the required number and always ready for use. The locations of the portable fire extinguishers are easily visible and are kept clear at all times. Portable fire extinguishers allow for quick initial firefighting. They are implemented in a clearly visible position along escape routes, near access doors to rooms with an increased fire load, near access doors in stairwells and in easily accessible places within buildings. The selection of extinguishing media depends on the type of fire and the possible consequential damage caused by them. The number and size of the fire extinguishers depends on the fire load. Carbon dioxide extinguishers are available in the direct vicinity of electrical systems and equipment.

Wall hydrants are arranged inside the buildings in accordance with the model industrial buildings directive (MIndBauRL) and are connected to a wet riser. The wall hydrants have reels with 23 m and 30 m of dimensionally stable hoses with a D-jet pipe or Euro nozzle and are arranged in the rooms such that any possible fire source can be reached with the extinguishing water jet. There are no wall hydrants in the area of halls 1 to 8 since no fire extinguishing using water is planned in this area.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

<u>WAK including VEK</u>

Alternative measures are specified in the operating manual of the WAK and VEK. For work with an increased risk of sparking or high heat generation, e.g. cutting and grinding or welding work, additional hand-held fire extinguishers or other suitable extinguishing features must be placed in the direct vicinity. A hot work permit is required for such work. If smoke is likely to be generated during the work, the fire detectors in the affected area are to be deactivated for the duration of the work to prevent false alarms. During this period, a permanent fire watch is required.

The KIT CN on-site fire brigade should preferably use portable CO_2 or powder extinguishers; the use of light/medium foam is permissible. Water must not be used.

3.2.3 Administrative and organisational fire protection issues

Nuclear power plants

Organisational and administrative fire protection provisions are in place to prevent the occurrence of fires. For defensive fire protection, appropriate precautions and measures have been taken that are necessary to fight a fire and to control the effects of the fire.

The devices, vehicles and equipment required with regard to operational hazards are provided as minimum technical equipment.

A professionally qualified fire protection officer is appointed for each nuclear power plant. The fire protection officer has the right to communicate directly to the plant management. The tasks of the fire protection officer include supervision of compliance with fire prevention provisions, e.g. regarding the storage of combustible materials or performance of welding work. The fire protection officer is also involved in the regular implementation of fire protection drills and in the preparation and regular review of:

- the fire protection concept,
- the fire safety regulations,
- the fire protection plans, and
- the plans for the deployment of the fire brigade.

The fire protection officer is provided with the training and education necessary for the fulfilment of duties, taking into account the operational requirements.

The fire safety regulations are part of the operating manual (according to KTA 1201 /KTA 15c/). The fire safety regulations particularly regulate the measures for fire prevention and firefighting, the behaviour in case of fire as well as the organisation and responsibilities of the fire protection personnel.

The tasks and responsibilities from the point of view of nuclear law are also regulated for the responsible personnel with regard to fire protection aspects in the personnel operating regulations. The relevant documents are also distributed externally (e.g. competent authority).

The fire protection precautions, such as the implementation of structural fire compartmentation, fire extinguishing systems or access and escape routes, are documented and kept up to date.

For orientation and assessment of the situation in the event of fire, plans for fire brigade operations are available for the plant site as well as for the buildings in coordination with the fire brigade. These plans contain the information required for the fire brigade's tactical approach. The plans for fire brigade operations are kept up to date.

For nuclear power plants in the phase of residual operation, administrative and organisational fire protection means are reflected with respect to the requirements of the conventional regulations. The conceptual requirements that also apply to power operation remain essentially unchanged. As a rule, due to the significant reduction of the radiological release potential in case of fire after removal of the fuel elements, a dedicated on-site fire brigade is no more needed and extinguishing necessary can be carried out by the public fire brigade. Meeting conventional building law requirements continues to be ensured. Defensive fire protection can be adapted to the extent required for the risk potential still present at the installation.

Research reactors

<u>FR MZ</u>

Any fire alarm is automatically forwarded to the Mainz professional fire brigade. The police is notified at the same time. An automatic message is also sent to the main gate of the Johannes Gutenberg University Mainz and to the on-call service of the FR MZ. The alarm regulations also contain an alarm notification list. The operating management decides on the notification of the university management and the nuclear supervisory and licensing authority.

The personnel of the FR MZ and of the associated research and administration buildings are prompted by sirens to leave the buildings immediately and go to the selected assembly point. The reactor operator manually scrams the reactor, checks that all experimenters have left the reactor hall and also leaves the building immediately.

FRM II

The aspects of organisational and defensive fire protection are described in the next paragraphs.

Fuel cycle facilities

BFL

Due to increased safety requirements for the BFL premises, fire safety regulations in parts A, B and C were implemented for all buildings in agreement with the authorities responsible for preventive fire protection in accordance with DIN 14096 (Fire precaution regulation – Rules for drafting and placarding). These fire safety regulations specify the organisational and equipment-related technical measures required for fire prevention and effective firefighting, taking into account the aspects of criticality safety and radiation protection.

Part A of the fire precaution regulation is posted in all building areas at clearly visible places. Parts B and C are accessible in the operating manual to every employee.

The specifications for fire protection include the following:

- fire extinguishing drills by the dedicated on-site fire brigade as well as fire alarm evacuation drills in connection with a fire drill using the on-site fire brigade,
- regular training of all employees in the use of hand-held fire extinguishers,
- training and education of the dedicated on-site fire brigade,
- provision of suitable extinguishing media for use in controlled areas to ensure effective fire suppression and to prevent harmful consequential reactions (e.g. criticality),
- fire prevention means, such as minimising combustible materials, written permissions for work involving an increased risk of fire.

In accordance with the requirements of KTA 1201 /KTA 15c/, the operating manual contains parts that are classified as safety specifications. The fire safety regulations as one of the operating regulations are classified as safety specifications.

UAG

The operating instructions for preventive fire protection at UAG include the following provisions:

- implementing fire safety regulations, fire brigade plans (deployment plans for special objects) and access and escape plans,
- training of the plant personnel regarding fire protection: test alarms and fire extinguishing drill in connection with exercises on the control of releases of radioactive substances,
- fire protection provisions in controlled and supervised areas, particularly the use of suitable extinguishing media to ensure effective firefighting and to prevent harmful consequential reactions (e.g. criticality or spread of contaminated extinguishing water),
- preparedness planning for fire protection, radiation protection and first aid personnel,

- fire protection provisions with information on general fire prevention, particularly regarding access and escape routes to be kept clear,
- fire protection provisions during welding work, roofing work, work with combustible insulation materials and other handling of open fire (e.g. fire watches),
- training and education of the dedicated on-site fire brigade; regular fire drills and training with the voluntary fire brigade,
- technical equipment of the on-site fire brigade including maintenance and servicing of the equipment,
- displaying notices with general rules of conduct in the event of fire as defined in DIN 14096, Part A,
- in-service inspections of the structural and equipment-related fire protection features.

On-site spent fuel and radioactive waste storage facilities

Part of the operating manual are the fire safety regulations, which describe the provisions for fire prevention and fire suppression and regulate the behaviour in case of fire. Firefighting plans are available for quick orientation and assessment of the situation. The plans contain all information required for tactical actions. The effectiveness of these organisational measures is ensured by regular alarm drills.

In order to enable a safe escape from the fire location to the outside, access and escape routes are provided and clearly marked, which also serve as attack routes for the fire brigade. These access and escape routes represent the shortest connection between the respective plant area and the outside.

Regular emergency exercises performed together with the fire brigade and the high proportion of first aid firefighters from the plant personnel are another important aspect.

<u>Storage facility North</u>

In addition to the above-mentioned aspects, a dedicated on-site fire brigade of group size is present at the ZLN site by EWN (corresponding to safety category K3.2 of the industrial buildings directive). A dedicated on-site fire brigade consisting of full-time and part-time firefighters trained in accordance with the principles for professional fire brigades is available for firefighting. The on-site fire brigade is alerted by the inner security checkpoint in the ZLN guard house and arrives in firefighting group strength (10 persons). In addition, the alarm is forwarded to the control centre of the on-site fire brigade. The fire location is reached within 5 min at the latest. The doors and gates needed for access and fire attack can be opened independently by the on-site fire brigade.

Incipient fires are, as far as possible, extinguished by hand-held fire extinguishers. If a stationary fire extinguishing system is available in the area, it is manually actuated by the on-site fire brigade.

Access to the entire site from public roads is provided via the public access road. At the site of the ZLN itself, access is possible via sufficiently large traffic routes to the buildings. Between the buildings, there are also sufficiently large traffic routes and movement areas for the fire brigade. If there are any modifications to the access routes to the ZLN and the site of EWN in terms of the space available for emergency vehicles to be implemented and move around, it will be ensured that these access routes are maintained to the extent necessary.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

Part of the WAK operating manual are the fire safety regulations, which describe the provisions for fire prevention and fire suppression and regulate the behaviour in case of fire. Firefighting plans are available for quick orientation and assessment of the situation. The plans contain all the instructions required for the tactical approach of the emergency service manager and the fire brigade. The effectiveness of these organisational measures is ensured by regular alarm drills.

In order to enable a safe escape of the fire location to the exterior, access and escape routes are provided and marked, which also serve as attack routes for the fire brigade. These access and escape routes are the shortest connection between the respective area of the building and the outside. The maximum access and escape route length to the outside is 35 m for all plant areas.

The regular emergency exercises performed together with the fire brigade and the high proportion of first aid firefighters from the plant personnel are another important aspect.

All aspects of fire protection are constantly checked and adapted to the respective dismantling situation. For this reason, e.g., external stairway towers were retrofitted to ensure a maximum access and escape route length.

To keep the stairwells of the VEK smoke-free, an overpressure ventilation system has been installed, taking into account the existing nuclear installation.

The ventilation systems are designed such that a directed flow within the buildings from the outside to the inside is maintained even when the access and escape doors are open. An uncontrolled spread of smoke is prevented.

3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

Nuclear power plants

Firefighting is performed by trained personnel with suitable fire extinguishing features. The following systems and equipment are used for firefighting:

- portable fire extinguishers,
- above-ground hydrants on the premises and wall hydrants in the buildings, and
- stationary fire extinguishing systems.

To fight incipient fires, portable fire extinguishers are provided in sufficient number, particularly in all operational rooms, in the stairwells in front of entrances to operational facilities and at locations with fire risk. The selection of extinguishing media depends on the required fire class, taking into account the systems engineering requirements. For example, fighting fires next to and in electrical installations, the requirements of the DIN VDE 0132 guideline must be met.

Until the fire brigade arrives, initial firefighting can be carried out by plant employees working in the vicinity of the fire location using those fire extinguishing features directly available. These employees inform the shift management as well as the fire brigade arriving at the fire location on the situation there.

For the deployment of the fire brigade in the controlled area, the requirements of the Radiation Protection Ordinance and the fire brigade service regulation (Feuerwehrdienstvorschrift FwDV 500) need to be principally applied.

Firefighting is carried out in accordance with the fire safety regulations.

The fire brigade plans contain all information necessary for firefighting in the affected area (e.g., fire attack routes, permanently installed extinguishing systems, smoke extraction features, extinguishing water supply, special hazards and associated protective measures, etc.). This also includes necessary safety measures (e.g. start-up/shutdown of switchgears and aggregates).

The fire brigade proceeds according to the following principles:

- rescue of endangered persons,
- protecting items important to safety in the vicinity of the fire location,
- extinguishing the fire.

If there is an imminent risk of explosion, the fire brigade first takes evacuation and closing-off measures until further action is determined by the fire brigade commander.

When using CO_2, there may be an acute risk of asphyxiation. When using CO_2 extinguishers, appropriate safety measures (e.g. respiratory protection, forced ventilation) are therefore taken. Smoke-filled rooms may only be entered with breathing apparatus independent of the air in the room (respiratory apparatus). A squad-by-squad approach is taken and an intervention team is provided.

In case of fires in the controlled area, the fire brigade equips itself with alarm dosimeters. Compliance with radiation protection provisions within the controlled areas is regulated internally in the radiation protection regime.

Access to the controlled area is provided via the designated fire brigade access points, e.g. truck lock or controlled area access. In the event of fires in the containment, access is always provided via the personnel airlock.

Switching the control room or the computer room to recirculation mode will become necessary when sucking in flue gases from the environment, e.g. in the event of a fire outside buildings. This can be done, e.g., by triggering a gas alarm.

Research reactors

FR MZ

A specific fire suppression strategy that deviates from the usual internal attack of the fire brigade is not needed due to the local conditions of the FR MZ. Due to the almost excluded risk of radioactive substances being released from the reactor core as a result of a fire (inherent safety, no residual heat removal required) in the reactor hall, this appears to be justified from the point of view of the authorities and the licensee. Only the equipment of the fire brigade forces and the precautions to be taken when accessing certain rooms are already regulated in advance by the Rhineland-Palatinate dangerous materials concept /MIN 05/. At the FR MZ, there are rooms of hazard groups I to III. In the case of hazard group III (e.g. radionuclide laboratory in the reactor hall annex), the fire brigade may only operate with special equipment and under special supervision and decontamination precautions. When entering such areas, prior consultation by a competent person will be ensured. For areas of hazard groups II and III, general arrangements drawings for the fire brigade are to be prepared and kept available. These can be found at the FR MZ in the form of fire brigade route maps at the fire brigade information centre in the entrance area of the old building.

FRM II

The fire protection rules are set out in the fire safety regulations, the alarm regulations and the fire protection concept. For the organisation of operations, the fire brigade has general arrangements drawings and fire brigade route maps, which are kept centrally at the site gate and additional copies in the control room and the guardhouse. Access and escape route plans are clearly displayed in the buildings. All documents are kept up to date at all times.

Firefighting is carried out by trained personnel using suitable fire extinguishing provisions. The following means are used for extinguishing:

- portable fire extinguishers,
- above-ground hydrants on the premises and wall hydrants in the buildings, and
- fixed extinguishing systems.

To fight incipient fires, portable fire extinguishers are kept in sufficient number, especially in all operational rooms, in the stairwells in front of entrances to operating facilities and locations with fire risk. The selection of extinguishing media is based on the required fire class, taking into account the systems engineering requirements.

Until the fire brigade arrives, initial firefighting can be carried out by employees working in the vicinity of the fire location using the extinguishing features directly available. The entire personnel (100 % of the workforce) is trained in fighting incipient fires. These employees inform the shift supervisor on duty and the fire brigade arriving at the fire location about the situation there.

The dedicated on-site fire brigade is equipped in accordance with the requirements and is available 24/7. The voluntary fire brigades in the vicinity supplements the on-site fire brigade upon request.

For the deployment of the fire brigade in the controlled area, the measures of the Radiation Protection Ordinance and the fire brigade service regulation (Feuerwehrdienstvorschrift FwDV 500) need to be principally applied.

Firefighting is carried out in accordance with the fire safety regulations. Details of the organisational strategy are determined by the fire brigade commander in consultation with the head of operations, depending on the situation. Fire drills and regular walk-throughs take place at least once a year with all shifts of the fire brigade as part of acquiring and maintaining local knowledge.

The fire brigade plans contain all information necessary for firefighting (e.g. fire attack routes, permanently installed stationary extinguishing systems, smoke extraction features, extinguishing water supply, special hazards and associated protective measures, etc.). This also includes necessary safety measures (e.g. start-up/shutdown of switchgears and aggregates).

The fire brigade proceeds according to the following principles:

- rescue of endangered persons,
- protecting items important to safety in the vicinity of the fire location,
- extinguishing the fire.

If there is an imminent risk of explosion, the fire brigade first takes evacuation and closing-off measures until further action is determined by the fire brigade commander.

When using CO_2,there may be an acute risk of asphyxiation. When using CO_2 extinguishers, appropriate safety measures (e.g. respiratory protection, forced ventilation) are therefore taken. Smoke-filled rooms may only be entered with breathing apparatus independent of the air in the room (respiratory apparatus). A squad-by-squad approach is taken, and an intervention team is provided.

In the event of fires in the controlled area, the fire brigade equips itself with alarm dosimeters. Compliance with radiation protection provisions within the controlled areas is regulated internally in the radiation protection regime. Access to the controlled area is provided via the designated fire brigade access points, e.g. truck lock or controlled area access. In the event of fires in the containment, access is always provided via the personnel airlock.

Switching the control room or the computer room to recirculation mode will become necessary when sucking in flue gases from the environment, e.g. in the event of a fire outside buildings. This can be done, e.g., by triggering a gas alarm.

Fire brigade plans and route maps are available throughout the buildings. Responsibilities are regulated in the alarm regulations in the operating manual. All fire drills and operations are documented.

The FRM II site has four independent and spatially separated access roads. Due to the dimensions of these, their condition and that of the buildings, the inaccessibility of the premises for fire brigade operations is not to be assumed. The Federal Agency for Technical Relief is available for further support measures according to contractual obligations.

Fuel cycle facilities

BFL

BFL's fire safety regulations set out the organisational and technical responsibilities and measures required for fire prevention and effective firefighting, while taking into account criticality safety and radiation protection aspects.

UAG

General firefighting measures in the UAG are described in the operating instructions (e.g. J932 on the behaviour of the on-site fire brigade in case of an accident, fire and UF_6 release). For other building-related hazards, additional measures are described in the operating instructions.

The equipment of the on-site fire brigade forces and the precautions to be taken when accessing radiation protection areas are already regulated in advance. The fire brigade may only enter these areas with special equipment and under special supervision and decontamination precautions. When entering such areas, the presence of a competent person is required. Availability of the competent person is ensured by the permanent presence of the appropriately trained shift supervisor.

On-site spent fuel and radioactive waste storage facilities

The fire safety regulations specify the organisational and technical responsibilities and measures required for preventive fire protection and effective firefighting while taking into account the aspects of criticality safety (only for spent fuel storage facilities) and radiation protection.

The operational fire protection measures are laid down in the fire safety regulations as part of the operating manual. The following issues, amongst others, are regulated here:

- personnel organisation for fire protection,
- preventive fire protection provisions:
  - rules of conduct for employees,
  - theoretical and practical training and exercises,
  - special features of the maintenance and servicing of fire protection equipment,
  - preventive maintenance (e.g. replacement of fire detectors);
- procedure in case of fire alarm by
  - automatic fire detection and alarm,
  - manual fire detection and alarm;
- fire suppression:
  - behaviour in case of fire,
  - measures after fire suppression,
  - additional measures after fire suppression in the controlled area.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

The fire safety regulations of the WAK and VEK specify the organisational and technical responsibilities and measures required for preventive fire protection and effective firefighting in compliance with radiation protection.

3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

Nuclear power plants and FRM II research reactor

The following operating regulations of the operating manual are relevant with regard to fire protection (organisation, tasks, alerting, permission and monitoring of hot work, maintenance of fire protection features):

- fire safety regulations,
- personnel and operating regulations,
- maintenance rules,
- alarm regulations,
- radiation protection regime.

For more details, see paragraph 3.2.3.

In addition to the internal nuclear regulations, specific regulations for the fire brigade are relevant. An on-site fire brigade, if required, is dedicated by the competent authorities by means of an order. The recognition order specifies, among others, the following:

- principles regarding the relevant internal regulations or the area of the on-site fire brigade activities,
- organisation,
- personnel of the on-site fire brigade (including minimum personnel strength, requirements),
- training,
- exercises/drills, including the external fire brigades,
- vehicles, equipment and devices.

The recognition order is available for documentation by the licensee and the competent authority (e.g. district office).

Research reactor FR MZ

Active firefighting at the FR MZ is covered by the municipal professional fire brigade. In the event of a fire brigade operation, the alarm regulations of the FR MZ regulate the responsibilities and organisation. The operational management is responsible for managing and implementing the necessary measures for hazard prevention at the FR MZ (entire building complex) in the event of an alarm. In the event of a fire, the fire brigade commander takes the lead in the firefighting operations. The FR MZ has no influence on the internal organisation and responsibilities of the fire brigade.

Fuel cycle facilities

BFL

In the operating manual of the BFL, the organisation and responsibilities in fire protection are described in the personnel operational organisation and in the fire safety regulations, also under the aspect of repair measures and the related documentation.

According to the fire safety regulations, any person discovering a fire is obliged to immediately inform the permanently staffed office and, if possible, to start fighting the fire or to initiate rescue measures while observing self-protection. For this purpose, all persons are instructed in the use of fire extinguishers on a regular basis.

BFL also maintains a permanently operational dedicated on-site fire brigade, which is trained in accordance with fire brigade service regulations.

The municipal fire brigade is automatically alerted by a signal of the fire detection and alarm system forwarded if the investigation by the on-site fire brigade has not resulted in any clarification within the short response time. The municipal fire brigade is familiar with the local conditions through walk-throughs and drills for cooperation between the forces of the external and internal fire brigades. The municipal fire brigade always has the latest information on fighting fires at the BFL.

UAG

The following operating instructions of the UAG describe the responsibilities, organisation and documentation with regard to fire protection:

- fire safety regulations,
- personnel operational organisation,
- maintenance rules,
- alarm regulations,
- radiation protection regime.

Since the commissioning of the UAG on 18 June 1985, Urenco Deutschland has a dedicated on-site fire brigade. During the plant expansion, the former plant fire brigade of Urenco Deutschland was established as a dedicated on-site fire brigade as of 1 April 2005 and recognised as a n on-site fire brigade by the Münster district government. In terms of organisation, equipment and training, it complies with the requirements for public professional fire brigades and with a fixed operational strength in the form of a group (10 firefighters). The on-site fire brigade takes non-police defence measures in the event of fires, accidents and UF_6 or U_3O_8 releases in the buildings and facilities at the Urenco Deutschland site.

For A- or C-defence operations according to FwDV 500, the minimum tactical strength is a squad. This can only be provided in cooperation with the Gronau fire brigade.

The Urenco Deutschland on-site fire brigade deploys its command vehicle directly to the scene of an emergency in the event of a defined alarm key words in the city of Gronau, e.g. human life in danger, to support the voluntary off-site fire brigade. The firefighters deployed are members of voluntary fire brigades and provide the required personnel reserves for the municipal fire brigade. The necessary personnel of the on-site fire brigade as well as the fire truck remain on the premises for hazard prevention.

On-site spent fuel and radioactive waste storage facilities

In the operating manual of the spent fuel and radioactive waste storage facilities, the organisation and responsibilities in fire protection are described in the personnel operational organisation and in the fire safety regulations, also under the aspect of repair measures and the related documentation.

According to the fire safety regulations, any person discovering a fire is obliged to immediately inform the permanently staffed office and, if possible, to start fighting the fire or to initiate rescue measures while observing self-protection. For this purpose, all persons are instructed in the use of fire extinguishers on a regular basis.

The on-site fire brigade is alerted at the Biblis site by the security guard service in the permanently staffed office in the security centre and at the ZLN site directly. The on-site fire brigade is familiar with the local conditions. If necessary, the on-site fire brigade alerts the municipal fire brigade for support. The municipal fire brigade always has the latest information on firefighting.

Emergency exercises are carried out at regular intervals in coordination with the on-site fire brigade, if necessary, with the involvement of public fire brigades. The interaction with the site security service, the radiation protection personnel and the plant personnel is practised. The exercises are documented in protocols.

The training of the on-site fire brigade is carried out in accordance with the training plan implemented for this purpose, based on the fire brigade service regulations. All firefighters must be fit for respiratory protection. The physical fitness requirements for respiratory protection equipment wearers as well as the basic and advanced training according to FwDV 7 "Respiratory Protection" are complied with.

Fire brigade plans were implemented in accordance with the Land building regulations and in agreement with the on-site fire brigade; these were made available to the on-site fire brigade.

In accordance with the workplace guideline, access and escape route plans have been implemented in sufficient numbers and posted at suitable locations. Suitable locations are, in particular, areas where people are frequently present. For the buildings under consideration where there are changes in the building geometry, the existing access and escape route plans are adapted in accordance with the licensee's specifications and posted and updated as it is appropriate to the location.

Before starting work, the company's own as well as external personnel are instructed on fire prevention and how to behave in the event of a fire, taking into account the particularities of the respective area of activity. Employees are instructed on the correct use of firefighting equipment once a year as part of the annual fire safety training, and every two years each employee is trained in the practical use of hand-held fire extinguishers. In addition, the licensees provide training to employees as evacuation assistants who support the evacuation of persons in case of an alarm. They also receive refresher training at regular intervals.

The entire personnel is informed about the presence of stationary fire extinguishing and fire detection and alarm features, their function and alarm signalling. The necessary behaviour when these systems are actuated is trained. All instructions and training are prepared, conducted, and documented by the respective management.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

<u>WAK including VEK</u>

the operating manual of the WAK the organisation and responsibilities in fire protection are described in the personnel operational organisation and in the fire safety regulations, also under the aspect of repair measures and the related documentation.

The KTE has an appointed fire protection officer, whose main task is to support the company and all its managers in identifying and implementing appropriate fire protection measures. In coordination with the on-site fire brigade, fire drills are carried out. In these drills, the interaction with the site security service, the radiation protection personnel and the plant personnel is practised and the suitability of the specified measures is checked.

3.2.3.3 Specific provisions, e.g. loss of access

Nuclear power plants

Even in the event of a loss of access to the plant site, there is no risk that the nuclear protection goals could be endangered by a fire. For plants with fuel elements, the implemented fire protection means – structural, equipment-related, organisational and administrative, and, in particular, preventive – are effective. Compliance with the nuclear protection goals is essentially based on the structural and equipment-related fire protection means. Nevertheless, the provision of an on-site fire brigade ensures defensive fire protection, irrespective of the access of external fire brigades to the plant site. In the event of limited accessibility on the site itself, there are several entrances to the buildings so that access and escape routes as well as attack routes for the on-site fire brigade are always available.

For installations free of nuclear fuel, the release potential in the event of a postulated fire is reduced by several orders of magnitude compared to plants in commercial power operation, since the remaining amounts of radioactive substances are significantly lower and substantially bound in metallic structures (activation). Radiological analyses in the frame of the dismantling licensing procedures show that potential releases for postulated fires in installations that are free of fuel elements are significantly below the exposure limits of § 104 StrlSchV for design basis accidents, even if defensive fire protection fails. In terms of compliance with the nuclear protection goals, defensive fire protection is only a measure to mitigate the radiological consequences of a fire.

Restriction of accessibility is only conceivable in the event of external fires in combination with internal fires. Such hazards can be extreme weather conditions, external floods, e.g. with flooding of the site, earthquakes, explosion pressure waves, or aircraft crashes. However, mitigation of the radioactive releases from fires is no longer required for these unlikely external boundary conditions.

Research reactors

FR MZ

In case of limited accessibility on the university campus, there are several entrances to the buildings of the FR MZ so that access and escape routes as well as attack routes are always available for the fire brigade.

Furthermore, due to its fuel design, the FR MZ offers the advantage that a loss of coolant, e.g. as a result of a fire event, cannot lead to cladding tube damage. The robustness analysis from 2012, already mentioned in paragraph 2.2.6.2, analysed a comprehensive fire scenario with a hypothetical aircraft crash and demonstrated that a complete loss of coolant at the FR MZ does not endanger the protection goals.

The fact that earthquakes, which could endanger the infrastructure for the fire brigade and rescue forces as well as the stability of buildings, are practically impossible in the geographical location of the FR MZ, is an additional locational advantage at the FR MZ.

FRM II

Due to the site-specific conditions, inaccessibility of buildings or parts of buildings of the FRM II does not have to be assumed. All relevant buildings, including the fire brigade buildings themselves, are sufficiently resistant against earthquakes. Corresponding investigations were carried out as part of the assessments after the reactor accidents at Fukushima Dai-ichi (referred to as RSK safety review). Doors are designed such that they are either earthquake-proof or so lightly constructed that the fire brigade can open them with their own means even if blocked.

Fuel cycle facilities

BFL

In the event of restricted access for defensive fire protection in the buildings or on the premises of the BFL, e.g. due to construction measures or major maintenance activities in the buildings themselves, there are usually several access points to the buildings so that both the requirements for escape and rescue routes and attack routes for active firefighting are provided. The BFL operating manual specifies requirements that are to be considered in the above-mentioned cases.

UAG

At the UAG, compliance with the nuclear protection goals is essentially based on the structural and equipment-related fire protection means. However, the provision of an on-site fire brigade ensures defensive fire protection regardless of the access of external fire brigades to the plant site. In the event of limited accessibility on the plant site itself, there are several entrances to the buildings so that escape and rescue routes as well as attack routes for the on-site fire brigade are always available.

On-site spent fuel and radioactive waste storage facilities

Compliance with the nuclear protection goals in the spent fuel and radioactive waste storage facilities is based to a large extent on the structural and equipment-related fire protection means. In the event of limited accessibility on the site itself, there are several entrances to the buildings so that access and escape routes as well as attack routes for the on-site fire brigade are always available.

Conditioning of radioactive waste at the storage facility North

The fire brigade plans stipulate that the caissons may only be opened in the event of fire if this is indispensable for successful extinguishing of the fire.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

In case of limited access possibilities for defensive fire protection in the buildings of the WAK including VEK, e.g. due to dismantling measures, several access points to the buildings are available so that the requirements for access and escape routes as well as attack routes for active firefighting are met.

3.3 Passive fire protection

3.3.1 Prevention of fire spreading (barriers)

3.3.1.1 Design approach

The structural fire protection means are designed to withstand the effects of fire as described in paragraph 2.1.3 without loss of their fire protection function (e.g. stability, fire compartmentation).

The individual building structures are constructed as fire compartments by means of sufficiently fire-resistant structural elements or are separated from each other by sufficient distances to prevent the spread of fire. Each building represents a fire compartment. The further structural fire protection partitioning within the buildings is provided by fire sub-compartments, which are usually also formed by storey. Exceptions are permissible for systems engineering reasons or due to operational needs /KTA 15/.

The fire sub-compartments are areas requiring special protection, which is ensured by compartment boundaries formed by certified fire-rated structural elements (see Appendix A3) for operational and/or safety-related reasons. In many cases, this is done for reasons of separating SSC important to safety of different redundant trains and separating specific fire loads and therefore goes beyond the basic building law requirements that must generally be complied with, as an additional measure needed for operational reasons.

However, the requirements of the KTA for the nuclear licensing and for the building licensing process differ only in some areas; they widely do not differ or only a little.

In the reactor building or in the turbine hall, respectively, systems engineering or operational needs result in exceeding the fire compartment size prescribed by the conventional building regulations. Redundant safety system equipment or redundant emergency system equipment always has to be separated by sufficiently qualified fire-resistant structural elements such that the requirements specified in paragraph 2.1.1 are met. However, by means of compensatory measures, e.g. by:

- separation by distance,
- encapsulations or formation of fire sub-compartments for special areas (these are listed in KTA 2101.2, Section 5.2),
- cable systems with functional integrity,
- additional equipment-related fire protection provisions, or
- a combination of these means,

required fire protection is ensured.

For the formation of fire compartments or fire sub-compartments, only structural elements or construction products whose usability has been proven are used in accordance with the requirements under building law. DIN 4102 and successively harmonised European standards (see Appendix A3) are taken into account with regard to the fire behaviour of building materials and the fire resistance rating of structural elements.

If additional requirements are to be taken into account in the design (e.g. radiation protection requirements, gas tightness, reduced temperature increase on the side facing away from the fire), these are taken as a basis for determining the fire resistance of the structural elements. The guidelines and criteria for testing introduced by building law are applied analogously under the aforementioned conditions.

If nuclear power plant-specific requirements exist which go beyond the requirements of the building inspectorate, verifications according to KTA 2101.2 /KTA 15a/ can be carried out by calculations, by experiments, or by analogy or plausibility considerations. KTA 2101.2 also specifies a simplified procedure specific to nuclear power plants for determining the required fire resistance rating of structural fire protection means in Appendix A.

For practical design, however, it has proven useful to specify a uniform fire resistance rating. Thus, all structural fire protection means are usually designed to be fire-resistant. This simplifies the fire protection concept through a uniform specification to be complied with. A detailed analysis of fire loads to minimise fire resistance rating is not conducted. If higher fire loads are present, an additional fire extinguishing system (see paragraph 3.2.2) is installed, or other compensatory measures are taken.

As already described in paragraph 2.1.1, event combinations of a fire with another event are postulated depending on the causality, probability, and extent of damage. Thus, those structural fire protection means whose fire protection function must also be ensured after an earthquake are designed for the earthquake effects determined in accordance with KTA 2201.1 /KTA 11/, provided that the intensity of the design basis earthquake is higher than VI (EMS-98). Safety demonstrations for fire and earthquake are carried out independently of each other.

During decommissioning and dismantling, at the latest when all fuel elements have been removed, the requirement for a separation of redundant trains does no longer apply. In this respect, fire sub-compartments that have served for separation of redundant trains are no longer needed. Access and escape routes are maintained in accordance with requirements.

Fire compartments may be combined if this does not result in unacceptably high fire risks. This will be particularly the case if the fire loads in these fire compartments have become sufficiently low due to the dismantling of SSC with the result that the fire risk as such is low in each of the fire compartments to be merged.

In addition to operational requirements, the layout of the buildings also takes into account the needs with respect to.

- the fire protection separation through distance between buildings,
- a fast and safe rescue of persons in case of fire, and
- the access for firefighting.

The requirements of DIN 14090 as well as those of KTA 2101.2 /KTA 15a/, paragraphs 4.2 to 4.5 apply.

Research reactors

FR MZ

The building complex is partitioned into different fire compartments, which are separated from each other by at least fire-resistant fire walls and fire-retardant fire doors. The fire doors are either permanently closed or close automatically in the event of a fire actuated by their own smoke detectors or, alternatively, in the event of a power failure. Due to the inherent safety of the reactor fuel, the automatic shutdown by control rod drop in the event of a loss of power and the fact that residual heat removal is not necessary, there was no need for structural separation of the redundant cooling circuit pumps, which are located in the reactor machine room. However, this room is separated from the reactor hall by a fire-resistant door.

FRM II

The third barrier in the defence in-depth safety concept is to prevent the spread of fires and thus minimising their impact on essential functions.

The spread of fires is prevented by fire-resistant fire compartments and fire sub-compartments. Required cable, pipe and ventilation penetrations are appropriately sealed and/or equipped with automatically actuated fire dampers (fusible link, motor). Access points are fire-resistant. The dampers can additionally be operated manually from the control room. Alternatively, ventilation ducts crossing fire compartments are fully fire-resistantly enclosed. The redundant trains required to meet the protection goals are located in different fire compartments, as well as the necessary documentation. Fire compartments are secured by concrete walls with a thickness of at least 20 cm or masonry walls with a thickness of at least 24 cm. Fire dampers and doors are regularly inspected in accordance with inspection lists (typically at least annually). The general structural condition is regularly assessed by walk-throughs by the experts in accordance with § 20 AtG /ATG 22/ and the fire inspections by the city of Garching.

An essential feature for complying with the protection goals is the arrangement of components under water (e.g. control rods) or their fail-safe behaviour in case of fire events (triggering a reactor scram).

Structural fire protection means, such as the formation of fire compartments or fire sub-compartments, are implemented with priority over equipment-related provisions. To prevent the spread of fire, buildings are partitioned into fire compartments and fire sub-compartments that are at least fire-resistant. This is ensured by approved building materials, appropriate partitioning and, in the long term, by in-service inspections.

The structural fire protection means are designed to withstand the effects of fire without losing their fire protection function (e.g. mechanical stability, fire compartmentation).

The individual building structures are designed as fire compartments by means of sufficiently fire-resistant structural elements or are separated from each other by sufficient distances to prevent the spread of fire. Each building represents a fire compartment. The further structural fire protection partitioning within the buildings is done by forming fire sub-compartment, which are usually also formed storey by storey. Exceptions are permissible for engineering reasons or due to operational needs /KTA 15/. The fire sub-compartments are areas requiring special protection, which is ensured by compartment boundaries formed by certified fire-rated structural elements for operational and/or safety-related reasons. In many cases, this is done for reasons of redundancy separation of SSC important to safety and separation of special fire loads and therefore goes beyond the basic building law requirements that must generally be complied with, as an additional measure needed for operational reasons.

In the reactor building, systems engineering or operational needs may lead to exceeding the fire compartment size prescribed by the conventional building regulations. Redundant items important to safety are generally separated by sufficiently fire-resistant structural elements such that the requirements specified in paragraph 2.1.1 are met. However, compensatory measures, such as

- separation by distance,
- encapsulation or formation of fire sub-compartments for special areas,
- cable systems with functional integrity,

- additional equipment-related fire protection features (e.g. spraywater deluge or sprinkler systems), or
- a combination of these means,

the required fire protection is ensured.

For the formation of fire compartments or fire sub-compartments, only structural elements or construction products whose usability has been proven are applied in accordance with the requirements under building law. DIN 4102 is taken into account with regard to the fire behaviour of building materials and the fire resistance rating of structural elements.

If additional requirements are to be taken into account in the design (e.g. radiation protection requirements), these are used as a basis for determining the fire resistance of the structural elements. The guidelines and criteria for testing introduced under building law are applied analogously under the aforementioned conditions.

For practical design, however, it has proven useful to specify a uniform fire resistance rating. Thus, all structural fire protection meanes are usually designed to be fire-resistant. This simplifies the fire protection concept through a uniform specification to be complied with. A detailed analysis of fire loads to minimise fire resistance rating is not conducted. If higher fire loads are present, an additional extinguishing system is installed, or other compensatory measures are taken.

In addition to operational requirements, the layout of the buildings also takes into account the needs with respect to

- the fire protection separation by distance between buildings,
- the fast and safe rescue of persons in the event of fire, and
- the access for firefighting.

The requirements of DIN 14090 as well as those of KTA 2101.2 /KTA 15a/, paragraphs 4.2 to 4.5 apply.

For the rescue of persons, the access and escape route lengths to the next secured area shall not exceed 35 m; in unfavourable locations, fire escape hoods are additionally available. Access and escape routes are adequately dimensioned (usually at least 1.2 m wide) and, as far as necessary, protected from the effects of fires (e.g. dripping of overheated cable insulation).

Fuel cycle facilities

<u>BFL</u>

The essential basis of the BFL for fire protection is the protective function of the buildings or individual parts of the buildings, e.g. through the use of non-combustible building materials, the fire protection separation of areas and the design of the ventilation system, which limits the spread of a fire. This also complies with the requirements from the BFL licences and the applicable Land building regulations for the fire protection of a building.

The spread of fire is prevented by compliance with the applicable national and Land-specific provisions and regulations, e.g. Land building regulations, industrial buildings directive, safety requirements for nuclear fuel cycle facilities and the regulations listed therein.

The fire resistance classes of the structural building elements used in the BFL are assessed according to both DIN 4102 and the European classification DIN EN 13501.

By updating the existing fire protection concepts, current developments in the regulations are taken into account.

UAG

The buildings of the UAG are buildings of special use as well as buildings of low height according to the respective Land building regulations. In addition, they are special buildings according to the applicable Land building regulations.

It was stipulated in the UAG licence that only non-combustible building materials of building material class A (according to DIN 4102) are used for load bearing elements. Spatial and structural fire compartmentation was performed for fire protection within the buildings.

The formation of different fire compartments within the buildings, which are separated by fire walls and fire doors in accordance with DIN 4102, prevents the spread of fire. A further structural fire protection-related partitioning within the fire compartments is reached by forming fire sub-compartments.

On-site spent fuel and radioactive waste storage facilities

The spread of fire is prevented in the spent fuel and radioactive waste storage facilities by compliance with the applicable national and Land-specific provisions and laws as well as technical regulations listed therein.

The essential basis of the spent fuel and radioactive waste storage facilities with regard to fire protection is the protective function of the buildings or individual parts of the buildings, e.g. through the use of non-combustible building materials, the fire protection separation of areas and the design of the ventilation system (if present), which limits the spread of fire.

The load-bearing and bracing structural elements of the storage facility buildings are designed to be at least fire resistant in accordance with the applicable Land building regulations. The licensed ground storage building and the main supporting structure of the roof are fire-resistant in accordance with the industrial buildings directive.

The fire protection concept takes into account the current regulatory requirements.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plant and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

The structural fire protection means at the WAK including VEK are designed to withstand the effects of fire without losing their required fire protection function.

The individual building structures are designed as fire compartments by means of sufficiently fire-resistant structural elements or are separated from each other by sufficient distances to prevent the spread of fire.

All load-bearing structural elements of the VEK were manufactured using materials of building material class A1 according to DIN 4102 (non-combustible). The building was made of concrete with armouring. Stages and platforms were made of concrete or steel structures. All reinforced concrete parts were made fire-resistant.

The doors and gates are mainly made of steel. In some cases, especially for radiation protection doors, shielding material is also used inside the doors.

In the cells and areas where floor liners or tubs are required, these are made of stainless steel.

Exposed expansion joints are sealed with non-combustible materials.

3.3.1.2 Description of fire compartments and/or cells design and key features

Nuclear power plants

Walls separating fire compartments from adjacent buildings or parts of buildings are principally qualified fire barriers. Instead of fire walls, there may be offset walls that are sufficiently fire-resistant, but at least fire-retardant and made of non-combustible building materials, if this is required for the use of the building (e.g. controlled area within a BWR electrical building).

These walls always have to be constructed in connection with ceilings without openings with at least the same fire resistance rating. If openings in these ceilings are technically required, they have to be closed like openings in fire walls.

Closures of openings in compartment boundaries formed by certified fire-rated structural elements [i.e. fire barrier elements] include

- fire protection closures (fire doors, gates, dampers),
- windows,
- fire dampers,
- cable penetration seals,
- pipe penetration seals, and
- joint sealings.

The fire resistance rating of the fire barrier elements is basically the same as the required fire resistance rating of the fire barriers. In the case of pipe penetrations, the function of the partitioning is ensured both in the event of a fire and during specified normal operation.

Penetrations of piping systems as well as openings in fire barriers between fire compartments and fire sub-compartments are always sufficiently fire-resistant sealed. It is permissible to close openings automatically only in the event of a fire or to open closures for the duration of pressure equalisation. If, for systems engineering reasons or due to operational needs (e.g. pressure equalisation openings), fire barrier elements cannot be implemented, additional equipment-related or defensive fire protection means are provided to achieve an equivalent level of protection.

In the case of cable penetrations whose fire protection function is to be demonstrated after earthquakes, the relative deformations at the cable penetration seal in the direction of the cable penetration as a result of the dynamic stresses during earthquakes are limited by design provisions (e.g. fixed point arrangement) to a level at which the fire resistance rating of the penetration seal is not inadmissibly limited.

Research reactors

FR MZ

Generally, the building boundaries between the old building, the reactor hall and the extension building define their own fire compartments (see Fig. 2-1). In the old building, there is an additional partitioning into six fire sub-compartments by fire-resistant walls and doors along the vertical bisecting line of the building and the two storey ceilings. The reactor hall annex with the staircase and the laboratory and storage rooms located there also form another fire compartment. Adjacent fire compartments are equipped with fire doors with automatically actuated closing function by smoke detectors. The walls to adjacent buildings (reactor hall to the old building, old building to the extension building) are designed as outer building walls in accordance with the Land building regulations. Due to the concrete wall of 2.3 m thickness and a height of more than 6 m, the biological shield of the reactor core also forms an effective barrier against the effects of fire and can therefore be regarded as a fire wall with the fundamental safety function of confining the radioactive inventory.

FRM II

The functions required to achieve the protection goals are ensured in all plant operational states through fire barriers between redundant trains. Fire compartments are qualified fire-resistant or higher. This also applies to all types of penetrations (fire dampers, cable and pipe penetration seals, fire doors). If not otherwise possible, separation by distance is used in exceptional cases. In addition, firefighting equipment is provided to the extent necessary. In particularly sensitive areas (e.g. increased fire load, storage area for combustible radioactive waste), this includes automatically actuated sprinkler systems and manually actuated spraywater deluge systems.

Fuel cycle facilities

BFL

The fire sub-compartments formed at BFL are designed in accordance with the structural requirements for the fire resistance rating of walls and ceilings. Necessary penetrations (fire dampers, cable and pipe penetrations seals, doors, gates) also meet these requirements. The fire sub-compartments are designed in accordance with the applicable building law (Land building regulations, MIndBauRL, etc.).

These structural means, in combination with the fire detection and alarm system, serve to detect, confine and fight fires locally and thus to ensure that fires are controlled locally, taking into account the nuclear protection goals and the protection of persons.

UAG

With the exception of a few rooms with low fire loads, the fire compartments in the UAG are equipped with an automatic fire detection and alarm system. The structural requirements for the walls and ceilings are ensured by fire-resistant boundaries. Fire spread is prevented by the implementation of fire dampers, penetration seal systems for pipes and cables, fire doors and gates. These necessary penetrations through structural barriers (walls and ceilings) are also of the same fire resistance class.

The fire compartments are classified in safety category K3.2 according to the industrial buildings directive.

On-site spent fuel and radioactive waste storage facilities

Storage at the Biblis site

The fire sub-compartments formed at the spent fuel and radioactive waste storage facilities and listed in the operating manual serve, in interaction with the fire detection and alarm system, for the local detection, confinement and suppression of fires and thus for ensuring that fires are controlled locally, taking into account the nuclear protection goals and the protection of persons.

The fire sub-compartments formed are designed in accordance with the respective applicable Land building regulations.

An essential element of structural fire protection is the formation of fire compartments. This measure aims at limiting a possible fire, to keep it spatially manageable and to provide a time frame for the preparation of extinguishing measures. Penetrations through different fire compartments and from the corridors into the technical rooms are equipped with penetration seal partitioning systems approved by the building authorities. Escape and rescue routes are designed in accordance with national guidelines.

The fire protection requirements to be met by the building are specified in the Land building regulations, the federal workplace ordinances and guidelines, the industrial buildings directive and the ESK Guidelines for dry cask storage of spent fuel and heat-generating waste.

Inside buildings, fire compartments with dimensions of no more than 40 m x 40 m are to be formed. Deviations from these requirements may be possible in case of operational requirements. Deviations are only permissible with the approval of the competent supervisory authority.

Storage at the storage facility North

The ZLN is divided into 15 fire compartments, which are described in the fire protection concept. Larger fire compartments are partitioned into fire sub-compartments. One fire compartment exceeds the permissible fire compartment size. The existing building with the existing fire compartments has been licensed. As a compensatory measure, the fire compartment was partitioned into fire sub-compartments. The determination and limitation of the fire loads for this area are dealt with separately in the fire protection concept.

The outer boundaries (walls, ceilings, and doors) of the fire compartments are fire-resistant. The walls meet the requirements regarding mechanical stability (fire walls) after fire. Load-bearing components are at least fire-resistant and made of non-combustible building materials.

Doors, gates and glazing in boundaries of fire-resistant separated areas are at least fire-retardant. Pipes, cables, or ventilation ducts (including fire dampers) penetrating fire barriers between fire compartments or fire sub-compartments are also fire-resistant.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

<u>WAK including VEK</u>

The shell of the WAK process building was constructed with reinforced concrete and the infill with brickwork. This construction method complied with the regulations in force at the time of construction. The fire barriers of the utilisation units have been removed. This means that the fire compartments have been eliminated but since the fire load and the risk potential have been significantly reduced at the same time by the dismantling work, the elimination is unproblematic. The partitioning of the buildings into fire sub-compartments is specified in the fire safety regulations. The fire sub-compartments are formed by fire-resistant walls. Closures of openings such as doors, pipe and cable penetration seals are also made of fire-resistant structural elements.

The VEK building is partitioned into fire sub-compartments. The boundaries of fire sub-compartments are fire-resistant walls. Closures of openings are formed by fire-resistant structural elements. Pipe and cable penetrations as well as doors are also made of fire-resistant structural elements that form the fire compartment boundaries. All passive fire protection features are important in terms of safety and regularly inspected.

3.3.1.3 Performance assurance through installation lifetime

Nuclear power plants

By using construction products with usability certificates, sufficient service life has already been proven through these and is ensured by proper application of these products. In-service inspections of fire protection features, e.g. fire protection closures or fire dampers, are carried out in accordance with KTA 2101.1 /KTA 15/ or the technical requirements according to the usability certificates or the technical testing and inspection regulations.

Table 3-1 Items to be tested and test intervals for in-service inspections according to KTA 2101.1 /KTA 15/

No.	Test Object	Type of Test	Testing Interval Licensee	Remarks
1	Room-Isolating Structural Elements with Fire-Protection Related Requirements			
1.1	Fire shields for cables	S	2 a	extent of tests may be chronologically subdivided
1.2	Fire shields for pipes	S	2 a	extent of tests may be chronologically subdivided
1.3	Fire protection closures (e.g., doors, hatches)	F	1 a	
2	Fire Protection Measures for Mechanical and Electrical Components			
2.1	Special measures regarding separation of redundancies (e.g., encapsulation, coating systems, heat insulation)	S	2 a	
2.2	Measures regarding reducing the fire hazard of components (e.g., oil pans, splatter protection, special protection of cables)	S	2 a	
2.3	Cable facilities with integrated functional integrity	S	2 a	
3	Smoke Removal Facilities, (excepted are mechanical smoke extractors)	F	6 m	
4	Fire Detection and Alarm Systems			
4.1	Fire detectors	F	1 a	
4.2	Data buses	F	3 m	Deviations in accordance with DIN VDE 0833-1 are admissible
4.3	Fire detection centers, including power supply	F	3 m	
4.4	Control equipment a) for forwarding signals to the control room and for processing the signals	F	6 m	
	b) for automatic triggering of fire protection equipment	F	6 m	
	c) for triggering the fire-detection forwarding equipment to external organizations	F	6 m	
4.5	Locking systems of fire protection closures	F	1 m	
5	Fire Protection Measures for Ventilation Systems			
5.1	Ventilation systems with functions in the event of fire, including the functions of necessary fire protection dampers, the corresponding controls and signaling a) equipment-related heat and smoke removal systems	F	1 a	
	b) ventilation systems to keep necessary staircases and airlock antechambers free of smoke	F	1 a	
5.2	Fire protection dampers and smoke removal dampers including corresponding controls and signaling	F	1 a	
5.3	Fire resistant ventilation and smoke removal ducts (excluded are concrete ducts)	S	1 a	
6	Firefighting Water Supply			
6.1	Triggering and power supply of the equipment under No. 6.2	F	1 w	
6.2	Fire pumps including pressurizer and water make-up equipment	F	1 m	
6.3	Pressure vessels	in accordance with BetrSichV		

No.	Test Object	Type of Test	Testing Interval Licensee	Remarks
6.4	Pipe network regarding overall supply capacity	F	2 a	
6.5	Valves and fittings in the pipe network	F	1 a	
6.6	Building isolation valves and penetration valves	F	1 m	
6.7	Hydrants on the plant site	F	1 a	
6.8	Wall hydrants	F	1 a	Including flow pressure measurement at the highest point
7	Spray Water Fire Extinguishing System			
7.1	Remotely controlled valves (including pneumatic and hydraulic valves)	F	6 m	
7.2	Pipe networks and spray nozzles	S	1 a	
7.3	Pipe networks and spray nozzles, water or pressurized air supply as applicable	F	5 a	
7.4	Triggering / Signaling	F	6 m	
8	Sprinkler Systems			
8.1	Dry-run-alarm valve station, rapid openers, rapid air removal	F	6 m	
8.2	Pipe networks and sprinklers	S	6 m	
8.3	Triggering / Signaling	F	6 m	
9	Fire Extinguishing Foam System			
9.1	Overall plant including mechanical seals of the admixture facility	S	1 m	
9.2	Initiation system	F	6 m	
9.3	Triggering / Signaling	F	1 m	
10	Fire extinguishing Gas System			
10.1	Overall plant	F	6 m	
10.2	Triggering and alarm system	F	6 m	
10.3	Pressure vessel	in accordance with BetrSichV		
11	Mobile Fire Extinguishing Equipment Inside Civil structures	S	1 a	if necessary, additional test in accordance with BetrSichV
12	Mobile Auxiliary Equipment Inside Civil structures for the Fire Department	S	1 a	if necessary, additional test in accordance with BetrSichV
13	Markings and Accessibility of the Rescue Routes	S	1a	
14	Plant Walk-Through Regarding Fire Protection	S	at end of maintenance	
15	Checking Fire Protection Concept whether it is up to date	S	4 a	

F function test (including visual inspection)
S visual inspection (comparison of the actual condition to the required condition, check regarding damage-free condition, check of the local measurement locations)

w testing interval in week(s)
m testing interval in month(s)
a testing interval in year(s); admissible deviations are tests in inaccessible areas that must be performed during refueling

Non-compliance of fire protection features in a nuclear power plant with the requirements represent a reportable event. Such an event is analysed and assessed with respect to safety, and corrective actions for deficiencies identified are carried out. In addition, the analysis and assessment can result in the preparation of an information notice (see Appendix A2). During decommissioning and dismantling, the KTA safety standards are applied in a protection-goal-oriented manner. By reducing the nuclear risk potential (no relevant radioactive releases in the event of fire), the in-service inspections to be carried out in accordance with conventional regulations (such as the technical testing and inspection regulations). The scope of testing and inspections by the authorised experts under nuclear law is essentially reduced. A high availability of the tested fire protection features is already ensured by applying the conventional non-nuclear regulations.

Research reactors

The aforementioned safety standard KTA 2101.1 /KTA 15/ with regard to in-service inspections is applied analogously according to the risk potential of the respective research reactor.

FR MZ

In-service inspections for fire protection features are regulated in the inspection manual of the FR MZ, which has been prepared in line with KTA 1202 /KTA 17/ and approved by the supervisory authority.

The fire detection and alarm system is tested regularly every three months by the manufacturer. In this context, a random selection of fire detectors from different detection lines is tested. This also involves checking the availability of all fire brigade route maps at the fire alarm board. A siren test takes place once a year. The fire dampers are tested once a year. Each damper is actuated manually, and its integrity is ensured through visual inspection.

In-service inspections regarding the functional operability of the automatically closing fire doors are carried out annually. Deficiencies identified are documented and corrective actions taken immediately by specialist companies. The fire barrier elements are documented, and the suitability of the building materials used for their construction is demonstrated. As part of the in-service inspection, a visual inspection of the walls, floors, penetrations and expansion joints in the reactor building is carried out every three years in accordance with the inspection manual. During these inspections, damages at fire walls are identified, documented and appropriate corrective actions initiated.

FRM II

The long-term compliance with the specified requirements is ensured by preventive or reactive maintenance and the concept of in-service inspections in line with safety standard KTA 2101.1 /KTA 15/.

Fuel cycle facilities

BFL

In-service inspections are carried out for BFL's fire detection and extinguishing features in accordance with the operating manual, in some cases accompanied by authorised experts.

Inspection and maintenance of these features is largely carried out by qualified personnel from external specialist companies.

The results of the in-service inspections demonstrate the high reliability of the fire detection and extinguishing features.

UAG

Ageing management concepts for structural and equipment-related fire protection are implemented in the operating manual of the UAG. The in-service inspections did not reveal any anomalies.

On-site spent fuel and radioactive waste storage facilities

In-service inspections are carried out for the fire detection and extinguishing features of the spent fuel and radioactive waste storage facilities in accordance with the operating manual, in some cases accompanied by authorised experts. Most of the inspections and maintenance of the systems and equipment are carried out by competent persons from external specialised companies.

The facility is regularly inspected with regard to fire protection. The condition of the fire barriers is also checked (formation of cracks, proper closure of penetrations, door closure, etc.). Fire doors and gates are inspected regularly by an expert at the specified inspection intervals. Type and scope of the in-service inspections of fire protection features are specified in the inspection manual and the inspection lists. Modifications are implemented via modification notifications and in accordance with the regulations for modifications, which also lead to an inspection by the fire protection officer. Any deficiencies identified are recorded and corrective actions taken immediately.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

<u>WAK including VEK</u>

By using construction products with usability certificates, sufficient service life of the WAK including VEK has already been proven through these and is ensured by the proper use of these products. In-service inspections of fire protection features are carried out in accordance with the maintenance rules with involvement of authorised experts.

3.3.2 Ventilation systems

3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

Nuclear power plants

With regard to a fire, ventilation systems meet the requirements for the functions as specified as well as those for the following:

- prevention of smoke and activity carry-over,
- continuing ventilation of unaffected redundant trains as far as necessary,
- prevention of smoke ingress into necessary stairwells and airlock vestibules,
- enabling manual firefighting, and
- heat and smoke removal

to the extent necessary to comply with the nuclear and conventional fire protection goals.

Almost all buildings are equipped with forced ventilation. The separation of redundant trains and the partitioning of buildings into fire compartments is also taken into account in the design of the ventilation systems in order to prevent the spread of fire beyond the affected fire compartment or fire sub-compartment and to continue ventilating areas separated by fire barriers as far as this is necessary for safety and availability reasons. Ventilation systems are designed such as to ensure that in the event of a fire in one redundant train the requested function of other redundant trains is maintained.

The design of ventilation systems takes into account radiation protection concerns (e.g. maintaining subatmospheric pressure in case of incidents/accidents, avoiding activity carry-over) and maintaining the functional operability of the safety system or emergency equipment. In the event of a fire, smoke and activity carry-over into unaffected areas is also prevented.

Ventilation systems shall be designed such that the safety system or the emergency system are not inadmissibly impaired and persons are not endangered by a fire.

The ventilation supply to the control room and the emergency control room is also ensured in the event of a fire in an adjacent fire sub-compartment. However, this does not apply to fire in the ventilation systems supplying the control room and the emergency control room. In the event of a fire in the ventilation system, the continued operation of the control room and the emergency control room can be ensured by manual measures.

Smoke and hot fire gases are prevented from entering the individual buildings in which the safety system or emergency systems are located via the ventilation systems by means of gas-tight isolation dampers. These can usually be closed remotely from the control room. In some cases, automatic actuation via gas warning devices or duct smoke detectors is also implemented.

Smoke removal from the buildings within the controlled area is generally permissible if it is necessary for firefighting and for rescuing people and if it is possible via the release paths for radioactive substances specified for normal operation. Large-scale smoke removal from the interior of the reactor building is not feasible with regard to the control of a loss-of-coolant accident.

In necessary stairwells, openings for smoke removal need to be provided. If this is not possible for reasons of plant operation or radiation protection, mechanical systems are to be provided to prevent the penetration of smoke into necessary stairwells or to remove any smoke entered from necessary stairwells. Inside the reactor containment, the specific systems engineering features are to be taken into account.

Ventilation systems and equipment for heat and smoke removal shall be designed against the impact from events if their function must be ensured after the occurrence of event combinations. If the event combination is an earthquake and consequential fire and intensity I of the design basis earthquake is higher than VI (EMS-98), these ventilation systems and equipment for heat and smoke removal shall be designed for the earthquake impact determined in accordance with KTA 2201.1 /KTA 11/.

If filter systems are available in the ventilation, it must be ensured that they are not inadmissibly impaired by the loads caused by, e.g., temperature, pressure, fire products or extinguishing media. For this purpose, a bypass can be provided around the filter system, taking into account, e.g., the expected radiation exposure to the environment. For this purpose, tightly closing ventilation dampers are installed upstream and downstream of the filter units with activated carbon.

Ventilation ducts are always made of non-combustible building materials of class A1 according to DIN 4102. Deviations are permissible if corrosive gases are to be removed (e.g. from battery and laboratory rooms) and at least flame-retardant building materials are used.

Connections between individual fire compartments through ventilation systems are avoided wherever possible. Ventilation systems that supply several fire compartments of a building or supply fire compartments in other buildings are always separated by fire resistant barriers.

The supply air volume flow required for smoke extraction is ensured. In the case of mechanical smoke extraction, the required supply air volume flow is also introduced via the supply air of a room air conditioning system. In this case, continued operation of the heat and smoke removal system after closing any fire dampers on the supply air side is only permissible if no impermissible pressure differences build up.

If the fire-resistant boundary of a fire compartment or a fire sub-compartment is penetrated by a ventilation duct (on the supply and exhaust side), a fire damper is installed at these locations. If a fire damper closure is not possible, e.g. for systems engineering reasons, the ventilation duct routed through several fire compartments or fire sub-compartments is fire-resistant. Only self-closing fire-resistant fire dampers with corresponding building authority approvals are used.

The fire dampers are usually actuated independently: via temperature-dependent actuation (by fusible link) or manual actuation

The following minimum feedback signals are available for fire dampers:

- individual response of the position to the respective local control centre and collective feedback from the control centre to the control room,
- individual response to the control room if further measures are to be taken based on the feedback from the control room staff.

Provisions for maintaining subatmospheric pressure and thus ensuring a measurable release of radioactivity to the environment continue to be important in terms of the nuclear protection goals also for plants in the phase of residual operation after defuelling. For other ventilation systems, however, no nuclear significance remains after the fuel elements have been removed. In this respect, they are subject to the standards and requirements of conventional fire protection (LüAR: guideline on fire protection requirements for ventilation systems), taking into account that for existing buildings no changes are required. Parts of the ventilation system required as part of redundancy separation during power operation (ventilation ducts, fire dampers) will generally not even be subject to conventional fire protection requirements during decommissioning and dismantling because the separation by fire barriers is no longer required.

Research reactors

<u>FR MZ</u>

The reactor hall with the hall extension, the old building and the extension building each have their own air supply and exhaust systems. There is no connection between the buildings in terms of ventilation. The air pressure in the reactor hall is kept at subatmospheric pressure of 30 Pa compared to the outside pressure by throttling the volume flow of the supply air to prevent uncontrolled escape of the room air through the door gaps. The exhaust air from the hall is subject to constant monitoring by inert gas and aerosol monitors installed on the exhaust duct.

All fire dampers in the buildings of the FR MZ are fire-resistant. In the reactor hall with the hall extension, there are a total of 51 fire dampers with actuation by fusible link triggering, which is detected via response contacts by the control system of the building control system. The old building has 97 fire dampers with actuation by fusible link and response contacts. In the extension building, which was only completed in 2008, there are 173 motorised fire dampers with response contacts to the building control system.

With regard to a fire, ventilation systems meet the requirements for the functions as specified as well as those for the following:

- prevention of smoke and activity carry-over,
- prevention of smoke ingress into necessary stairwells and airlock vestibules,
- enabling manual firefighting, and
- removal of heat and smoke

to the extent necessary to comply with the nuclear and conventional fire protection goals.

Almost all buildings are equipped with forced ventilation. The partitioning of buildings into fire compartments is also taken into account in the design of the ventilation systems in order to prevent the spread of fire beyond the affected fire compartment or fire sub-compartment and to continue ventilating areas separated by fire barriers as far as this is necessary for safety and availability reasons.

The design of ventilation systems takes into account radiation protection concerns (e.g. maintaining subatmospheric pressure in case of incidents/accidents, avoiding activity carry-over) and maintaining the functional operability of the safety system or emergency equipment. In the event of a fire, smoke and activity carry-over into unaffected areas is also prevented.

Ventilation systems shall be designed such that safety system equipment or the emergency systems are not inadmissibly impaired and persons are not endangered by a fire.

Smoke removal from the buildings within the controlled area is generally permissible if it is necessary for firefighting and for rescuing people and if it is possible via the release paths for radioactive substances specified for normal operation.

From the areas of the controlled area that are demonstrably not radiologically relevant in terms of fire protection and ventilation (e.g. necessary stairwells), heat and smoke may be removed via paths other than those specified for normal operation (e.g. via dampers installed for heat and smoke removal to the outside).

In necessary stairwells, openings for smoke removal need to be provided. If this is not possible for reasons of plant operation or radiation protection, mechanical systems are to be provided to prevent the penetration of smoke into necessary stairwells or to remove any smoke entered from necessary stairwells.

Connections of individual fire compartments by ventilation systems are prevented wherever possible. Ventilation systems that supply several fire compartments of a building or that supply fire compartments in other buildings are always separated in a fire-resistant manner.

The supply air volume flow required for smoke extraction is ensured. In the case of mechanical smoke extraction, the required supply air volume flow is also ensured via the supply air of a room air conditioning system. In this case, continued operation of the heat and smoke removal system after closing of any fire dampers on the supply air side is only permissible if no impermissible pressure differences build up.

If a fire compartment boundary or a fire sub-compartment compartment is penetrated by a ventilation duct (supply and exhaust air side), a fire damper is installed at these locations. If a closure by fire dampers is not possible, e.g. for system related reasons, the ventilation duct penetrating through several fire compartments or fire sub-compartments is fire-resistant. Only self-closing fire-resistant fire dampers with corresponding building authority approvals are used.

The fire dampers are usually actuated in independent ways: via temperature-dependent actuation (by fusible link) or manual actuation.

<u>FRM II</u>

Ventilation systems are designed such that the separation of redundant trains of the SSC important to safety is ensured in the event of fire, e.g. by means of penetration seals and fire dampers. In the event of fire, the necessary stairwells can be kept free of smoke by pressurisation. The ventilation systems in switchgear rooms are designed such that they can be used for heat and smoke removal. In the event of loss of the ventilation system, the safe enclosure of radioactivity is ensured on demand by means of building isolation. The ventilation systems are equipped with duct smoke detectors to the extent required.

If necessary, a ventilation-related building isolation can be actuated at the FRM II. Separation of redundant trains is still ensured in case of fire. In total, there are approx. 300 fire dampers in the ventilation systems of the FRM II.

With regard to fire, ventilation systems meet the requirements for the functions as specified as well as those for the following:

- prevention of smoke and activity carry-over,
- continuing ventilation of unaffected redundant trains as far as necessary,
- prevention of smoke ingress into necessary stairwells and airlock vestibules,
- enabling manual firefighting, and
- removal of heat and smoke,

to the extent necessary, to comply with the nuclear and conventional fire protection goals.

Almost all safety significant buildings are equipped with forced ventilation. The separation of redundant trains as well as the partitioning of buildings by into fire compartments is also taken into account in the design of the ventilation systems in order to prevent a fire from spreading beyond the affected fire compartment or fire sub-compartment and to continue ventilating areas separated by fire barriers, as far as this is necessary for safety and availability reasons. Ventilation systems shall be designed such that in the event of a fire in one redundant train, the function of the other redundant trains is maintained.

The design of ventilation systems takes into account radiation protection concerns (e.g. maintaining subatmospheric pressure in the event of incidents/accidents, avoiding activity carry-over) and maintaining the functional operability of SSC. In the event of a fire, smoke and radioactivity are also prevented from spreading to unaffected areas. Ventilation systems are designed such that SSC important to safety are not inadmissibly impaired and persons are not endangered by a fire.

The ventilation supply to the control room is also ensured in the event of a fire in an adjacent fire sub-compartment. However, this does not apply to fire in the ventilation systems supplying the control room. In the event of a fire in the ventilation system, the continued operation of the control room can be ensured by manual means.

Smoke and hot fire gases are prevented by fire dampers from penetrating via the ventilation systems into the individual rooms/compartments of other redundant trains in which SSC are located.

Smoke removal from the buildings within the controlled area is generally permissible if it is necessary for firefighting and for rescuing people and if it is possible via the release paths for radioactive substances specified for normal operation.

From the areas of the controlled area that are demonstrably not radiologically relevant in terms of fire protection and ventilation (e.g. necessary stairwells), heat and smoke may be removed via paths other than those specified for normal operation (e.g. via dampers installed for heat and smoke removal to the outside).

In necessary stairwells, openings for smoke removal need to be provided. If this is not possible for reasons of plant operation or radiation protection, mechanical systems are provided to prevent the penetration of smoke into necessary stairwells or to remove any smoke entered from necessary stairwells.

With the exception of the fire dampers for the cold neutron source, it is not necessary to design the ventilation components for function or stability after an aircraft crash.

For ventilation filter systems it is ensured that they are not inadmissibly impaired as a result of the loads by, e.g., temperature, pressure, fire products or extinguishing media. For this purpose, a bypass is provided around the filter system, taking e.g. the expected radiation exposure to the environment into account. Tightly closing ventilation dampers are installed upstream and downstream of the filter units with activated carbon.

Ventilation ducts are always made of non-combustible building materials of class A1 according to DIN 4102.

Connections of individual fire compartments through ventilation systems are prevented wherever possible. Ventilation systems that supply several fire compartments of a building or supply fire compartments in other buildings are always separated in a fire-resistant manner.

The supply air volume flow required for smoke extraction is ensured. In the case of mechanical smoke extraction, the required supply air volume flow is also ensured via the supply air of a room air conditioning system. In this case, continued operation of the system for heat and smoke removal after closing any fire dampers on the supply air side is only permissible if no impermissible pressure differences build up.

If the fire-resistant boundary of a fire compartment or a fire sub-compartment is penetrated by a ventilation duct (on the supply and exhaust side), a fire damper is installed at these locations. If a closure by fire dampers is not possible, e.g. for systems engineering reasons, the ventilation duct routed through several fire compartments or fire sub-compartments is fire-resistant. Only self-closing fire-resistant fire dampers with corresponding building authority approvals are used.

The fire dampers are usually triggered in independent ways: via temperature-dependent triggering (fusible link) or manual triggering.

The following minimum response signals are available for fire dampers:

- individual response of the position to the respective local control centre and collective response from the control centre to the control room,
- individual response to the control room if further measures are to be taken based on the response from the control room staff.

Fuel cycle facilities

BFL

Due to its design and the separation of the dry conversion plant from the other nuclear production areas in terms of ventilation, the nuclear production building is equipped with two ventilation systems.

In order to comply with the radiological safety objectives of the BFL, no fire protection dampers are installed in the exhaust air system at fire compartment penetrations, contrary to the LüAR. To compensate for this, a redundant fire detection and alarm system is installed in these areas, and only persons trained in handling fire extinguishers are allowed to work there. In addition, an on-site fire brigade is permanently present so that a fire can be extinguished in the early stages. Apart from this, the ventilation system is switched to fire mode, i.e. the supply air is switched off and the exhaust air system runs in reduced mode.

UAG

Due to the closed construction, the rooms of the UAG are equipped with a ventilation system for air supply and exhaust of the rooms.

In addition, the ventilation systems in the areas where UF_6 is handled are also designed for ventilation in the event of a UF_6 leak. For this purpose, they are equipped with a filter device that filters escaping UF_6 out of the outside air and prevents emission. These filter devices are installed as part of central ventilation systems in separate rooms. Separation between the production areas and the ventilation centres is ensured by fire barriers. The requirements of the RS Manual are taken into account.

Furthermore, gas extraction systems are installed in some areas. These are used for the extraction of planned UF_6 emissions that may occur, for example, when containers or pipes are opened.

The ventilation systems are equipped with duct smoke detectors to the extent necessary for the early detection of smoke fires that may arise.

If ventilation ducts are routed through fire-resistant walls or ceilings, fire-resistant fire dampers approved by the building authorities are installed. Alternatively, floors, rooms, fire compartments or fire sub-compartments as well as stairwells separated by fire barriers are bridged by fire-resistant ventilation ducts.

The ventilation systems are or will be equipped with fire dampers that are controlled by smoke detectors and thermocouples.

On-site spent fuel and radioactive waste storage facilities

Storage at the Biblis site

All spent fuel storage facilities in Germany are designed as dry storage facilities in which transport and storage casks loaded with spent fuel or vitrified high-level radioactive waste are stored. The storage facilities are designed with passive natural convection cooling, which removes the heat from the casks independently of active technical systems.

In radioactive waste storage facilities with ventilation systems, the ventilation concept is designed in a manner that the entire ventilation system is switched off in the event of fire. The ventilation systems are or will be equipped with fire dampers that are controlled by smoke detectors and thermocouples.

Storage at the ZLN

The individual rooms in the ZLN storage building are ventilated in different ways due to their different functions. The main components are located in the ventilation centres in the administration and social buildings. The ventilation systems are designed in accordance with the LüAR.

Due to their use, no stationary smoke extraction systems are provided in the rooms of the storage building. For fire protection, the buildings are divided into numerous compartments to which a possible fire remains limited. Building materials of class B are present and protected by special measures (hydraulic oil of low flammability). Rapid firefighting and associated heat extraction are thus possible. The filter media of the filters provided are made of glass fibre material or chemical fibre material in combination with aluminium separators and are non-combustible. The filter frames of the filters in the supply air systems are made of galvanised sheet steel with neoprene seals. In the exhaust air systems, the filter frames are made of stainless steel with neoprene seals.

Non-combustible building materials (building material class A) are used for the ventilation ducts. If ventilation ducts are routed through fire-resistant building components, they are either fire-resistant or separated by fire-resistant fire dampers in the boundaries.

When ventilation ducts pass through fire-resistant components, fire dampers must be installed if the ventilation ducts are not fire-resistant. The position of the fire dampers (open and closed) is indicated on the local control panels of the ventilation control centre and directly at the fire dampers. The fire dampers can be individually closed or opened manually for maintenance and testing purposes.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

Due to the current state of the facility, the ventilation ducts of the WAK are not fire resistant. Only components in access and escape routes are designed with the corresponding fire resistance rating. If a fire is detected, the system automatically switches to a predefined operating mode. The air supply system is switched off and the exhaust air is reduced.

Where ventilation ducts are routed through fire-resistant walls or ceilings, fire-resistant fire dampers approved by the building authorities have been installed and the openings sealed accordingly. The supply and exhaust air system with the connecting ventilation ducts to or from concrete ventilation shafts are each combined to one fire sub-compartment. Connecting ventilation ducts are therefore provided with fire-resistant jackets. To ensure proper operation, no fire dampers have been installed here.

The fire sub-compartments were taken into account in the design of the VEK ventilation system. The air supply and exhaust systems with the connecting ventilation ducts to and from the concrete ventilation shafts are each combined to one fire sub-compartment. The connecting ventilation ducts are therefore provided with fire-resistant sheathing. To ensure the proper operation of the systems, no fire dampers have been installed here.

All air supply and exhaust ducts leading from the shafts to the floors are provided with a fire damper directly located at the shaft. The positioning of the remaining fire dampers results from the division of the fire sub-compartments. Fire dampers with general construction approval are installed. The dampers close after being actuated thermally. The actuation of a fire damper leads to the closing of the remaining fire dampers, which are assigned to the two fire sub-compartments.

3.3.2.2 Performance and management requirements under fire conditions

Nuclear power plants

For heat and smoke removal from the individual buildings, the following is used on a case-by-case basis:

- the existing ventilation systems for mechanical smoke extraction,
- mechanical heat and smoke vents,
- dampers of the heat and smoke extraction system, or
- mobile smoke extraction units.

The smoke extraction provisions take into account radiation protection requirements and requirements for maintaining the functionality of the safety system.

The respective provisions for heat and smoke removal as well as the required smoke extraction time and the required air volume flows are determined in each individual case depending on the local conditions. At least the following aspects are taken into account:

- location of the room,
- possibility of air supply and exhaust ducting via ventilation systems,
- smoke extraction (e.g. enable rescue and manual firefighting), and
- restrictions for reasons of radiation protection (e.g. low fresh air and exhaust air flows).

Accident filtration systems are not used for smoke extraction. The accident filtration systems controlled by the reactor protection system are not closed off with fire dampers for safety-related reasons. In such cases, fire and smoke propagation to other fire compartments is prevented by the type of duct or duct routing.

For ventilation systems with specified functions in the event of fire, it is ensured that the power supply (e.g. cables and their routes including controls) is maintained for the required function duration.

Ventilators that are used exclusively for keeping escape routes free of smoke or for heat and smoke removal are equipped with local controls for their manual actuation. For stairwells, these ventilators are additionally controlled either remotely from the control room or automatically via smoke detectors. This ensures that during start-up of the smoke extraction ventilator, the corresponding smoke extraction damper is already open or that it can still be opened during operation of the ventilator.

Smoke removal ducts and smoke removal dampers are designed according to the expected temperatures. The design shall basically be based on a temperature of 600 °C.

Deviations are admissible if it is proven that

- the smoke will cool off along the smoke removal duct, or
- lower temperatures are expected inside the fire compartment or sub-compartments.

Research reactors

FR MZ

The fire dampers with fusible link trigger if the temperature of the exhaust air in the respective duct rises above 72 °C due to a fire event. The motorised fire dampers are actuated in the areas where a fire event has been detected by a local temperature measurement. They are also opened again by motor. In addition, all fire dampers in the extension building close when a fire event is detected by the fire detection and alarm system, or a manual fire detector is actuated.

FRM II

In case of fire, the ventilation mainly ensures the following provisions and functions:

- ventilation closure of the fire compartment/fire sub-compartment with fire barriers,
- mechanical heat and smoke removal from switchgear rooms,

- natural heat and smoke removal (e.g. stairwells, neutron conductor hall),
- maintaining overpressure of the stairwells in the reactor building.

In case of fire, smoke can only be emitted from the controlled area via the ventilation system if there are no concerns from a radiation protection point of view. Within the controlled area, a directed air flow from rooms with a low contamination possibility to rooms with a higher contamination possibility is maintained in relation to the room air during specified normal operation. During specified normal operation, the air is filtered from the controlled area via the HEPA filter exhaust air system and discharged via the chimney. This path can also be used for smoke extraction.

At maximum filter load due to smoke particles, it is possible to switch over to the reserve filter, or the filters can be bypassed. This flue gas discharge is possible until the fire dampers close due to the release of the respective fusible link.

In addition, active and passive smoke extraction systems with manually or automatically actuated motorised opening for smoke extraction are available.

Fuel cycle facilities

<u>BFL</u>

BFL's ventilation concept for the nuclear production areas provides, amongst others, that in the event of fire, the supply air of the ventilation system is switched off and the ventilation system is switched to pure exhaust air operation with reduced exhaust air capacity. This serves to retain radioactive substances by maintaining a defined subatmospheric pressure and to ensure that no uncontrolled release can occur.

With regard to the design of ventilation systems, the LüAR generally applies. The exception for compliance with the radiological safety objectives or for minimising the radiological effects was mentioned in paragraph 3.3.2.1.

<u>UAG</u>

In case of fire, the ventilation mainly ensures the following measures and functions:

- ventilation closure of the fire compartment or fire sub-compartment,
- mechanical heat and smoke removal, if applicable,
- natural heat and smoke removal (e.g. stairwells, access and escape routes),
- if necessary, maintaining overpressure of stairwells.

The LüAR is observed and complied with during the construction and operation of ventilation systems. Ventilation centres as defined by the LüAR are or will be separated from other rooms by fire-resistant walls.

On-site spent fuel and radioactive waste storage facilities

In accordance with the protection-goal-oriented application, the following functions of ventilation systems are ensured in the spent fuel and radioactive waste storage facilities in the event of fire:

- limiting the effects of fire to individual fire compartments or fire sub-compartments (automatically actuated fire dampers),
- directed flow into the controlled area,
- smoke removal,
- keeping secured access and escape routes free of smoke.

The ventilation system also fulfils the following functions:

- heating or cooling of the building,
- maintaining directed flow inside the building,
- supplying the fire compartments/fire sub-compartments with correspondingly high proportions of fresh air,
- ensuring by controlled air supply and exhaust operation that the maximum workplace limit values or the biological limit values are not exceeded,
- ensuring directed airflow into the controlled area.

After a fire, the smoke is removed via the ventilation system.

With regard to the design of ventilation systems, the LüAR is generally observed.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

<u>WAK including VEK</u>

In the event of fire, the ventilation in the WAK mainly ensures the ventilation closure of as well as heat and smoke removal from the respective fire sub-compartment.

With regard to the design of the VEK ventilation systems, the LüAR is generally taken into account.

Fire gases that could be sucked in from outside via the ventilation system are detected and the air supply is switched off..- The ventilation system is switched to the corresponding operating mode.

3.4 Licensee's experience of the implementation of the fire protection concept

As already explained before, for all German installations considered in the NAR, the fire protection concept is an overall concept that serves to achieve the fundamental safety functions, the radiological safety objectives and the conventional non-nuclear protection goals. In this context, the entirety of all active and passive fire protection means for fire prevention, a fast and reliable detection and alarm of incipient fires, successful fire suppression and prevention of fire spreading should ensure compliance with these objectives. In this respect, the various parts of the fire protection concept must not be considered and evaluated individually, but always as a whole.

Paragraphs 2.1.6.2, 2.2.6.2, 2.3.6.2, 2.4.6.2, 2.5.6.2 and 2.6.6.2 describe examples of events relevant for fire safety in nuclear power plants, research reactors, fuel cycle facilities, spent fuel and radioactive waste storage facilities, and installations under decommissioning as well as the resulting optimisation measures. Optimisation measures are derived, amongst others, from fire hazard analyses or the analysis of events occurred.

The design principles and regulations for fire prevention have proven to be effective. This is reflected by the low fire frequency in German nuclear installations.

Nuclear power plants

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.

For decommissioning and dismantling, adjustments are made with regard to decommissioning and dismantling based on the fire protection concept that has proven itself during commercial power operation. If concentrated fire loads, such as the turbine oil tank, are no longer needed, the associated extinguishing system can be taken out of service.

In the course of decommissioning and dismantling, plant adaptations and the further reduction of the risk potential during the dismantling, further facilitations in fire protection can be successively incorporated in updates of the fire protection concept. Separation of redundant trains, for example, is no longer necessary after requirements for residual heat removal requirements do no longer apply. Fire protection requirements are gradually approaching the requirements of conventional regulations.

Completed fire prevention measures are presented in paragraph 2.1.6.2. From the reviews of fire events as well as of other events relevant in terms of fire protection, no ongoing measures are currently open.

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. the use of non-combustible containers) and potential ignition sources (e.g. provision of fire watches) additionally contribute to fire prevention.

Challenges arise from the decommissioning and dismantling of nuclear power plants. Additional temporary fire loads and potential ignition sources, e.g. machines, are introduced into the plant. Work with a fire risk potential need to be identified and suitable measures specified. The same applies to temporary storage areas in rooms of nuclear power plants.

Research reactors

<u>FR MZ</u>

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. In case of fire detection by the fire detection and alarm system, all fire dampers in the extension building are closed by the electronic control system. In addition, the motors in the air exhaust and supply lines of the ventilation systems are stopped. In the old building, for example, only the fire damper directly affected is actuated, depending on the fire location. Due to the lack of a central electronic control system, no fan motors are controlled and switched off here. Together with other 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 organisational provisions for fire protection include, in particular, a periodic instruction of all employees on an annual basis. Guests and scientific visitors are instructed individually before starting work. Due to the scientific teaching activities, there is a high fluctuation of students in the laboratories of the FR MZ, most of whom work for only a few months and at different non-synchronised times. This high fluctuation leads to a permanently high personnel expense for instructing the student employees.

In the frame of several assessments and revisions of the corresponding fire protection concepts, these concepts and the associated fire prevention provisions have been and are being continuously developed, see also the explanations in paragraph 2.2.6.2. Apart from the complaints about the old laboratory and administration building, which will become obsolete when the new building will be occupied, there are currently no open measures or requirements from the last inspections and the fire protection concepts derived from them for the buildings of the FR MZ.

Regular involvement of technical staff and specialised personnel in carrying out in-service inspections of the fire detection features and of the technical fire protection precautions lead to a high level of knowledge among the personnel. The corresponding inspection and testing intervals, especially the quarterly testing of fire detectors, allow for a high degree of confidence in the technical measures taken.

On the organisational side, students and researchers (scientific personnel) as well as all other technical and administrative personnel are involved in exercises on the main topics of fire prevention and actions to be taken in the event of fire and are instructed annually by the fire protection officer. Guests and short-term visitors are instructed in general safety and radiation protection before starting their activities.

False alarms (mostly triggered by specialist companies working on site) and other incidents in the last ten years have shown that fire prevention, firefighting, communication of the persons involved with the fire brigade, access of the fire brigade, as well as the behaviour of persons in the building and their independent evacuation in the event of an alarm, etc. complement each other and function very well.

From the licensee's point of view, the fire protection concept of the FR MZ is considered to be technically and organisationally suitable, adapted to the risk potential of the facility and well-practised in the event of an alarm.

<u>FRM II</u>

The fire protection concept is always kept up to date. The fire protection concept contains an overall assessment of the structural, equipment-related, operational and administrative, and defensive fire protection, oriented towards nuclear and conventional protection goals, as well as 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.

Completed fire prevention measures are presented in paragraph 2.2.6.2. No ongoing measures are currently open from the reviews of fire events.

The concept applied at the FRM II of determining permissible fire loads, deriving the necessary fire protection provisions from this, as well as the defence-in-depth concept and the regular internal and external inspections, has proven to be robust in practice and can be implemented to the extent required. Based on previous operating experience, no need for further analyses could be identified.

Fuel cycle facilities

BFL

The precautionary measures taken to prevent fires have proven to be adequate and effective during more than 40 years of operation.

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 (see also paragraph 2.3.4).

Deviations, such as existing but not necessarily required fire loads, observed during the walk-throughs are remedied in a timely manner, and the correct implementation is checked during the next walk-through.

There are currently no ongoing actions open from fire event reviews.

During more than 40 years of operation at BFL, the existing design, dimensioning and performance of the fire protection and firefighting equipment in accordance with the fire protection concept and operating manual have all in all proven themselves.

The fire protection and firefighting features are basically in operation or ready for use at all times.

The increased safety requirements for the BFL are stipulated by the safety requirements for nuclear fuel supply facilities, the Radiation Protection Act /BMJ 22/, the Radiation Protection Ordinance /BMJ 21/ and by the 12th BImSchV, and are taken into account in the fire protection concept.

By updating the fire protection concept, amendments of and updates to the relevant regulations are evaluated and taken into account where necessary.

UAG

The fire prevention provisions taken have proven to be adequate and effective in more than 37 years of operation.

The provisions for fire prevention also proved effective in the case of the small fire on the machine hall roof of UTA-1. The protective measures specified in the hot work permit resulted in early fire detection and immediate successful firefighting.

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 UF_6 or the installation of duct smoke detectors based on the information notice from GRS and findings from the fire event in the BFL (see also paragraph 2.3.4).

The in-service inspections specified in the operating manual ensure the condition of the fire protection equipment in accordance with the requirements.

If deviations are found during the walk-throughs, they are remedied in a timely manner, and the correct implementation of the measures is checked during the next walk-through.

There are currently no ongoing actions open from the reviews of on-site inspections.

During more than 37 years of operation, the existing design, dimensioning and operation of the fire protection and firefighting equipment in accordance with the fire protection concept and the operating manual have all in all proven themselves.

The fire protection concept developed applies the KTA safety standards, the industrial buildings directive and DIN 18230 for demonstrating that the fire protection requirements are met.

In addition, the fire protection concept facilitates the implementation of future fire inspections and/or in-service inspections in connection with the granted building permit by clearly outlining fire protection measures and compensatory measures for possible deviations from provisions under building regulations.

The increased safety requirements are also stipulated by the safety requirements for nuclear fuel supply facilities, the Radiation Protection Ordinance and the Major Accidents Ordinance – 12th BImSchV and were taken into account in the fire protection concept.

On-site spent fuel and radioactive waste storage facilities

The underlying procedure with regard to fire protection planning, licensing, operation and regular review as well as updating of the preventive and defensive fire protection provisions in the on-site spent fuel and radioactive waste storage facilities has so far fully met the nuclear requirements.

Deviations observed during the walk-throughs are remedied in a timely manner, and the correct implementation of the measures is checked during the next walk-through.

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.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

In the many years of operation, the existing design, dimensioning and operation of the fire protection and firefighting features of the WAK and VEK have proven themselves.

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.

During regular internal inspections, the implementation of fire prevention provisions is checked and, if necessary, appropriate countermeasures are derived. In addition, fire protection inspections are carried out in all buildings at least every five years by the supervisory authority with participation of the authorised expert and an accompanying fire prevention inspection.

The adaptation of fire protection to the progress of dismantling must be carried out continuously. 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. This leads to the challenge of keeping up with the dynamic progress of dismantling when updating and reviewing fire protection.

3.5 Regulator's assessment of the fire protection concept and conclusions

Nuclear power plants

The fire protection concept and its implementation in German nuclear power plants are correctly presented in Section 3.

The relevant regulatory requirements (see paragraph 1.2) for the various parts of the fire protection concept (fire prevention, active and passive fire protection) are complied with.

The regulations of the supervisory authority explicitly provide for equipment-related fire protection as one of the inspection areas to be regularly checked during on-site supervision. Corresponding supervisory activities include, for example, fire safety walk-throughs, participation in in-service inspections (e.g. of fire detection and alarm features) and access to the related records, participation in fire alarms and fire drills of the on-site fire brigade, inspection of the condition of cable routes, fuel and lubrication oil systems, spraywater deluge systems, fire doors, and much more.

Based on the comprehensive and high-level fire protection concept achieved during commercial power operation, residual operation and decommissioning of the nuclear power plants now represent a different mode of operation compared to the preceding power operation period which will continuously change as dismantling progresses, which in turn can have a direct impact on the fire protection requirements.

The need for additional or modified fire prevention means may result from the dismantling process applied and the equipment and tools used.

For the remaining operation period, there is a possibility of fire due to the fire loads present in the installation and the systems and equipment remaining in operation from the preceding power operation period. These possibilities for fire can be controlled with the fire protection means available from the preceding power operation period.

The possibility of fire during residual operation may increase by the measures and processes of dismantling.

For considering the above-mentioned boundary conditions during residual operation and dismantling of nuclear power plants, the necessity of additional specific fire protection means is assessed in the supervisory procedure when specifying the dismantling planning by means of a modification notification or dismantling descriptions.

Decommissioning of systems takes place in the frame of modification procedures. In the supervisory procedure, they are checked to ensure their justification regarding fire protection and the absence of feedback effects on the systems remaining in operation.

Overall, this ensures that the entire fire protection means summarised in the fire protection concept are suitable for ensuring that the protection goals are met and that the required functions can be performed during the remaining period of operation.

Research reactors

FR MZ

At the outset, it should be noted that the descriptions in the previous paragraphs on design considerations and fire prevention means and the approach for management and control of fire loads and potential ignition sources have been presented comprehensively and correctly for the FR MZ.

The nuclear supervisory authority and the authorised experts assess the active and passive fire protection provisions –including also organisational provisions and precautions for fire prevention and firefighting – as correct and adequate and appropriate to the risk potential of the FR MZ.

The fire protection features are periodically inspected to ensure their functionality. This procedure is closely monitored and controlled by the competent nuclear supervisory authority. Adverse effects regarding general, active or passive fire protection have so far not been identified. Therefore, no fire protection adjustments had to be initiated in the supervisory procedure so far.

The competent nuclear supervisory authority assesses the general fire protection concept correctly presented in Section 3 for the FR MZ to be comprehensive in the sense of meeting the requirements of the conventional regulations under building law as well as of the nuclear regulations. The active, passive and organisational provisions of preventive and defensive fire protection are appropriate to the risk potential of the installation. Functionality is ensured by in-service inspections, which are accompanied by the nuclear supervisory authority.

Modifications to fire protection features are subject to the modification procedure, which requires the review and approval by the nuclear supervisory authority. In the event of modifications to the condition of the facility, fire protection is considered, assessed and integrated into the overall fire protection concept.

In conclusion, it can be stated that the fire protection provisions implemented are effective. Due to the fire prevention provisions, no fire occurred in the long-term operation of the FR MZ to date. Therefore, the nuclear supervisory authority considers the fire protection goal to be complied with.

FRM II

The descriptions in paragraph 3.1.1 regarding design considerations and fire prevention means as well as the overview given in paragraph 3.1.2 on the approach for management and control of fire loads and potential ignition sources, are correctly presented.

The regulations and precautions established as part of the facility's fire protection concept are intended to ensure compliance with the protection goals. For this purpose, a comprehensive range of provisions for fire prevention, fire mitigation and firefighting has been specified. These are continuously monitored by the licensee and within the supervisory procedure regarding their functional operability. 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. The measures contained in the fire protection concept thus represent a comprehensive and proven means of active and passive fire protection and compliance with the protection targets. To date, no fire protection-related adjustments had to be initiated in the supervisory procedure.

Fuel cycle facilities

BFL

BFL's fire protection concept is correctly presented in the respective paragraphs of Section 3.

The fire protection concept of BFL is based on preventive fire protection means, the early detection of fires and the effective suppression of incipient fires. The protective function of the building, in particular the separation in terms of fire protection and the use of non-combustible building materials, is essential for compliance with the radiological safety objectives, the prevention of activity releases and the confinement and retention of radioactive materials.

The structural as well as the equipment-related as well as the organisational and administrative fire protection means are adequate. There are no findings on deficiencies in BFL's fire protection concept. The fire protection concept and the fire safety regulations laid down in the operating manual are suitable for an effective fire protection at the BFL.

The on-site fire brigade of the BFL conducts regular drills with the public off-site fire brigade to ensure operational readiness in the event of fire. The drills are carried out with the participation of the nuclear supervisory authority and other competent authorities.

Agreement of the fire protection measures taken at BFL with the fire protection concept is reviewed in the nuclear licensing procedure as well as in the supervisory procedure.

The fire protection concept is updated, taking into account modifications to the facility as well as updates of regulations and the progressing state of the art in science and technology. In the frame of the first PSR of BFL, the fire protection concept was last assessed in 2021 as suitable for compliance with the conventional protection goals and the nuclear protection goals in accordance with the safety requirements for the production of light water reactor fuel with low-enriched uranium.

UAG

The fire prevention provisions were comprehensively described and assessed by the fire protection expert consulted within the licensing procedure for facility expansion with notice No. 7/6 UAG. The experience gained from the operation of the existing facility with regard to fire protection was incorporated into this assessment. In summary, the assessment of fire protection showed that the basic requirements of fire protection are also taken into account for the expansion of the UAG. The nuclear licensing authority came to the conclusion that, from the point of view of fire protection, the expansion of the plant was compatible with the existing fire protection concept of the UAG and that the fire prevention means required by the provisions under building law and the state of the art in science and technology as defined by the Atomic Energy Act had been taken.

Planned modifications with interfaces to fire protection features important to safety and the updating of the fire protection concept and operating regulations are reviewed by the nuclear supervisory authority with the involvement of an authorised fire protection expert. Prior to starting the operation of safety related systems and equipment, a functional and acceptance test is to be performed in the presence of the authorised fire protection expert.

The fire prevention means are suitable to prevent an incipient fire or to detect it at an early stage, thus limiting its spread to one fire compartment and preventing a major release of radioactive substances.

Weaknesses in the fire prevention provisions are currently not known.

The structural, equipment-related, organisational and administrative measures for fire prevention have proven to be effective in the past and are continuously adapted to the state of the art in science and technology.

The regular fire protection walk-throughs generally identify only minor deficiencies, which can always be remedied directly or in a timely manner.

The in-service inspections specified in the operating manual, with the participation of authorised experts consulted by the authorities, continuously ensure that the fire protection features are in the required condition.

The content of the UAG fire protection concept described in Section 3 is correctly presented.

The fire protection concept is based on the respective versions of the applicable Land building regulations, the Radiation Protection Ordinance, the Major Accident Ordinance, the KTA safety standards, the industrial buildings directive and DIN 18230 valid at the time of preparation. The requirements of the RS Manual are presented comprehensively and correctly.

The modular structure of the fire protection concept simplifies updating due to modifications or expansions as well as their review. In addition to a general concept part, there are further parts for each building and the respective fire loads within these buildings.

Updating and adaptation of the fire protection concept (e.g. due to new findings in light of the state of the art in science and technology, adaptation regulations, possible deficiencies or events, etc.) require the respective approval by the nuclear supervisory authority. For this purpose, a fire protection expert is usually consulted in the frame of the inspection. The structural, equipment-related, organisational and administrative measures for fire prevention have proven to be effective in the past and are continuously adapted to the state of the art in science and technology.

Spent fuel storage facilities

The fire protection concepts of the Biblis spent fuel storage facility and the spent fuel storage facility North and their implementation are correctly presented in Section 3. In addition to the requirements of the conventional building regulations, they also meet the requirements under nuclear law. They include preventive and defensive fire protection provisions.

The fire protection required for the spent fuel storage facilities is essentially already covered by the properties of the stored casks: The transport and storage casks are designed against fires that could occur during emplacement and retrieval operations. An average flame temperature of 800 °C with a fire duration of 30 min was taken as a basis. Even under these conditions, the safe confinement of the radioactive inventory in the container is guaranteed.

Due to the low fire loads in the storage building, a fire is not expected to occur there. Nevertheless, extensive organisational and preventive fire protection measures have been implemented. Fire protection is part of the site's safety philosophy.

In case of modifications to the facility, fire protection is regularly taken into account and the fire protection concept is adapted if necessary. The measures applied are effective, no fires have occurred, and the protection goal of fire prevention has been fully achieved during many years of operation.

On-site radioactive waste storage facilities

The fire protection concepts of the storage facilities for radioactive waste at the Biblis site and at the ZLN and their implementation are presented correctly in Section 3. In addition to the requirements of conventional building regulations, they also meet the requirements of radiation protection law. They include preventive and defensive fire protection provisions.

Organisationally, the radioactive waste storage facilities are subject to the general site regulations. This means that the high standards implemented for the spent fuel storage facilities also apply to the radioactive waste storage facilities.

Due to the low fire loads in the storage building, a fire is not expected to occur there. Nevertheless, extensive organisational and preventive fire protection measures have been implemented. Fire protection is part of the site's safety philosophy.

In case of modifications to the facilities, fire protection is regularly taken into account, and the fire protection concept is adapted as necessary. The measures applied are effective and have achieved the protection goal of fire prevention over many years of operation.

In the case of the radioactive waste storage facility at the ZLN, the special nature of the conditioning of radioactive waste was correctly represented. The fire protection concept took into account the special nature of handling combustible radioactive waste in processing caissons, and appropriate preventive and defensive fire protection provisions were implemented. These included, in particular, the partitioning into fire compartments, the semi-stationary foam extinguishing system for caisson 2 and the deployment of the on-site fire brigade, which can start fighting the fire after approx. 5 min. The implementation of the fire protection concept has proven itself so far.

Installations under decommissioning

Nuclear power plants and research reactors under decommissioning are considered in the respective paragraphs on nuclear power plants and research reactors. The following refers only to the WAK and VEK.

WAK including VEK

The fire protection concept and its implementation at the WAK including VEK are correctly presented in Section 3.

The regulations of the supervisory authority explicitly provide for equipment-related fire protection as one of the inspection areas to be regularly checked during on-site supervision.

The changes that occur as dismantling progresses are also reviewed by the supervisory authorities with regard to their impact on fire protection within the scope of modification notifications.

Overall, this ensures that all fire protection requirements continue to be achieved.

3.6 Conclusions on the adequacy of the fire protection concept and its implementation

As confirmed by the competent nuclear supervisory authorities of the Länder in paragraph 3.5, the fire protection concepts and their implementation for all described installations are presented appropriately in Section 3.

The relevant requirements from rules and regulations for the various parts of the fire protection concepts (fire prevention, active and passive fire protection) are complied with.

The fire protection features are periodically inspected to ensure their functionality, and this procedure is closely monitored and controlled by the competent nuclear supervisory authority. This ensures that the implementation of the fire protection concepts is permanently ensured.

Modifications and decommissioning of systems are carried out within the framework of modification procedures. In the supervisory procedure, they are checked to ensure their justification regarding fire protection and the absence of feedback effects on the systems remaining in operation. This ensures that fire protection during decommissioning and dismantling always remains appropriate to the risk potential.

4 Overall assessment and general conclusions

The above presentations result in the following overall assessment regarding fire safety of the considered, representatively selected nuclear installations in Germany:

1. In Germany, consideration of protection of nuclear installations against fires already began with the design/layout of the nuclear power plants, research reactors, nuclear fuel cycle and storage facilities. By measures considered in the design, construction and operation of nuclear power plants, precautions against fire events have been taken, which were also laid down in the construction and operating licences.

2. The conventional regulations on fire protection from building law and occupational health and safety are supplemented by the nuclear regulations, in particular the "Safety Requirements for Nuclear Power Plants" and safety standard KTA 2101, Parts 1 – 3, which are applied in a graded approach depending on the risk potential of the various nuclear installations.

3. The German regulations are highly compliant with the international fire safety requirements of WENRA, IAEA and Euratom.

4. The nuclear installations operated in Germany are continuously adapted to the state of the art in science and technology as regards fire safety. The operating experience from the German installations confirms the effectiveness of fire protection in German installations.

5. For nuclear power plants in operation (power operation as well as low-power and shutdown operation), deterministic fire hazard analyses and probabilistic fire risk analyses (so-called Fire PSA) were performed in accordance with the German regulations.

6. For research reactors, nuclear fuel cycle and storage facilities, fire safety has already been considered in the planning phase.

7. Fire safety has been continuously expanded during operation based on the progressing state of knowledge. For this purpose, various sources were used and, where necessary, appropriate measures have been implemented to prevent and control fires.

8. Where possible, conditions have been created in German nuclear power plants for improving fire safety based on extensive research and development work.

9. Fire safety in German nuclear installations is reviewed by the nuclear supervisory authorities of the Länder and the effectiveness of the provisions is confirmed. The practised procedure ensures that the high level of safety during operation is maintained for the installations considered here.

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Annexes to the NAR

A1 Complete list of nuclear installations, including those not considered in detail in the NAR

Nuclear power plants (all under decommissioning)		
Abbreviation	**Name (reactor type)**	**Site**
GKN II	Kernkraftwerk Neckarwestheim, Unit 2 (PWR)	Neckarwestheim, Baden-Württemberg
KKI 2	Kernkraftwerk Isar, Unit 2 (PWR)	Essenbach, Bavaria
KKE	Kernkraftwerk Emsland (PWR)	Lingen, Lower Saxony
KRB C	Kernkraftwerk Gundremmingen, Unit C (BWR)	Gundremmingen, Bavaria
KKP 2	Kernkraftwerk Philippsburg, Unit 2 (PWR)	Philippsburg, Baden-Württemberg
KWG	Kernkraftwerk Grohnde (PWR)	Grohnde, Lower Saxony
KBR	Kernkraftwerk Brokdorf (PWR)	Brokdorf, Schleswig-Holstein
KRB B	Kernkraftwerk Gundremmingen, Unit B (BWR)	Gundremmingen, Bavaria
KKG	Kernkraftwerk Grafenrheinfeld	Grafenrheinfeld, Bavaria
GKN I	Kernkraftwerk Neckarwestheim, Unit 1 (PWR)	Neckarwestheim, Baden-Württemberg
KKI 1	Kernkraftwerk Isar, Unit 1 (PWR)	Essenbach, Bavaria
KKP 1	Kernkraftwerk Philippsburg, Unit 2 (BWR)	Philippsburg, Baden-Württemberg
KWB-A	Kernkraftwerk Biblis, Unit A (PWR)	Biblis, Hesse
KWB-B	Kernkraftwerk Biblis, Unit B (PWR)	Biblis, Hesse
KKK	Kernkraftwerk Krümmel (BWR)	Geesthacht, Schleswig-Holstein
KKU	Kernkraftwerk Unterweser (PWR)	Stadland, Lower Saxony
KWO	Kernkraftwerk Obrigheim (PWR)	Obrigheim, Baden-Württemberg
KKS	Kernkraftwerk Stade	Stade, Lower Saxony

Research reactor (*: decommissioning applied for, **: under decommissioning)		
Abbreviation	**Name (reactor type)**	**Site**
FR MZ	Forschungsreaktor Mainz (TRIGA Mark II)	Mainz, Rhineland-Palatinate
FRM II	Forschungs-Neutronenquelle Heinz Maier-Leibnitz (swimming pool research reactor)	Technical University of Munich, Garching, Bavaria
SUR	Siemens Unterrichtsreaktor (teaching reactor)	Hochschule Furtwangen, Furtwangen, Baden-Württemberg
SUR	Siemens Unterrichtsreaktor (teaching reactor)	Hochschule Stuttgart, Stuttgart, Baden-Württemberg
SUR	Siemens Unterrichtsreaktor (teaching reactor)	Hochschule Ulm, Ulm, Baden-Württemberg
AKR/AKR-2	Ausbildungskernreaktor Dresden (training reactor, SUR type)	Dresden University of Technology, Dresden, Saxony
BER II*	Berliner Experimentier-Reaktor II (swimming pool research reactor)	Helmholtz-Zentrum Berlin, Berlin, Berlin
FRG 1*	Forschungsreaktor Geesthacht 1 (swimming pool research reactor)	Geesthacht, Schleswig-Holstein
FRG 2*	Forschungsreaktor Geesthacht 2 (swimming pool research reactor)	Geesthacht, Schleswig-Holstein
SUR AA**	Siemens Unterrichtsreaktor (teaching reactor)	Rheinisch-Westfälische Technische Hochschule, Aachen, North Rhine-Westphalia
FRM**	Forschungsreaktor München (swimming pool research reactor)	Technical University of Munich, Garching, Bavaria
FRJ 2**	Forschungsreaktor Jülich 2 (tank-type research reactor, D_2O)	Forschungszentrum Jülich, Jülich, North Rhine-Westphalia
Fuel cycle facilities		
Abbreviation	**Name and type**	**Site**
BFL	Brennelemente-Fertigungsanlage Lingen (fuel fabrication facility)	Lingen, Lower Saxony
UAG	Urananreicherungsanlage Gronau (uranium enrichment facility)	Gronau, North Rhine-Westphalia
PKA	Pilotkonditionierungsanlage Gorleben (pilot conditioning plant)	Gorleben, Lower Saxony

Central dry storage facilities for spent fuel		
Abbreviation	**Name**	**Site**
BZG	Brennelemente-Zwischenlager Gorleben	Gorleben, Lower Saxony
BZA	Brennelemente-Zwischenlager Ahaus	Ahaus, North Rhine-Westphalia
ZLN	Zwischenlager Nord	Rubenow, Mecklenburg-Western Pomerania
AVR-BL	AVR-Behälterlager	Jülich, North Rhine-Westphalia
On-site dry storage facilities for spent fuel		
Abbreviation	**Name**	**Site**
BZB	Brennelemente-Zwischenlager Biblis	Biblis, Hesse
BZF	Brennelemente-Zwischenlager Brokdorf	Brokdorf, Schleswig-Holstein
SZB	Standort-Zwischenlager Brunsbüttel (Brennelemente-Zwischenlager)	Brunsbüttel, Schleswig-Holstein
BZD	Brennelemente-Zwischenlager Grohnde	Grohnde, Lower Saxony
BZM	Brennelemente-Zwischenlager Gundremmingen	Gundremmingen, Bavaria
BZI	Brennelemente-Zwischenlager Isar	Essenbach, Bavaria
BZK	Brennelemente-Zwischenlager Krümmel	Grafenrheinfeld, Bavaria
BZL	Brennelemente-Zwischenlager Lingen	Lingen, Lower Saxony
BZN	Brennelemente-Zwischenlager Neckarwestheim	Neckarwestheim, Baden-Württemberg
BZP	Brennelemente-Zwischenlager Philippsburg	Philippsburg, Baden-Württemberg
BZR	Brennelemente-Zwischenlager Grafenrheinfeld	Grafenrheinfeld, Bavaria
BZU	Brennelemente-Zwischenlager Unterweser	Stadland, Lower Saxony
Dry central storage facility for radioactive waste		
Abbreviation	**Name**	**Site**
AZG	Abfall-Zwischenlager Gorleben	Gorleben, Lower Saxony
AZA	Abfall-Zwischenlager Ahaus	Ahaus, North Rhine-Westphalia
AZU 1 and AZU 2	Abfall-Zwischenlager Unterweser 1 and Abfall-Zwischenlager Unterweser 2	Stadland, Lower Saxony

ZLN	Zwischenlager Nord	Rubenow, Mecklenburg-Western Pomerania
EB	Entsorgungsbetriebe	Karlsruhe, Baden-Württemberg
Decentralised dry storage facilities for radioactive waste		
Abbreviation	**Name**	**Site**
AZB 1 and AZB 2	Abfall-Zwischenlager Biblis 1 and Abfall-Zwischenlager Biblis 2	Biblis, Hesse
AZR	Abfall-Zwischenlager Grafenrheinfeld	Grafenrheinfeld, Bavaria
AZN	Abfall-Zwischenlager Neckarwestheim	Neckarwestheim, Baden-Württemberg
AZO	Abfall-Zwischenlager Obrigheim	Obrigheim, Baden-Württemberg
AZP	Abfall-Zwischenlager Philippsburg	Philippsburg, Baden-Württemberg
AZS	Abfall-Zwischenlager Stade	Stade, Lower Saxony
AZW	Abfall-Zwischenlager Würgassen	Würgassen, North Rhine-Westphalia
Installations under decommissioning[3]		
Abbreviation	**Name**	**Site**
WAK and VEK	Wiederaufarbeitungsanlage Karlsruhe and Verglasungseinrichtung Karlsruhe	Karlsruhe, Baden-Württemberg

[3] Nuclear power plants and research reactors under decommissioning are included under nuclear power plants and research reactors.

A2 List of GRS information notices with relevance in terms of fire protection

Information notice WLN No.	Title	IRS No.
1983/09	Fire in a charcoal bed of the off-gas system	359
1991/06	Hydrogen fire following a line rupture in the reactor building annulus	1225
1992/08	Fire water system gate valves fail to open	1296
1994/01	Malfunction of the thermal actuation mechanism of fire dampers in XXX and XXX	1424
1994/01A	Malfunction of the thermal actuation mechanism of fire dampers in XXX and XXX	none
1994/01B	Malfunction of the thermal actuation mechanism of fire dampers in XXX and XXX	none
1994/01C	Malfunction of the remote actuation mechanism of fire dampers in XXX	none
1994/01D	Malfunction of the remote actuation mechanism of fire dampers in XXX	none
1994/01E	Deficiencies at newly installed fire dampers	none
2001/02	Impured measuring lines in the fire extinguishing system at the nuclear power plant XXX, Unit X, on XX.XX.2000	none
2001/06	Failure of valves in the fire extinguishing system in the nuclear power plants XXX, unit X, on XX.XX.2000 and XXX, unit X, on XX.XX.2001	none
2003/10	Fire in a 500 V switchgear of the UNS system at the XXX nuclear power plant on XX.XX.2002	none
2003/13	Failure of the fire alarm system of the reactor building due to a fault in the voltage supply in the XXX nuclear power plant on XX.XX.2002	none
2006/01	Spurious Actuation of Stationary CO2–Fire Extinguishing System in a Computer Room at XXX NPP on XX.XX.2005	7965
2008/07	Intrusion of fire gas into the control room of the XXX nuclear power plant during the generator transformer fire on XX.XX.2007	8049
2013/02	Findings on structural fire protection measures at the XXX nuclear power plant starting XX.XX.2012	8317
2013/02A	Findings on structural fire protection measures at the XXX nuclear power plant starting XX.XX.2012	none
2015/02	Smoldering fire of waste material within the dryer facility at XXX NPP, Unit X on XX.XX.2011	none
2016/09	Spurious actuation of fire dampers in the independent sabotage and incident protection system (USUS) due to a malfunction in the MFXX fire alarm system at the XXX nuclear power plant, reported on XX.XX.2013	none
2016/14	Assembly fault in a fire alarm system at the XXX nuclear power plant, reported on XX.XX.2016	none

Information notice WLN No.	Title	IRS No.
2016/14A	Addendum to WLN 2016/04: Assembly fault in a fire alarm system at the XXX nuclear power plant, reported on XX.XX.2016	none
2022/03	Malfunction of the fire alarm system in the XXX nuclear power plant dated XX.XX.2022	none

A3 Classification of building materials and structural elements according to old DIN and current EN standards

This list represents an overview of the most common classifications of building materials and structural elements according to relevant German standards, which are gradually being replaced by harmonised European standards.

Building materials

“nichtbrennbar” (non-combustible), classified acc. DIN 4102-1
“non-combustible materials” acc. EN 13501-1

“schwerentflammbar” (not easily flammable), classified acc. DIN 4102-1
“combustible materials with very limited contribution to fire” acc. EN 13501-1

“normalentflammbar” (normally flammable), classified acc. DIN 4102-1
“combustible materials with limited contribution to fire” acc. EN 13501-1

“leichtentflammbar” (easily flammable), classified acc. DIN 4102-1
“combustible materials with limited contribution to fire” acc. EN 13501-1

Structural elements

Fire doors

“feuerhemmend” (fire-retardant):	T30 acc. DIN 4102-5	EI_2 30-S_aC_5 acc. EN 13501-2
“feuerbeständig” (fire-resistant):	T90 acc. DIN 4102-5	EI_2 90-S_aC_5 acc. EN 13501-2

Fire dampers

“feuerhemmend” (fire-retardant):	K30 acc. DIN 4102-6	EI 30(v_eh_o i↔o)-S acc. EN 13501-3
“feuerbeständig” (fire-resistant):	K90 acc. DIN 4102-6	EI 90(v_eh_o i↔o)-S acc. EN 13501-3

Ventilation ducts

“feuerhemmend” (fire-retardant):	L30 acc. DIN 4102-6	EI 30(v_eh_o i↔o)-S acc. EN 13501-3
“feuerbeständig” (fire-resistant):	L90 acc. DIN 4102-6	EI 90(v_eh_o i↔o)-S acc. EN 13501-3

Cable penetrations

“feuerhemmend” (fire-retardant):	S30 acc. DIN 4102-9	EI 30 acc. EN 13501-2
“feuerbeständig” (fire-resistant):	S90 acc. DIN 4102-9	EI 90 acc. EN 13501-2

Pipe penetrations

“feuerhemmend” (fire-retardant):	R30 acc. DIN 4102-11	EI 30 acc. EN 13501-2
“feuerbeständig” (fire-resistant):	R90 acc. DIN 4102-11	EI 90 acc. EN 13501-2